No. 16-1430

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

TRUCK TRAILER MANUFACTURERS ASSOCIATION, INC.,
Petitioner,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al.*,
Respondents,

and

CALIFORNIA AIR RESOURCES BOARD, *et al.*,
Intervenors.

On Petition for Review from a Final Rule of the
United States Environmental Protection Agency and the
National Highway Traffic Safety Administration

JOINT APPENDIX

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DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 523, 534, 535, and 538

[EPA–HQ–OAR–2014–0827; NHTSA–2014–0132; FRL–9950–25–OAR]

RIN 2060–AS16; RIN 2127–AL52

Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2

AGENCY: Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Final rule.

SUMMARY: EPA and NHTSA, on behalf of the Department of Transportation, are establishing rules for a comprehensive Phase 2 Heavy-Duty (HD) National Program that will reduce greenhouse gas (GHG) emissions and fuel consumption from new on-road medium- and heavy-duty vehicles and engines. NHTSA's fuel consumption standards and EPA's carbon dioxide (CO_2) emission standards are tailored to each of four regulatory categories of heavy-duty vehicles: Combination tractors; trailers used in combination with those tractors; heavy-duty pickup trucks and vans; and vocational vehicles. The rule also includes separate standards for the engines that power combination tractors and vocational vehicles. Certain requirements for control of GHG emissions are exclusive to the EPA program. These include EPA's hydrofluorocarbon standards to control leakage from air conditioning systems in vocational vehicles and EPA's nitrous oxide (N_2O) and methane (CH_4) standards for heavy-duty engines. Additionally, NHTSA is addressing misalignment between the Phase 1 EPA GHG standards and the NHTSA fuel efficiency standards to virtually eliminate the differences. This action also includes certain EPA-specific provisions relating to control of emissions of pollutants other than GHGs. EPA is finalizing non-GHG emission standards relating to the use of diesel auxiliary power units installed in new tractors. In addition, EPA is clarifying the classification of natural gas engines and other gaseous-fueled heavy-duty engines. EPA is also finalizing technical amendments to EPA rules that apply to emissions of non-GHG pollutants from light-duty motor vehicles, marine diesel engines, and other nonroad engines and equipment. Finally, EPA is requiring that engines from donor vehicles installed in new glider vehicles meet the emission standards applicable in the year of assembly of the new glider vehicle, including all applicable standards for criteria pollutants, with limited exceptions for small businesses and for other special circumstances.

DATES: This final rule is effective on December 27, 2016. The incorporation by reference of certain publications listed in this regulation is approved by the Director of the Federal Register as of December 27, 2016.

ADDRESSES: EPA and NHTSA have established dockets for this action under Docket ID No. EPA–HQ–OAR–2014–0827 (for EPA's docket) and NHTSA–2014–0132 (for NHTSA's docket). All documents in the docket are listed on the *https://www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.,* CBI or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available either electronically in *https://www.regulations.gov* or in hard copy at the following locations:

EPA: Air and Radiation Docket and Information Center, EPA Docket Center, EPA/DC, EPA WJC West Building, 1301 Constitution Ave. NW., Room 3334, Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742.

NHTSA: Docket Management Facility, M–30, U.S. Department of Transportation, West Building, Ground Floor, Rm. W12–140, 1200 New Jersey Avenue SE., Washington, DC 20590. The telephone number for the docket management facility is (202) 366–9324. The docket management facility is open between 9 a.m. and 5 p.m. Eastern Time, Monday through Friday, except Federal Holidays.

FOR FURTHER INFORMATION CONTACT:

EPA: Tad Wysor, Office of Transportation and Air Quality, Assessment and Standards Division (ASD), Environmental Protection Agency, 2000 Traverwood Drive, Ann Arbor, MI 48105; telephone number: (734) 214–4332; email address: *wysor.tad@epa.gov.*

NHTSA: Ryan Hagen, Office of Chief Counsel, National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE., Washington, DC 20590. Telephone: (202) 366–2992; *ryan.hagen@dot.gov.*

SUPPLEMENTARY INFORMATION:

A. Does this action apply to me?

This action will affect companies that manufacture, sell, or import into the United States new heavy-duty engines and new Class 2b through 8 trucks, including combination tractors, all types of buses, vocational vehicles including municipal, commercial, recreational vehicles, and commercial trailers as well as ¾-ton and 1-ton pickup trucks and vans. The heavy-duty category incorporates all motor vehicles with a gross vehicle weight rating of 8,500 lbs. or greater, and the engines that power them, except for medium-duty passenger vehicles already covered by the greenhouse gas standards and corporate average fuel economy standards issued for light-duty model year 2017–2025 vehicles.[1] Regulated categories and entities include the following:

Category	NAICS code [a]	Examples of potentially affected entities
Industry	336111 336112 333618 336120 336212	Motor Vehicle Manufacturers, Engine Manufacturers, Truck Manufacturers, Truck Trailer Manufacturers.
Industry	541514 811112	Commercial Importers of Vehicles and Vehicle Components.

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[1] As discussed in Section I.A, the term heavy-duty is generally used in this rulemaking to refer to all vehicles with a gross vehicle weight rating above 8,500 lbs, including vehicles that are sometimes otherwise known as medium-duty vehicles.

Category	NAICS code [a]	Examples of potentially affected entities
Industry	811198 336111 336112 422720 454312 541514 541690 811198	Alternative Fuel Vehicle Converters.

Note:
[a] North American Industry Classification System (NAICS).

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely covered by these rules. This table lists the types of entities that the agencies are aware may be regulated by this action. Other types of entities not listed in the table could also be regulated. To determine whether your activities are regulated by this action, you should carefully examine the applicability criteria in the referenced regulations. You may direct questions regarding the applicability of this action to the persons listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

B. Did EPA conduct a peer review before issuing this document?

This regulatory action is supported by influential scientific information. Therefore, EPA conducted a peer review consistent with OMB's Final Information Quality Bulletin for Peer Review. As described in Section II.C, a peer review of updates to the vehicle simulation model (GEM) for the Phase 2 standards has been completed. This version of GEM is based on the model used for the Phase 1 rule, which was peer reviewed by a panel of four independent subject matter experts. The peer review report and EPA's response to the peer review comments are available in Docket ID No. EPA–HQ–OAR–2014–0827. We note that this rulemaking is based on a vast body of existing peer-reviewed work, *i.e.,* work that was peer-reviewed outside of this action, as noted in the references throughout this Preamble, the Regulatory Impacts Analysis, and the rulemaking docket. EPA also notified the SAB of its plans for this rulemaking and on June 11, 2014, the chartered SAB discussed the recommendations of its work group on the planned action and agreed that no further SAB consideration of the supporting science was merited.

C. Executive Summary

(1) Commitment to Greenhouse Gas Emission Reductions and Vehicle Fuel Efficiency

In June 2013, the President announced a comprehensive Climate Action Plan for the United States to reduce carbon pollution, prepare for the impacts of climate change, and lead international efforts to address global climate change.[2] In this plan, President Obama reaffirmed his commitment to reduce U.S. greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020. More recently, in December 2015, the U.S. was one of over 190 signatories to the Paris Climate Agreement, widely regarded as the most ambitious climate change agreement in history. The Paris agreement reaffirms the goal of limiting global temperature increase to well below 2 degrees Celsius, and for the first time urged efforts to limit the temperature increase to 1.5 degrees Celsius. The U.S. submitted a non-binding intended nationally determined contribution (NDC) target of reducing economy-wide GHG emissions by 26–28 percent below its 2005 level in 2025 and to make best efforts to reduce emissions by 28 percent.[3] This pace would keep the U.S. on a trajectory to achieve deep economy-wide reductions on the order of 80 percent by 2050.

As part of his Climate Action plan, the President specifically directed the Environmental Protection Agency (EPA) and the Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA) to set the next round of standards to reduce greenhouse gas (GHG) emissions and improve fuel efficiency for heavy-duty vehicles pursuant to and consistent with the agencies' existing statutory authorities.[4] More than 70 percent of the oil used in the United States and 26 percent of GHG emissions come from the transportation sector, and since 2009 EPA and NHTSA have worked with industry, states, and other stakeholders to develop ambitious, flexible standards for both the fuel economy and GHG emissions of light-duty vehicles and the fuel efficiency and GHG emissions of heavy-duty vehicles.[5] [6] The standards here (referred to as Phase 2) will build on the light-duty vehicle standards spanning model years 2012 to 2025 and on the initial phase of standards (referred to as Phase 1) for new medium and heavy-duty vehicles (MDVs and HDVs) and engines in model years 2014 to 2018. Throughout every stage of development for these programs, EPA and NHTSA (collectively, the agencies, or ''we'') have worked in close partnership not only with one another, but also with the vehicle manufacturing industry, environmental community leaders, and the State of California among other entities to create a single, effective set of national standards.

Through two previous rulemakings, EPA and NHTSA have worked with the auto industry to develop new fuel economy and GHG emission standards for light-duty vehicles. Taken together with NHTSA's 2011 CAFE standards, the light-duty vehicle standards span model years 2011 to 2025 and are the first significant improvement in fuel economy in approximately two decades. Under the final program, average new car and light truck fuel economy is expected to nearly double by 2025

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[2] The White House, The President's Climate Action Plan (June, 2013). *http://www.whitehouse.gov/share/climate-action-plan.*

[3] United States of America, Intended Nationally Determined Contribution, March 31, 2015, *http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf.*

[4] EPA's HD Phase 2 GHG emission standards are authorized under the Clean Air Act, and NHTSA's HD Phase 2 fuel consumption standards are authorized under the Energy Independence and Security Act of 2007.

[5] The White House, Improving the Fuel Efficiency of American Trucks—Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation (Feb. 2014), 2.

[6] U.S. Environmental Protection Agency. April 2016. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012. EPA 430–R–16–002. Mobile sources emitted 28 percent of all U.S. GHG emissions in 2012. Available at *https://www3.epa.gov/climatechange/Downloads/ghgemissions/US–GHG-Inventory-2016-Main-Text.pdf.*

compared to 2010 vehicles.[7] In the 2012 rule, the agencies projected the standards would save consumers $1.7 trillion at the pump—roughly $8,200 per vehicle for a MY 2025 vehicle—reducing oil consumption by 2.2 million barrels a day in 2025 and slashing GHG emissions by 6 billion metric tons over the lifetime of the vehicles sold during this period.[8] These fuel economy standards are already delivering savings for American drivers. Between model years 2008 and 2013, the unadjusted average test fuel economy of new passenger cars and light trucks sold in the United States has increased by about four miles per gallon. Altogether, light-duty vehicle fuel economy standards finalized after 2008 have already saved nearly one billion gallons of fuel and avoided more than 10 million tons of carbon dioxide emissions.[9]

Similarly, EPA and NHTSA have previously developed joint GHG emission and fuel efficiency standards for MDVs and HDVs. Prior to these Phase 1 standards, heavy-duty trucks and buses—from delivery vans to the largest tractor-trailers—were required to meet pollution standards for soot and smog-causing air pollutants, but no requirements existed for the fuel efficiency or carbon pollution from these vehicles.[10] By 2010, total fuel consumption and GHG emissions from MDVs and HDVs had been growing, and these vehicles accounted for 23 percent of total U.S. transportation-related GHG emissions[11] and about 20 percent of U.S. transportation-related energy use. In August 2011, the agencies finalized the groundbreaking Phase 1 standards for new MDVs and HDVs in model years 2014 through 2018. This program, developed with support from the trucking and engine industries, the State of California, Environment and Climate Change Canada, and leaders from the environmental community, set standards based on the use of off-the-shelf technologies. These standards are expected to save a projected 530 million barrels of oil and reduce carbon emissions by about 270 million metric tons, representing one of the most significant programs available to reduce domestic fuel consumption and emissions of GHGs.[12] The Phase 1 program, as well as the many additional actions called for in the President's 2013 Climate Action Plan[13] including this Phase 2 rulemaking, not only result in meaningful decreases in GHG emissions and fuel consumption, but also support—indeed are critical for—United States leadership to encourage other countries to also achieve meaningful GHG reductions and fuel conservation.

This rule builds on our commitment to robust collaboration with stakeholders and the public. It follows an expansive and thorough outreach effort in which the agencies gathered input, data and views from many interested stakeholders, involving over 400 meetings with heavy-duty vehicle and engine manufacturers, technology suppliers, trucking fleets, truck drivers, dealerships, environmental organizations, and state agencies.[14] As with the previous light-duty rules and the heavy-duty Phase 1 rule, the agencies have consulted frequently with the California Air Resources Board (CARB) staff during the development of this rule, given California's unique ability among the states to adopt their own GHG standards for on-highway engines and vehicles. Through this close coordination, the agencies are finalizing a Phase 2 program that will be fully aligned between EPA and NHTSA, while providing CARB with the opportunity to adopt a Phase 2 program that will allow manufacturers to continue to build a single fleet of vehicles and engines.

(2) Overview of Phase 1 Medium- and Heavy-Duty Vehicle Standards

The Phase 1 program covers new trucks and heavy vehicles in model years 2014 and later. That program includes specific standards for combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles and includes separate standards for both vehicles and engines. The program offers extensive flexibility, allowing manufacturers to reach standards through average fleet calculations, a mix of technologies, and the use of various credit and banking programs.

The Phase 1 program was developed by the agencies through close consultation with industry and other stakeholders, resulting in standards tailored to the specifics of each different class of vehicles and engines.

- *Heavy-duty combination tractors.* Combination tractors—semi trucks that typically pull trailers—are regulated under nine subcategories based on weight class, cab type, and roof height. These vehicles represent approximately 60 percent of the fuel consumption and GHG emissions from MDVs and HDVs.
- *Heavy-duty pickup trucks and vans.* Heavy-duty pickup and van standards are based on a ''work factor'' attribute that combines a vehicle's payload, towing capabilities, and the presence of 4-wheel drive. These vehicles represent about 23 percent of the fuel consumption and GHG emissions from MDVs and HDVs.
- *Vocational vehicles.* Specialized vocational vehicles, which consist of a very wide variety of truck and bus types (*e.g.,* delivery, refuse, utility, dump, cement, transit bus, shuttle bus, school bus, emergency vehicles, and recreational vehicles) are regulated in three subcategories based on engine classification. These vehicles represent approximately 17 percent of the fuel consumption and GHG emissions from MDVs and HDVs. The Phase 1 program includes EPA GHG standards for recreational vehicles, but not NHTSA fuel efficiency standards.[15]
- *Heavy-duty engines.* The Phase 1 rule has independent standards for heavy-duty engines to assure they contribute to reducing GHG emissions and fuel consumption because the Phase 1 tractor and vocational vehicle standards do not account for the contributions of engine improvements to reducing fuel consumption and GHG emissions.

The Phase 1 standards were premised on utilization of technologies that were already in production on some vehicles at the time of the Phase 1 FRM and are adaptable to the broader fleet. The Phase 1 program provides flexibilities that facilitate compliance. These flexibilities help provide sufficient lead time for manufacturers to make necessary technological improvements and reduce the overall cost of the program, without compromising overall environmental and fuel consumption objectives. The primary flexibility provisions are an engine averaging, banking, and trading (ABT) program and a vehicle ABT program. These ABT programs allow for emission and/or fuel consumption credits to be averaged, banked, or traded within each of the averaging sets.

The Phase 1 program was projected to save 530 million barrels of oil and avoid 270 million metric tons of GHG emissions.[16] At the same time, the

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[7] The White House, Improving the Fuel Efficiency of American Trucks—Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation (Feb. 2014), 2.

[8] *Id.*

[9] *Id.* at 3.

[10] *Id.*

[11] *Id.*

[12] *Id.* at 4.

[13] The President's Climate Action Plan calls for GHG-cutting actions including, for example, reducing carbon emissions from power plants and curbing hydrofluorocarbon and methane emissions.

[14] ''Heavy-Duty Phase 2 Stakeholder Meeting Log'', August 2016.

[15] The Phase 2 program will also include NHTSA recreational vehicle fuel efficiency standards.

[16] The White House, Improving the Fuel Efficiency of American Trucks—Bolstering Energy

program was projected to produce $50 billion in fuel savings and $49 billion of net societal benefits. Today, the Phase 1 fuel efficiency and GHG reduction standards are already reducing GHG emissions and U.S. oil consumption, and producing fuel savings for America's trucking industry. The market appears to be very accepting of the Phase 1 technologies.

(3) Overview of Phase 2 Medium- and Heavy-Duty Vehicle Standards

The Phase 2 GHG and fuel efficiency standards for MDVs and HDVs are a critical next step in improving fuel efficiency and reducing GHG emissions. The Phase 2 national program carries forward our commitment to meaningful collaboration with stakeholders and the public, as they build on more than 400 meetings with manufacturers, suppliers, trucking fleets, dealerships, state air quality agencies, non-governmental organizations (NGOs), and other stakeholders; over 200,000 public comments; and two public hearings to identify and understand the opportunities and challenges involved with this next level of fuel-saving technology. These meetings and public feedback, in addition to close coordination with CARB, have been invaluable to the agencies, enabling the development of a program that appropriately balances all potential impacts, effectively minimizes the possibility of unintended consequences, and allows manufacturers to continue to build a single fleet of vehicles and engines.

Phase 2 will include technology-advancing standards that will phase in over the long-term (through model year 2027) to result in an ambitious, yet achievable program that will allow manufacturers to meet standards through a mix of different technologies at reasonable cost. The terminal requirements go into effect in 2027, and would apply to MY 2027 and subsequent model year vehicles, unless modified by future rulemaking. The Phase 2 standards will maintain the underlying regulatory structure developed in the Phase 1 program, such as the general categorization of MDVs and HDVs and the separate standards for vehicles and engines. However, the Phase 2 program will build on and advance Phase 1 in a number of important ways including the following: basing standards not only on currently available technologies but also on utilization of technologies now under development or not yet widely deployed while providing significant lead time to assure adequate time to develop, test, and phase in these controls; developing first-time GHG and fuel efficiency standards for trailers; further encouraging innovation and providing flexibility; including vehicles produced by small business manufacturers with appropriate flexibilities for these companies; incorporating enhanced test procedures that (among other things) allow individual drivetrain and powertrain performance to be reflected in the vehicle certification process; and using an expanded and improved compliance simulation model.

The Phase 2 program will provide significant GHG reductions and save fuel by:

- *Strengthening standards to account for ongoing technological advancements.* Relative to the baseline as of the end of Phase 1, these final standards are projected to achieve vehicle fuel savings as high as 25 percent, depending on the vehicle category. While costs are higher than for Phase 1, benefits greatly exceed costs, and payback periods are short, meaning that consumers will see substantial net savings over the vehicle lifetime. Payback is estimated at about two years for tractors and trailers, about four years for vocational vehicles, and about three years for heavy-duty pickups and vans. The agencies are finalizing a program that phases in the MY 2027 standards with interim standards for model years 2021 and 2024 (and for certain types of trailers, EPA is finalizing model year 2018 phase-in standards as well). The final program includes both significant strengthening of certain standards from the NPRM as well as adjustments to better align other standards with new data, analysis, and stakeholder and public feedback received since the time of the proposal.
- *Setting standards for trailers for the first time.* In addition to retaining the vehicle and engine categories covered in the Phase 1 program, the Phase 2 standards include fuel efficiency and GHG emission standards for trailers used in combination with tractors. Although the agencies are not finalizing standards for all trailer types, the majority of new trailers will be covered.
- *Encouraging technological innovation while providing flexibility and options for manufacturers.* For each category of HDVs, the standards will set performance targets that allow manufacturers to achieve reductions through a mix of different technologies and generally leave manufacturers free to choose any means of compliance. For tractor standards, for example, different combinations of improvements like advanced aerodynamics, engine improvements and waste-heat recovery, automated transmission, lower rolling resistance tires, and automatic tire inflation can be used to meet standards. For tractors and vocational vehicles, enhanced test procedures and an expanded and improved compliance simulation model enable the vehicle standards to encompass more of the complete vehicle than the Phase 1 program and to account for engine, transmission and driveline improvements. With the addition of the powertrain and driveline to the compliance model, representative drive cycles and vehicle baseline configurations become critically important to assure the standards promote technologies that improve real world fuel efficiency and GHG emissions. This rule updates drive cycles and vehicle configurations to better reflect real world operation. The final program includes adjustments to technical elements of the proposed compliance program, *e.g.,* test procedures, reflecting the significant amount of stakeholder and public comment the agencies received on the program. Additionally, the agencies' analyses indicate that this rule should have no adverse impact on vehicle or engine safety.
- *Providing flexibilities to help minimize effect on small businesses.* All small businesses are exempt from the Phase 1 standards. The agencies are regulating small business entities under Phase 2 (notably certain trailer manufacturers), but we have conducted extensive proceedings pursuant to section 609 of the Regulatory Flexibility Act, and engaged in extensive consultation with stakeholders, and developed an approach to provide targeted flexibilities geared toward helping small businesses comply with the Phase 2 standards. Specifically, the agencies are delaying the initial implementation of the Phase 2 standards by one year and simplifying certification requirements for small businesses. We are also adopting additional flexibilities and exemptions adapted to particular vehicle categories.

The following tables summarize the impacts of the Heavy-Duty Phase 2 rule.

Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation (Feb. 2014), 4.

SUMMARY OF THE PHASE 2 MEDIUM- AND HEAVY-DUTY VEHICLE RULE IMPACTS TO FUEL CONSUMPTION, GHG EMISSIONS, BENEFITS AND COSTS OVER THE LIFETIME OF MODEL YEARS 2018–2029 [a] [b]

	3%	7%
Fuel Reductions (billion gallons)	71–82	
GHG Reductions (MMT, CO$_2$eq)	959–1098	
Pre-Tax Fuel Savings ($billion)	149–169	80–87
Discounted Technology Costs ($billion)	24–27	16–18
Value of reduced emissions ($billion)	60–69	48–52
Total Costs ($billion)	29–31	19–20
Total Benefits ($billion)	225–260	136–151
Net Benefits ($billion)	197–229	117–131

Notes:

[a] Ranges reflect two analysis methods: Method A with the 1b baseline and Method B with the la baseline. For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the “flat” baseline, 1a, and the “dynamic” baseline, 1b, please see Section X.A.1.

[b] Benefits and net benefits (including those in the 7% discount rate column) use the 3 percent average Social Cost of CO$_2$, the Social Cost of CH$_4$, and the Social Cost of N$_2$O.

SUMMARY OF THE PHASE 2 MEDIUM- AND HEAVY-DUTY VEHICLE ANNUAL FUEL AND GHG REDUCTIONS, PROGRAM COSTS, BENEFITS AND NET BENEFITS IN CALENDAR YEARS 2040 AND 2050 [a]

	2040	2050
Fuel Reductions (Billion Gallons)	10.8	13.0
GHG Reduction (MMT, CO$_2$eq)	166.8	199.3
Vehicle Program Costs (including Maintenance; Billions of 2013$)	−$6.5	−$7.5
Fuel Savings (Pre-Tax; Billions of 2013$)	$53.1	$63.4
Benefits (Billions of 2013$)	$24.8	$31.7
Net Benefits (Billions of 2013$)	$71.4	$87.6

Note:

[a] Benefits and net benefits (including those in the 7% discount rate column) use the 3 percent average Social Cost of CO$_2$, the Social Cost of CH$_4$, and the Social Cost of N$_2$O. Values reflect the final program using Method B relative to the flat baseline (a reference case that projects very little improvement in new vehicle fuel economy absent new standards).

SUMMARY OF THE PHASE 2 MEDIUM- AND HEAVY-DUTY VEHICLE PROGRAM EXPECTED PER-VEHICLE FUEL SAVINGS, GHG EMISSION REDUCTIONS, AND COST FOR KEY VEHICLE CATEGORIES

	MY 2021	MY 2024	MY 2027
Maximum Vehicle Fuel Savings and Tailpipe GHG Reduction (%):			
Tractors [b]	13	20	25
Trailers [a]	5	7	9
Vocational Vehicles [b]	12	20	24
Pickups/Vans	2.5	10	16
Per Vehicle Cost ($)[c d] (% Increase in Typical Vehicle Price):			
Tractors	$6,400–$6,480 (6%)	$9,920–$10,100 (10%)	$12,160–$12,440 (12%)
Trailers	$850–$870 (3%)	$1,000–$1,030 (4%)	$1,070–$1,110 (4%)
Vocational Vehicles	$1,110–$1,160 (1%)	$1,980–$2,020 (2%)	$2,660–$2,700 (3%)
Pickups/Vans	$520–$750 (1%)	$760–$960 (2%)	$1,340–$1,360 (3%)

Notes:

[a] Note that the EPA standards for trailers begin in model year 2018

[b] All engine costs are included

[c] Please refer to Preamble Chapters 6 and 10 for additional information on the reference fleet used to analyze costs and benefits of the rule. Please also refer to these chapters for impacts of the rule under more dynamic baseline assumptions for pickups and vans.

[d] Ranges reflect two analysis methods: Method A with the 1b baseline and Method B with the la baseline. For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the “flat” baseline, 1a, and the “dynamic” baseline, 1b, please see Section X.A.1.

[e] For this table, we use an approximate minimum vehicle price today of $100,000 for tractors, $25,000 for trailers, $100,000 for vocational vehicles and $40,000 for HD pickups/vans.

PAYBACK PERIODS FOR MY 2027 VEHICLES UNDER THE FINAL STANDARDS, BASED ON BOTH ANALYSIS METHODS A AND B

[Payback occurs in the year shown; using 7% discounting]

	Final standards
Tractors/Trailers	2nd.
Vocational Vehicles	4th.
Pickups/Vans [a]	3rd.

Note:

[a] Please refer to Preamble Chapters 6 and 10 for additional information on the reference fleet used to analyze costs and benefits of the rule. Please also refer to these chapters for impacts of the rule under more dynamic baseline assumptions for pickups and vans.

(4) Issues Addressed in This Final Rule

This Preamble contains extensive discussion of the background, elements, and implications of the Phase 2 program, as well as updates made to the final program from the proposal based on new data, analysis, stakeholder feedback and public comments. Section I includes information on the MDV and HDV industry, related regulatory and non-regulatory programs, summaries of Phase 1 and Phase 2 programs, costs and benefits of the final standards, and relevant statutory authority for EPA and NHTSA. Section II discusses vehicle simulation, engine standards, and test procedures. Sections III, IV, V, and VI detail the final standards for combination tractors, trailers, vocational vehicles, and heavy-duty pickup trucks and vans. Sections VII and VIII discuss aggregate GHG impacts, fuel consumption impacts, climate impacts, and impacts on non-GHG emissions. Section IX evaluates the economic impacts of the final program. Sections X and XI present the alternatives analyses and consideration of natural gas vehicles. Finally, Sections XII and XIII discuss the changes that the Phase 2 rules will have on Phase 1 standards and other regulatory provisions. In addition to this Preamble, the Regulatory Impact Analysis (RIA),[17] provides additional data, analysis and discussion of the standards, and the Response to Comments Document for Joint Rulemaking (RTC) provides responses to comments received on the Phase 2 rulemaking through the public comment process.[18]

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[17] Available on EPA and NHTSA's Web sites and in the public docket for this rulemaking.

[18] Available on EPA's Web site and in the public docket for this rulemaking.

I. Overview

The agencies issued a Notice of Proposed Rulemaking (NPRM) on July 13, 2015, that proposed Phase 2 GHG and fuel efficiency standards for heavy-duty engines and vehicles.[19] The agencies also issued a Notice of Data Availability (NODA) on March 2, 2016, to solicit comment on new material not available at the time of the NPRM.[20] The agencies have revised the proposed standards and related requirements to address issues raised in public comments. Nevertheless, the final rules being adopted today remain fundamentally similar to the proposed rules.

Although the agencies describe the final requirements in this document, readers are encouraged to also read supporting materials that have been place into the public dockets for these rules. In particular, the agencies note:

- The Final Regulatory Impact Analysis (RIA), provides additional technical information and analysis
- The Response to Comments Document for Joint Rulemaking (RTC), provides a detailed summary and analysis of public comments, including comments received in response to the NODA
- The NHTSA Final Environmental Impact Statement (FEIS)

This overview of the final Phase 2 GHG emissions and fuel efficiency standards includes a description of the heavy-duty truck industry and related regulatory and non-regulatory programs, a summary of the Phase 1 GHG emissions and fuel efficiency program, a summary of the Phase 2 standards and requirements being finalized, a summary of the costs and benefits of the Phase 2 standards, discussion of EPA and NHTSA statutory authorities, and other issues.

A. Background

For purposes of this Preamble (and consistent with all terminology used at proposal), the terms ‘‘heavy-duty’’ or ‘‘HD’’ are used to apply to all highway vehicles and engines that are not within the range of light-duty passenger cars, light-duty trucks, and medium-duty passenger vehicles (MDPV) covered by separate GHG and Corporate Average Fuel Economy (CAFE) standards.[21] (The terms also do not include motorcycles). Thus, in this rulemaking, unless specified otherwise, the heavy-duty category incorporates all vehicles with a gross vehicle weight rating above 8,500 lbs, and the engines that power them, except for MDPVs.[22] [23] [24] Note also that the terms heavy-duty truck and heavy-duty vehicle are sometimes used interchangeably, even though commercially the term heavy-duty truck can have a narrower meaning.

Consistent with the President’s direction, over the past three years as we have developed this rulemaking, the agencies have met on an on-going basis with a very large number of diverse stakeholders. This includes meetings, and in many cases site visits, with truck, trailer, and engine manufacturers; technology supplier companies and their trade associations (*e.g.,* transmissions, drivelines, fuel systems, turbochargers, tires, catalysts, and many others); line haul and vocational trucking firms and trucking associations; the trucking industries owner-operator association; truck dealerships and dealers associations; trailer manufacturers and their trade association; non-governmental organizations (NGOs, including environmental NGOs, national security NGOs, and consumer advocacy NGOs); state air quality agencies; manufacturing labor unions; and many other stakeholders. In addition, EPA and NHTSA have consulted on an on-going basis with the California Air Resources Board (CARB) over the past three years as we developed the Phase 2 rule. CARB staff and managers have also participated with EPA and NHTSA in meetings with many external stakeholders, including those with vehicle OEMs and technology suppliers.[25]

EPA and NHTSA staff also participated in a large number of technical and policy conferences over the past three years related to the technological, economic, and environmental aspects of the heavy-duty trucking industry. The agencies also met with regulatory counterparts from several other nations who either have already or are considering establishing fuel consumption or GHG requirements, including outreach with representatives from the governments of Canada, the European Commission, Japan, and China.

These comprehensive outreach actions by the agencies provided us with information to assist in our identification of potential technologies that can be used to reduce heavy-duty GHG emissions and improve fuel efficiency. The outreach has also helped the agencies to identify and understand the opportunities and challenges involved with these standards for the heavy-duty trucks, trailers, and engines detailed in this Preamble, including time needed for implementation of various technologies and potential costs and fuel savings. The scope of this outreach effort to gather input for the proposal and final rulemaking included well over 400 meetings with stakeholders. These meetings and conferences have been invaluable to the agencies. We believe they enabled us to refine the proposal in such a way as to appropriately consider all of the potential impacts and to minimize the possibility of unintended consequences in the final rules.

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[19] 80 FR 40137.

[20] 81 FR 10824.

[21] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule, 77 FR 62623, October 15, 2012.

[22] The CAA defines heavy-duty as a truck, bus or other motor vehicles with a gross vehicle weight rating exceeding 6,000 lbs (CAA section 202(b)(3)). The term HD as used in this action refers to a subset of these vehicles and engines.

[23] The Energy Independence and Security Act of 2007 requires NHTSA to set standards for commercial medium- and heavy-duty on-highway vehicles, defined as on-highway vehicles with a GVWR of 10,000 lbs or more, and work trucks, defined as vehicles with a GVWR between 8,500 and 10,000 lbs and excluding medium duty passenger vehicles.

[24] The term ‘‘medium-duty’’ is sometimes used to refer to the lighter end of this range of vehicles. This is typically in the context of statutes or reports that use the term ‘‘medium-duty.’’ For example, because the term medium-duty is used in EISA, the term is also used in much of the discussion of NHTSA’s statutory authority.

[25] Vehicle chassis manufacturers are known in this industry as original equipment manufacturers or OEMs.

(1) Brief Overview of the Heavy-Duty Truck Industry

The heavy-duty sector is diverse in several respects, including the types of manufacturing companies involved, the range of sizes of trucks and engines they produce, the types of work for which the trucks are designed, and the regulatory history of different subcategories of vehicles and engines. The current heavy-duty fleet encompasses vehicles from the ''18-wheeler'' combination tractor-trailers one sees on the highway to the largest pickup trucks and vans, as well as vocational vehicles covering the range between these extremes. Together, the HD sector spans a wide range of vehicles with often specialized form and function. A primary indicator of the diversity among heavy-duty trucks is the range of load-carrying capability across the industry. The heavy-duty truck sector is often subdivided by vehicle weight classifications, as defined by the vehicle's gross vehicle weight rating (GVWR), which is a measure of the combined curb (empty) weight and cargo carrying capacity of the truck.[26] Table I–1 below outlines the vehicle weight classifications commonly used for many years for a variety of purposes by businesses and by several Federal agencies, including the Department of Transportation, the Environmental Protection Agency, the Department of Commerce, and the Internal Revenue Service.

TABLE I–1—VEHICLE WEIGHT CLASSIFICATION

Class	2b	3	4	5	6	7	8
GVWR (lb.)	8,501–10,000	10,001–14,000	14,001–16,000	16,001–19,500	19,501–26,000	26,001–33,000	>33,000

In the framework of these vehicle weight classifications, the heavy-duty truck sector refers to ''Class 2b'' through ''Class 8'' vehicles and the engines that power those vehicles.[27]

Unlike light-duty vehicles, which are primarily used for transporting passengers for personal travel, heavy-duty vehicles fill much more diverse operator needs. Heavy-duty pickup trucks and vans (Classes 2b and 3) are used chiefly as work trucks and vans, and as shuttle vans, as well as for personal transportation, with an average annual mileage in the range of 15,000 miles. The rest of the heavy-duty sector is used for carrying cargo and/or performing specialized tasks. ''Vocational'' vehicles, which span Classes 2b through 8, vary widely in size, including smaller and larger van trucks, utility ''bucket'' trucks, tank trucks, refuse trucks, urban and over-the-road buses, fire trucks, flat-bed trucks, and dump trucks, among others. The annual mileage of these vehicles is as varied as their uses, but for the most part tends to fall in between heavy-duty pickups/vans and the large combination tractors, typically from 15,000 to 150,000 miles per year.

Class 7 and 8 combination tractor-trailers—some equipped with sleeper cabs and some not—are primarily used for freight transportation. They are sold as tractors and operate with one or more trailers that can carry up to 50,000 lbs or more of payload, consuming significant quantities of fuel and producing significant amounts of GHG emissions. Together, Class 7 and 8 tractors and trailers account for approximately 60 percent of the heavy-duty sector's total CO_2 emissions and fuel consumption. Trailer designs vary significantly, reflecting the wide variety of cargo types. However, the most common types of trailers are box vans (dry and refrigerated), which are a focus of this Phase 2 rulemaking. The tractor-trailers used in combination applications can and frequently do travel more than 150,000 miles per year and can operate for 20–30 years.

Heavy-duty vehicles differ significantly from light-duty vehicles in other ways. In particular, we note that heavy-duty engines are much more likely to be rebuilt. In fact, it is common for Class 8 engines to be rebuilt multiple times. Commercial heavy-duty vehicles are often resold after a few years and may be repurposed by the second or third owner. Thus issues of resale value and adaptability have historically been key concerns for purchasers.

EPA and NHTSA have designed our respective standards in careful consideration of the diversity and complexity of the heavy-duty truck industry, as discussed in Section I.C.

(2) Related Regulatory and Non-Regulatory Programs

(a) History of EPA's Heavy-Duty Regulatory Program and Assessments of the Impacts of Greenhouse Gases on Climate Change

To provide a context for EPA's program to reduce greenhouse gas emissions from motor vehicles, this subsection provides an overview of two important related areas. First, we summarize the history of EPA's heavy-duty regulatory program, which provides a basis for the compliance structure of this rulemaking. Next we summarize EPA prior assessments of the impacts of greenhouse gases on climate change, which provides a basis for much of the analysis of the environmental benefits of this rulemaking.

(i) History of EPA's Heavy-Duty Regulatory Program

Since the 1980s, EPA has acted several times to address tailpipe emissions of criteria pollutants and air toxics from heavy-duty vehicles and engines. During the last two decades these programs have primarily addressed emissions of particulate matter (PM) and the primary ozone precursors, hydrocarbons (HC) and oxides of nitrogen (NO_X). These programs, which have successfully achieved significant and cost-effective reductions in emissions and associated health and welfare benefits to the nation, were an important basis of the Phase 1 program. See *e.g.* 66 FR 5002, 5008, and 5011–5012 (January 18, 2001) (detailing substantial public health benefits of controls of criteria pollutants from heavy-duty diesel engines, including bringing areas into attainment with primary (public health) PM NAAQS, or contributing substantially to such attainment); *National Petrochemical Refiners Association* v. *EPA,* 287 F. 3d 1130, 1134 (D.C. Cir. 2002) (referring to the ''dramatic reductions'' in criteria pollutant emissions resulting from the EPA on-

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[26] GVWR describes the maximum load that can be carried by a vehicle, including the weight of the vehicle itself. Heavy-duty vehicles (including those designed for primary purposes other than towing) also have a gross combined weight rating (GCWR), which describes the maximum load that the vehicle can haul, including the weight of a loaded trailer and the vehicle itself.

[27] Class 2b vehicles manufactured as passenger vehicles (Medium Duty Passenger Vehicles, MDPVs) are covered by the light-duty GHG and fuel economy standards and therefore are not addressed in this rulemaking.

highway heavy-duty engine standards, and upholding all of the standards).

As required by the Clean Air Act (CAA), the emission standards implemented by these programs include standards that apply at the time that the vehicle or engine is sold and continue to apply in actual use. EPA's overall program goal has always been to achieve emissions reductions from the complete vehicles that operate on our roads. The agency has often accomplished this goal for many heavy-duty truck categories by regulating heavy-duty engine emissions. A key part of this success has been the development over many years of a well-established, representative, and robust set of engine test procedures that industry and EPA now use routinely to measure emissions and determine compliance with emission standards. These test procedures in turn serve the overall compliance program that EPA implements to help ensure that emissions reductions are being achieved. By isolating the engine from the many variables involved when the engine is installed and operated in a HD vehicle, EPA has been able to accurately address the contribution of the engine alone to overall emissions.

(ii) EPA Assessment of the Impacts of Greenhouse Gases on Climate Change

In 2009, the EPA Administrator issued the document known as the Endangerment Finding under CAA section 202(a)(1).[28] In the Endangerment Finding, which focused on public health and public welfare impacts within the United States, the Administrator found that elevated concentrations of GHG emissions in the atmosphere may reasonably be anticipated to endanger public health and welfare of current and future generations. See also *Coalition for Responsible Regulation* v. *EPA,* 684 F. 3d 102, 117–123 (D.C. Cir. 2012) (upholding the endangerment finding in all respects). The following sections summarize the key information included in the Endangerment Finding.

Climate change caused by human emissions of GHGs threatens public health in multiple ways. By raising average temperatures, climate change increases the likelihood of heat waves, which are associated with increased deaths and illnesses. While climate change also decreases the likelihood of cold-related mortality, evidence indicates that the increases in heat mortality will be larger than the decreases in cold mortality in the United States. Compared to a future without climate change, climate change is expected to increase ozone pollution over broad areas of the U.S., including in the largest metropolitan areas with the worst ozone problems, and thereby increase the risk of morbidity and mortality. Other public health threats also stem from projected increases in intensity or frequency of extreme weather associated with climate change, such as increased hurricane intensity, increased frequency of intense storms and heavy precipitation. Increased coastal storms and storm surges due to rising sea levels are expected to cause increased drownings and other adverse health impacts. Children, the elderly, and the poor are among the most vulnerable to these climate-related health effects. See also 79 FR 75242 (December 17, 2014) (climate change, and temperature increases in particular, likely to increase O_3 (ozone) pollution ''over broad areas of the U.S., including the largest metropolitan areas with the worst O_3 problems, increas[ing] the risk of morbidity and mortality'').

Climate change caused by human emissions of GHGs also threatens public welfare in multiple ways. Climate changes are expected to place large areas of the country at serious risk of reduced water supplies, increased water pollution, and increased occurrence of extreme events such as floods and droughts. Coastal areas are expected to face increased risks from storm and flooding damage to property, as well as adverse impacts from rising sea level, such as land loss due to inundation, erosion, wetland submergence and habitat loss. Climate change is expected to result in an increase in peak electricity demand, and extreme weather from climate change threatens energy, transportation, and water resource infrastructure. Climate change may exacerbate ongoing environmental pressures in certain settlements, particularly in Alaskan indigenous communities. Climate change also is very likely to fundamentally rearrange U.S. ecosystems over the 21st century. Though some benefits may balance adverse effects on agriculture and forestry in the next few decades, the body of evidence points towards increasing risks of net adverse impacts on U.S. food production, agriculture and forest productivity as temperature continues to rise. These impacts are global and may exacerbate problems outside the U.S. that raise humanitarian, trade, and national security issues for the U.S. See also 79 FR 75382 (December 17, 2014) (welfare effects of O_3 increases due to climate change, with emphasis on increased wildfires).

As outlined in Section VIII.A of the 2009 Endangerment Finding, EPA's approach to providing the technical and scientific information to inform the Administrator's judgment regarding the question of whether GHGs endanger public health and welfare was to rely primarily upon the recent, major assessments by the U.S. Global Change Research Program (USGCRP), the Intergovernmental Panel on Climate Change (IPCC), and the National Research Council (NRC) of the National Academies. These assessments addressed the scientific issues that EPA was required to examine, were comprehensive in their coverage of the GHG and climate change issues, and underwent rigorous and exacting peer review by the expert community, as well as rigorous levels of U.S. government review. Since the administrative record concerning the Endangerment Finding closed following EPA's 2010 Reconsideration Denial, a number of new major, peer-reviewed scientific assessments have been released. These include the IPCC's 2012 ''Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation'' (SREX) and the 2013–2014 Fifth Assessment Report (AR5), the USGCRP's 2014 ''Climate Change Impacts in the United States'' (Climate Change Impacts), and the NRC's 2010 ''Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean'' (Ocean Acidification), 2011 ''Report on Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia'' (Climate Stabilization Targets), 2011 ''National Security Implications for U.S. Naval Forces'' (National Security Implications), 2011 ''Understanding Earth's Deep Past: Lessons for Our Climate Future'' (Understanding Earth's Deep Past), 2012 ''Sea Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future,'' 2012 ''Climate and Social Stress: Implications for Security Analysis'' (Climate and Social Stress), and 2013 ''Abrupt Impacts of Climate Change'' (Abrupt Impacts) assessments.

EPA has reviewed these new assessments and finds that the improved understanding of the climate system they present further strengthens the case that GHG emissions endanger public health and welfare.

In addition, these assessments highlight the urgency of the situation as the concentration of CO_2 in the atmosphere continues to rise. Absent a reduction in emissions, a recent

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[28] ''Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the Clean Air Act,'' 74 FR 66496 (December 15, 2009) (''Endangerment Finding'').

National Research Council assessment projected that concentrations by the end of the century would increase to levels that the Earth has not experienced for millions of years.[29] In fact, that assessment stated that ''the magnitude and rate of the present greenhouse gas increase place the climate system in what could be one of the most severe increases in radiative forcing of the global climate system in Earth history.'' [30] What this means, as stated in another NRC assessment, is that:

> Emissions of carbon dioxide from the burning of fossil fuels have ushered in a new epoch where human activities will largely determine the evolution of Earth's climate. Because carbon dioxide in the atmosphere is long lived, it can effectively lock Earth and future generations into a range of impacts, some of which could become very severe. Therefore, emission reductions choices made today matter in determining impacts experienced not just over the next few decades, but in the coming centuries and millennia.[31]

Moreover, due to the time-lags inherent in the Earth's climate, the Climate Stabilization Targets assessment notes that the full warming from any given concentration of CO_2 reached will not be realized for several centuries.

The most recent USGCRP ''National Climate Assessment'' [32] emphasizes that climate change is already happening now and is happening in the United States. The assessment documents the increases in some extreme weather and climate events in recent decades, as well as the resulting damage and disruption to infrastructure and agriculture, and projects continued increases in impacts across a wide range of peoples, sectors, and ecosystems.

These assessments underscore the urgency of reducing emissions now. Today's emissions will otherwise lead to raised atmospheric concentrations for thousands of years, and raised Earth system temperatures for even longer. Emission reductions today will benefit the public health and public welfare of current and future generations.

Finally, it should be noted that the concentration of carbon dioxide in the atmosphere continues to rise dramatically. In 2009, the year of the Endangerment Finding, the average concentration of carbon dioxide as measured on top of Mauna Loa was 387 parts per million.[33] The average concentration in 2015 was 401 parts per million, the first time an annual average has exceeded 400 parts per million since record keeping began at Mauna Loa in 1958, and for at least the past 800,000 years according to ice core records.[34] Moreover, 2015 was the warmest year globally in the modern global surface temperature record, going back to 1880, breaking the record previously held by 2014; this now means that the last 15 years have been 15 of the 16 warmest years on record.[35]

(b) The EPA and NHTSA Light-Duty National GHG and Fuel Economy Program

On May 7, 2010, EPA and NHTSA finalized the first-ever National Program for light-duty cars and trucks, which set GHG emissions and fuel economy standards for model years 2012–2016 (see 75 FR 25324). More recently, the agencies adopted even stricter standards for model years 2017 and later (77 FR 62624, October 15, 2012). The agencies have used the light-duty National Program as a model for the HD National Program in several respects. This is most apparent in the case of heavy-duty pickups and vans, which are similar to the light-duty trucks addressed in the light-duty National Program both technologically as well as in terms of how they are manufactured (*i.e.,* the same company often makes both the vehicle and the engine, and several light-duty manufacturers also manufacture HD pickups and vans).[36] For HD pickups and vans, there are close parallels to the light-duty program in how the agencies have developed our respective heavy-duty standards and compliance structures. However, HD pickups and vans are true work vehicles that are designed for much higher towing and payload capabilities than are light-duty pickups and vans. The technologies applied to light-duty trucks are not all applicable to heavy-duty pickups and vans at the same adoption rates, and the technologies often produce a lower percent reduction in CO_2 emissions and fuel consumption when used in heavy-duty vehicles. Another difference between the light-duty and the heavy-duty standards is that each agency adopts heavy-duty standards based on attributes other than vehicle footprint, as discussed below.

Due to the diversity of the remaining HD vehicles, there are fewer parallels with the structure of the light-duty program. However, the agencies have maintained the same collaboration and coordination that characterized the development of the light-duty program throughout the Phase 1 rulemaking and the continued efforts for Phase 2. Most notably, as with the light-duty program, manufacturers will continue to be able to design and build vehicles to meet a closely coordinated, harmonized national program, and to avoid unnecessarily duplicative testing and compliance burdens. In addition, the averaging, banking, and trading provisions in the HD program, although structurally different from those of the light-duty program, serve the same purpose, which is to allow manufacturers to achieve large reductions in fuel consumption and emissions while providing a broad mix of products to their customers. The agencies have also worked closely with CARB to provide harmonized national standards.

(c) EPA's SmartWay Program

EPA's voluntary SmartWay Transport Partnership program encourages businesses to take actions that reduce fuel consumption and CO_2 emissions while cutting costs by working with the shipping, logistics, and carrier communities to identify low carbon strategies and technologies across their transportation supply chains. SmartWay provides technical information, benchmarking and tracking tools, market incentives, and partner recognition to facilitate and accelerate the adoption of these strategies. Through the SmartWay program and its related technology assessment center, EPA has worked closely with truck and trailer manufacturers and truck fleets over the past 12 years to develop test procedures to evaluate vehicle and component performance in reducing fuel consumption and has conducted testing and has established test programs to verify technologies that can achieve these reductions. SmartWay partners have demonstrated these new and emerging technologies in their business operations, adding to the body of technical data and information that EPA can disseminate to industry, researchers and other stakeholders. Over the last several years, EPA has developed hands-on experience testing the largest heavy-duty trucks and trailers and evaluating improvements in tire and vehicle aerodynamic performance. In developing the Phase 1

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[29] National Research Council, Understanding Earth's Deep Past, p. 1.

[30] Id., p.138.

[31] National Research Council, Climate Stabilization Targets, p. 3.

[32] U.S. Global Change Research Program, Climate Change Impacts in the United States: The Third National Climate Assessment, May 2014 Available at *http://nca2014.globalchange.gov/.*

[33] *ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_annmean_mlo.txt.*

[34] *http://www.esrl.noaa.gov/gmd/ccgg/trends/.*

[35] *http://www.ncdc.noaa.gov/sotc/global/201513.*

[36] This is more broadly true for heavy-duty pickup trucks than vans because every manufacturer of heavy-duty pickup trucks also makes light-duty pickup trucks, while only some heavy-duty van manufacturers also make light-duty vans.

program, the agencies drew from this testing and from the SmartWay experience. In the same way, the agencies benefitted from SmartWay in developing the Phase 2 trailer program.

(d) DOE's SuperTruck Initiative

The U.S. Department of Energy launched its SuperTruck I initiative in 2009. SuperTruck I was a DOE partnership with four industry teams, who at this point have either met the SuperTruck I 50 percent fuel efficiency improvement goal (relative to a 2009 best-in-class truck) or have laid the groundwork to succeed. Teams from Cummins/Peterbilt, Daimler, and Volvo exceeded the 50 percent efficiency improvement goal, with Navistar on track to exceed this target later this year. Research vehicles developed under SuperTruck I are Class 8 combination tractor-trailers that have dramatically increased fuel and freight efficiency through the use of advanced technologies. These technologies include tractor and trailer aerodynamic devices, engine waste heat recovery systems, hybrids, automated transmissions and lightweight materials. In March 2016 DOE announced SuperTruck II, which is an $80M follow-on to SuperTruck I, where DOE will continue to partner with industry teams to collaboratively fund new projects to research, develop, and demonstrate technologies to further improve heavy-truck freight efficiency—by more than 100 percent, relative to a manufacturer's best-in-class 2009 truck. Achieving these kinds of Class 8 truck efficiency increases will require an integrated systems approach to ensure that the various components of the vehicle work well together. SuperTruck II projects will utilize a wide variety of truck and trailer technology approaches to achieve performance targets, such as further improvements in engine efficiency, drivetrain efficiency, aerodynamic drag, tire rolling resistance, and vehicle weight.

The agencies leveraged the outcomes of SuperTruck I by projecting how these tractor and trailer technologies could continue to advance from this early developmental stage toward the prototype and production stages. For a number of the SuperTruck technologies, the agencies are projecting advancement into production, given appropriate lead time. For example, a number of the aerodynamic and transmission technologies are projected to be in widespread production by 2021, and the agencies are finalizing 2021 standards based in part on performance of these SuperTruck technologies. For other more advanced SuperTruck technologies, such as organic Rankine cycle waste heat recovery systems, the agencies are projecting that additional lead time is needed to ensure that these technologies will be effective and reliable in production. For these technologies, the agencies are finalizing 2027 standards whose stringency reflects a significant market adoption rate of advanced technologies, including waste heat recovery systems. Furthermore, the agencies are encouraged by DOE's announcement of SuperTruck II. We believe that the combination of HD Phase 2 and SuperTruck II will provide both a strong motivation and a proven means for manufacturers to fully develop these technologies within the lead times we have projected.

(e) The State of California

California has established ambitious goals for reducing GHG emissions from heavy-duty vehicles and engines as part of an overall plan to reduce GHG emissions from the transportation sector in California.[37] Heavy-duty vehicles are responsible for one-fifth of the total GHG emissions from transportation sources in California. In the past several years, the California Air Resources Board (CARB) has taken a number of actions to reduce GHG emissions from heavy-duty vehicles and engines. For example, in 2008, CARB adopted regulations to reduce GHG emissions from heavy-duty tractors that pull box-type trailers through improvements in tractor and trailer aerodynamics and the use of low rolling resistance tires.[38] The tractor–trailer operators subject to the CARB regulation are required to use SmartWay-certified tractors and trailers, or retrofit their existing fleet with SmartWay-verified technologies, consistent with California's state authority to regulate both new and in-use vehicles. In December 2013, CARB adopted regulations that establish its own parallel Phase 1 program with standards consistent with EPA Phase 1 standards. On December 5, 2014, California's Office of Administrative Law approved CARB's adoption of the Phase 1 standards, with an effective date of December 5, 2014.[39] Complementary to its regulatory efforts, CARB and other California agencies are investing significant public capital through various incentive programs to accelerate fleet turnover and stimulate technology innovation within the heavy-duty vehicle market (*e.g.,* Air Quality Improvement, Carl Moyer, Loan Incentives, Lower-Emission School Bus and Goods Movement Emission Reduction Programs).[40] Recently, California Governor Jerry Brown established a target of up to 50 percent petroleum reduction by 2030.

California has long had the unique ability among states to adopt its own separate new motor vehicle standards per section 209 of the Clean Air Act (CAA). Although section 209(a) of the CAA expressly preempts states from adopting and enforcing standards relating to the control of emissions from new motor vehicles or new motor vehicle engines (such as state controls for new heavy-duty engines and vehicles), CAA section 209(b) directs EPA to waive this preemption under certain conditions. Under the waiver process set out in CAA section 209(b), EPA has granted CARB a waiver for its initial heavy-duty vehicle GHG regulation.[41] Even with California's ability under the CAA to establish its own emission standards, EPA and CARB have worked closely together over the past several decades to largely harmonize new vehicle criteria pollutant standard programs for heavy-duty engines and heavy-duty vehicles. In the past several years EPA and NHTSA also consulted with CARB in the development of the Federal light-duty vehicle GHG and CAFE rulemakings for the 2012–2016 and 2017–2025 model years.

As discussed above, California operates under state authority to establish its own new heavy-duty vehicle and engine emission standards, including standards for CO_2, methane, N_2O, and hydrofluorocarbons. EPA recognizes this independent authority, and we also recognize the potential benefits for the regulated industry if the Federal Phase 2 standards could result

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[37] See *http://www.arb.ca.gov/cc/cc.htm* for details on the California Air Resources Board climate change actions, including a discussion of Assembly Bill 32, and the Climate Change Scoping Plan developed by CARB, which includes details regarding CARB's future goals for reducing GHG emissions from heavy-duty vehicles.

[38] See *http://www.arb.ca.gov/msprog/truckstop/trailers/trailers.htm* for a summary of CARB's ''Tractor-Trailer Greenhouse Gas Regulation.''

[39] See *http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013.htm* for details regarding CARB's adoption of the Phase 1 standards.

[40] See *http://www.arb.ca.gov/ba/fininfo.htm* for detailed descriptions of CARB's mobile source incentive programs. Note that EPA works to support CARB's heavy-duty incentive programs through the West Coast Collaborative (*http://westcoastcollaborative.org/*) and the Clean Air Technology Initiative (*https://www.epa.gov/cati*).

[41] *See* EPA's waiver of CARB's heavy-duty tractor-trailer greenhouse gas regulation applicable to new 2011 through 2013 model year Class 8 tractors equipped with integrated sleeper berths (sleeper-cab tractors) and 2011 and subsequent model year dry-can and refrigerated-van trailers that are pulled by such tractors on California highways at 79 FR 46256 (August 7, 2014).

in a single, National Program that would meet the EPA and NHTSA's statutory requirements to set appropriate and maximum feasible standards, and also be equivalent to potential future new heavy-duty vehicle and engine GHG standards established by CARB (addressing the same model years as addressed by the final Federal Phase 2 program and requiring the same technologies). In order to further the opportunity for maintaining coordinated Federal and California standards in the Phase 2 timeframe (as well as to benefit from different technical expertise and perspective), EPA and NHTSA consulted frequently with CARB while developing the Phase 2 rule. Prior to the proposal, the agencies' technical staff shared information on technology cost, technology effectiveness, and feasibility with the CARB staff. We also received information from CARB on these same topics. In addition, CARB staff and managers participated with EPA and NHTSA in meetings with many external stakeholders, in particular with vehicle OEMs and technology suppliers. The agencies continued significant consultation during the development of the final rules.

EPA and NHTSA believe that through this information sharing and dialog we have enhanced the potential for the Phase 2 program to result in a National Program that can be adopted not only by the Federal agencies, but also by the State of California, given the strong interest from the regulated industry for a harmonized State and Federal program. In its public comments, California reiterated its support for a harmonized State and Federal program, although it identified several areas in which it believed the proposed program needed to be strengthened.

(f) Environment and Climate Change Canada

On March 13, 2013, Environment and Climate Change Canada (ECCC), which is EPA's Canadian counterpart, published its own regulations to control GHG emissions from heavy-duty vehicles and engines, beginning with MY 2014. These regulations are closely aligned with EPA's Phase 1 program to achieve a common set of North American standards. ECCC has expressed its intention to amend these regulations to further limit emissions of greenhouse gases from new on-road heavy-duty vehicles and their engines for post-2018 MYs. As with the development of the current regulations, ECCC is committed to continuing to work closely with EPA to maintain a common Canada–United States approach to regulating GHG emissions for post-2018 MY vehicles and engines. This approach will build on the long history of regulatory alignment between the two countries on vehicle emissions pursuant to the Canada–United States Air Quality Agreement.[42] In furtherance of this coordination, EPA participated in a workshop hosted by ECCC on March 3, 2016 to discuss Canada's Phase 2 program.[43]

The Government of Canada, including ECCC and Transport Canada, has also been of great assistance during the development of this Phase 2 rule. In particular, the Government of Canada supported aerodynamic testing, and conducted chassis dynamometer emissions testing.

(g) Recommendations of the National Academy of Sciences

In April 2010, as mandated by Congress in the EISA, the National Research Council (NRC) under the National Academy of Sciences (NAS) issued a report to NHTSA and to Congress evaluating medium- and heavy-duty truck fuel efficiency improvement opportunities, titled ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-duty Vehicles.'' That NAS report was far reaching in its review of the technologies that were available and that might become available in the future to reduce fuel consumption from medium- and heavy-duty vehicles. In presenting the full range of technical opportunities, the report included technologies that may not be available until 2020 or even further into the future. The report provided not only a valuable list of off-the-shelf technologies from which the agencies drew in developing the Phase 1 program, but also provided useful information the agencies have considered when developing this second phase of regulations.

In April 2014, the NAS issued another report: ''Reducing the Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two, First Report.''[44] This study outlines a number of recommendations to the U.S. Department of Transportation and NHTSA on technical and policy matters to consider when addressing the fuel efficiency of our nation's medium- and heavy-duty vehicles. In particular, this report provided recommendations with respect to:

- The Greenhouse Gas Emission Model (GEM) simulation tool used by the agencies to assess compliance with vehicle standards
- Regulation of trailers
- Natural gas-fueled engines and vehicles
- Data collection on in-use operation

The agencies are adopting many of these recommendations into the Phase 2 program, including recommendations relating to the GEM simulation tool and to trailers.

B. Summary of Phase 1 Program

(1) EPA Phase 1 GHG Emission Standards and NHTSA Phase 1 Fuel Consumption Standards

The EPA Phase 1 mandatory GHG emission standards commenced in MY 2014 and include increased stringency for standards applicable to MY 2017 and later MY vehicles and engines. NHTSA's fuel consumption standards were voluntary for MYs 2014 and 2015, due to lead time requirements in EISA, and apply on a mandatory basis thereafter. They also increase in stringency for MY 2017. Both agencies allowed voluntary early compliance starting in MY 2013 and encouraged manufacturers' participation through credit incentives.

Given the complexity of the heavy-duty industry, the agencies divided the industry into three discrete categories for purposes of setting our respective Phase 1 standards—combination tractors, heavy-duty pickups and vans, and vocational vehicles—based on the relative degree of homogeneity among trucks within each category. The Phase 1 rules also include separate standards for the engines that power combination tractors and vocational vehicles. For each regulatory category, the agencies adopted related but distinct program approaches reflecting the specific challenges in these segments. In the following paragraphs, we briefly summarize EPA's Phase 1 GHG emission standards and NHTSA's Phase 1 fuel consumption standards for the three regulatory categories of heavy-duty vehicles and for the engines powering vocational vehicles and

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[42] *http://www.ijc.org/en_/Air_Quality__Agreement.*

[43] ''Phase 2 of the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations; Pre-Consultation Session,'' March 3, 2016.

[44] National Research Council ''Reducing the Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two.'' Washington, DC, The National Academies Press. Cooperative Agreement DTNH22–12–00389. Available electronically from the National Academy Press Web site at *http://www.nap.edu/catalog/18736/reducing-the-fuel-consumption-and-greenhouse-gas-emissions-of-medium-and-heavy-duty-vehicles-phase-two* (last accessed May 18, 2016). On September 24, 2016, NAS will release an update report, consistent with Congress' quinquennial update requirement.

tractors. See Sections II, III, V, and VI for additional details on the Phase 1 standards. To respect differences in design and typical uses that drive different technology solutions, the agencies segmented each regulatory class into subcategories. The category-specific structure enabled the agencies to set standards that appropriately reflect the technology available for each regulatory subcategory of vehicles and the engines for use in each type of vehicle. The Phase 1 program also provided several flexibilities, as summarized in Section I.B.(3).

The agencies proposed and are adopting Phase 2 standards based on test procedures that differ from those used for Phase 1, including the revised GEM simulation tool. Significant revisions to GEM are discussed in Section II and in the RIA Chapter 4, and other test procedures are discussed further in the RIA Chapter 3. The pre-proposal revisions from Phase 1 GEM reflected input from both the NAS and from industry.[45] Changes since the proposal generally reflect comments received from industry and other key stakeholders. It is important to note that due to these test procedure changes, the Phase 1 and Phase 2 standards are not directly comparable in an absolute sense. In particular, the revisions being made to the 55 mph and 65 mph highway cruise cycles for tractors and vocational vehicles have the effect of making the cycles more challenging (albeit more representative of actual driving conditions). We are not applying these revisions to the Phase 1 program because doing so would significantly change the stringency of the Phase 1 standards, for which manufacturers have already developed engineering plans and are now producing products to meet. Moreover, the changes to GEM address a broader range of technologies not part of the projected compliance path for use in Phase 1.

Because the numeric values of the Phase 2 tractor and vocational standards are not directly comparable to their respective Phase 1 standards, the Phase 1 numeric standards were not appropriate baseline values to use to determine Phase 2's improvements. To address this situation, the agencies applied all of the new Phase 2 test procedures and GEM software to tractors and vocational vehicles equipped with Phase 1 compliant levels of technology. The agencies used the results of this approach to establish appropriate Phase 1 baseline values, which *are* directly comparable to the Phase 2 standards. For example, in this rulemaking we present Phase 2 per vehicle percent reductions versus Phase 1, and for tractors and vocational vehicles these percent reductions were all calculated versus Phase 1 compliant vehicles, where we applied the Phase 2 test procedures and GEM software to determine these Phase 1 vehicles' results.

(a) Class 7 and 8 Combination Tractors

Class 7 and 8 combination tractors and their engines contribute the largest portion of the total GHG emissions and fuel consumption of the heavy-duty sector, approximately 60 percent, due to their large payloads, their high annual miles traveled, and their major role in national freight transport. These vehicles consist of a cab and engine (tractor or combination tractor) and a detachable trailer. The primary manufacturers of combination tractors in the United States are Daimler Trucks North America, Navistar, Volvo/Mack, and PACCAR. Each of the tractor manufacturers and Cummins (an independent engine manufacturer) also produce heavy-duty engines used in tractors. The Phase 1 standards require manufacturers to reduce GHG emissions and fuel consumption for these tractors and engines, which we expect them to do through improvements in aerodynamics and tires, reductions in tractor weight, reduction in idle operation, as well as engine-based efficiency improvements.[46]

The Phase 1 tractor standards differ depending on gross vehicle weight rating (GVWR) (*i.e.,* whether the truck is Class 7 or Class 8), the height of the roof of the cab, and whether it is a ‘‘day cab’’ or a ‘‘sleeper cab.’’ The agencies created nine subcategories within the Class 7 and 8 combination tractor category reflecting combinations of these attributes. The agencies set Phase 1 standards for each of these subcategories beginning in MY 2014, with more stringent standards following in MY 2017. The standards represent an overall fuel consumption and CO_2 emissions reduction up to 23 percent from the tractors and the engines installed in them when compared to a baseline MY 2010 tractor and engine.

For Phase 1, tractor manufacturers demonstrate compliance with the tractor CO_2 and fuel consumption standards using a vehicle simulation tool described in Section II. The tractor inputs to the simulation tool in Phase 1 are the aerodynamic performance, tire rolling resistance, vehicle speed limiter, automatic engine shutdown, and weight reduction.

In addition to the Phase 1 tractor-based standards for CO_2, EPA adopted a separate standard to reduce leakage of hydrofluorocarbon (HFC) refrigerant from cabin air conditioning (A/C) systems from combination tractors, to apply to the tractor manufacturer. This HFC leakage standard is independent of the CO_2 tractor standard. Manufacturers can choose technologies from a menu of leak-reducing technologies sufficient to comply with the standard, as opposed to using a test to measure performance. Given that HFC leakage does not relate to fuel efficiency, NHTSA did not adopt corresponding HFC standards.

(b) Heavy-Duty Pickup Trucks and Vans (Class 2b and 3)

Heavy-duty vehicles with a GVWR between 8,501 and 10,000 lb. are classified as Class 2b motor vehicles. Heavy-duty vehicles with a GVWR between 10,001 and 14,000 lb. are classified as Class 3 motor vehicles. Class 2b and Class 3 heavy-duty vehicles (referred to in these rules as ‘‘HD pickups and vans’’) together emit about 23 percent of today's GHG emissions from the heavy-duty vehicle sector.[47]

The majority of HD pickups and vans are ¾-ton and 1-ton pickup trucks, 12- and 15-passenger vans,[48] and large work vans that are sold by vehicle manufacturers as complete vehicles, with no secondary manufacturer making substantial modifications prior to registration and use. These vehicles can also be sold as cab-complete vehicles (*i.e.,* incomplete vehicles that include complete or nearly complete cabs that are sold to secondary manufacturers). The majority of heavy-duty pickups and vans are produced by companies with major light-duty markets in the United States. Furthermore, the technologies available to reduce fuel consumption and GHG emissions from this segment are similar to the technologies used on light-duty pickup trucks, including both engine efficiency improvements (for gasoline and diesel engines) and vehicle efficiency improvements. For these reasons, EPA and NHTSA concluded

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[45] For further discussion of the input the agencies received from NAS, *see* Section XII of the Phase 2 NPRM at 80 FR 40512, July 13, 2015.

[46] We note although the standards' stringency is predicated on use of certain technologies, and the agencies' assessed the cost of the rule based on the cost of use of those technologies, the standards can be met by any means. Put another way, the rules create a performance standard, and do not mandate any particular means of achieving that level of performance.

[47] EPA MOVES Model, *http://www3.epa.gov/otaq/models/moves/index.htm.*

[48] Note that 12-passenger vans are subject to the light-duty standards as medium-duty passenger vehicles (MDPVs) and are not subject to this proposal.

that it was appropriate to adopt GHG standards, expressed as grams per mile, and fuel consumption standards, expressed as gallons per 100 miles, for HD pickups and vans based on the whole vehicle (including the engine), consistent with the way these vehicles have been regulated by EPA for criteria pollutants and also consistent with the way their light-duty counterpart vehicles are regulated by EPA and NHTSA. This complete vehicle approach adopted by both agencies for HD pickups and vans was consistent with the recommendations of the NAS Committee in its 2010 Report.

For the light-duty GHG and fuel economy standards, the agencies based the emissions and fuel economy targets on vehicle footprint (the wheelbase times the average track width). For those standards, passenger cars and light trucks with larger footprints are assigned higher GHG and lower fuel economy target levels reflecting their inherent tendency to consume more fuel and emit more GHGs per mile. For HD pickups and vans, the agencies believe that setting standards based on vehicle attributes is appropriate, but have found that a work-based metric is a more appropriate attribute than the footprint attribute utilized in the light-duty vehicle rulemaking, given that work-based measures such as towing and payload capacities are critical elements of these vehicles' functionality. EPA and NHTSA therefore adopted standards for HD pickups and vans based on a ''work factor'' attribute that combines their payload and towing capabilities, with an added adjustment for 4-wheel drive vehicles.

Each manufacturer's fleet average Phase 1 standard is based on production volume-weighting of target standards for all vehicles, which in turn are based on each vehicle's work factor. These target standards are taken from a set of curves (mathematical functions), with separate curves for gasoline and diesel vehicles.[49] However, both gasoline and diesel vehicles in this category are included in a single averaging set. EPA phased in the CO_2 standards gradually starting in the 2014 MY, at 15–20–40–60–100 percent of the MY 2018 standards stringency level in MYs 2014–2015–2016–2017–2018, respectively (*i.e.,* the 2014 standards requires only 15 percent of the reduction required in 2018, etc.). The phase-in takes the form of a set of target curves, with increasing stringency in each MY.

NHTSA allowed manufacturers to select one of two fuel consumption standard alternatives for MYs 2016 and later. The first alternative defined individual gasoline vehicle and diesel vehicle fuel consumption target curves that will not change for MYs 2016–2018, and are equivalent to EPA's 67–67–67–100 percent target curves in MYs 2016–2017–2018–2019, respectively. The second alternative defined target curves that are equivalent to EPA's 40–60–100 percent target curves in MYs 2016–2017–2018, respectively. NHTSA allowed manufacturers to opt voluntarily into the NHTSA HD pickup and van program in MYs 2014 or 2015 at target curves equivalent to EPA's target curves. If a manufacturer chose to opt in for one category, they would be required to opt in for all categories. In other words, a manufacturer would be unable to opt in for Class 2b vehicles, but opt out for Class 3 vehicles.

EPA also adopted an alternative phase-in schedule for manufacturers wanting to have stable standards for model years 2016–2018. The standards for heavy-duty pickups and vans, like those for light-duty vehicles, are expressed as set of target standard curves, with increasing stringency in each model year. The Phase 1 EPA standards for 2018 (including a separate standard to control air conditioning system leakage) are estimated to represent an average per-vehicle reduction in GHG emissions of 17 percent for diesel vehicles and 12 percent for gasoline vehicles (relative to pre-control baseline vehicles). The NHTSA standard will require these vehicles to achieve up to about 15 percent reduction in fuel consumption by MY 2018 (relative to pre-control baseline vehicles). Manufacturers demonstrate compliance based on entire vehicle chassis certification using the same duty cycles used to demonstrate compliance with criteria pollutant standards.

(c) Class 2b–8 Vocational Vehicles

Class 2b–8 vocational vehicles include a wide variety of vehicle types, and serve a vast range of functions. Some examples include service for parcel delivery, refuse hauling, utility service, dump, concrete mixing, transit service, shuttle service, school bus, emergency, motor homes, and tow trucks. In Phase 1, we defined Class 2b–8 vocational vehicles as all heavy-duty vehicles that are not included in either the heavy-duty pickup and van category or the Class 7 and 8 tractor category. EPA's and NHTSA's Phase 1 standards for this vocational vehicle category generally apply at the chassis manufacturer level. Class 2b–8 vocational vehicles and their engines emit approximately 17 percent of the GHG emissions and burn approximately 17 percent of the fuel consumed by today's heavy-duty truck sector.[50]

The Phase 1 program for vocational vehicles has vehicle standards and separate engine standards, both of which differ based on the weight class of the vehicle into which the engine will be installed. The vehicle weight class groups mirror those used for the engine standards—Classes 2b–5 (light heavy-duty or LHD in EPA regulations), Classes 6 and 7 (medium heavy-duty or MHD in EPA regulations) and Class 8 (heavy heavy-duty or HHD in EPA regulations). Manufacturers demonstrate compliance with the Phase 1 vocational vehicle CO_2 and fuel consumption standards using a vehicle simulation tool described in Section II. The Phase 1 program for vocational vehicles limited the simulation tool inputs to tire rolling resistance. The model assumes the use of a typical representative, compliant engine in the simulation, resulting in one overall value for CO_2 emissions and one for fuel consumption.

(d) Engine Standards

The agencies established separate Phase 1 performance standards for the engines manufactured for use in vocational vehicles and Class 7 and 8 tractors.[51] These engine standards vary depending on engine size linked to intended vehicle service class. EPA's engine-based CO_2 standards and NHTSA's engine-based fuel consumption standards are being implemented using EPA's existing test procedures and regulatory structure for criteria pollutant emissions from heavy-duty engines. EPA also established engine-based N_2O and CH_4 emission standards in Phase 1.

(e) Manufacturers Excluded From the Phase 1 Standards

Phase 1 deferred greenhouse gas emissions and fuel consumption standards for any manufacturers of heavy-duty engines, manufacturers of combination tractors, and chassis manufacturers for vocational vehicles that meet the ''small business'' size criteria set by the Small Business Administration (SBA). 13 CFR 121.201

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[49] As explained in Section XI, as part of this rulemaking, EPA moved the Phase 1 requirements for pickups and vans from 40 CFR 1037.104 into 40 CFR part 86, which is also the regulatory part that applies for light-duty vehicles.

[50] EPA MOVES model, *http://www3.epa.gov/otaq/models/moves/index.htm.*

[51] See 76 FR 57114 explaining why NHTSA's authority under the Energy Independence and Safety Act includes authority to establish separate engine standards.

defines a small business by the maximum number of employees; for example, this is currently 1,500 for heavy-duty truck manufacturing and 1,000 for engine manufacturing.[52] In order to utilize this exemption, qualifying small businesses must submit a declaration to the agencies. See Section I.F.(1)(b) for a summary of how Phase 2 applies for small businesses.

The agencies stated that they would consider appropriate GHG and fuel consumption standards for these entities as part of a future regulatory action. This includes both U.S.-based and foreign small-volume heavy-duty manufacturers that introduce new products into the U.S.

(2) Costs and Benefits of the Phase 1 Program

Overall, EPA and NHTSA estimated that the Phase 1 HD National Program will cost the affected industry about $8 billion, while saving vehicle owners fuel costs of nearly $50 billion over the lifetimes of MY 2014–2018 vehicles. The agencies also estimated that the combined standards will reduce CO_2 emissions by about 270 million metric tons and save about 530 million barrels of oil over the life of MY 2014 to 2018 vehicles. The agencies estimated additional monetized benefits from CO_2 reductions, improved energy security, reduced time spent refueling, as well as possible dis-benefits from increased driving crashes, traffic congestion, and noise. When considering all these factors, we estimated that Phase 1 of the HD National Program will yield $49 billion in net benefits to society over the lifetimes of MY 2014–2018 vehicles.

EPA estimated the benefits of reduced ambient concentrations of particulate matter and ozone resulting from the Phase 1 program to range from $1.3 to $4.2 billion in 2030.[53]

In total, we estimated the combined Phase 1 standards will reduce GHG emissions from the U.S. heavy-duty fleet by approximately 76 million metric tons of CO_2-equivalent annually by 2030. In its Environmental Impact Statement for the Phase 1 rule, NHTSA also quantified and/or discussed other potential impacts of the program, such as the health and environmental impacts associated with changes in ambient exposures to toxic air pollutants and the benefits associated with avoided non-CO_2 GHGs (methane, nitrous oxide, and HFCs).

(3) Phase 1 Program Flexibilities

As noted above, the agencies adopted numerous provisions designed to give manufacturers a degree of flexibility in complying with the Phase 1 standards. These provisions, which are essentially identical in structure and function in EPA's and NHTSA's regulations, enabled the agencies to consider overall standards that are more stringent and that will become effective sooner than we could consider with a more rigid program, one in which all of a manufacturer's similar vehicles or engines would be required to achieve the same emissions or fuel consumption levels, and at the same time.[54]

Phase 1 included four primary types of flexibility: Averaging, banking, and trading (ABT) provisions; early credits; advanced technology credits (including hybrid powertrains); and innovative technology credit provisions. The ABT provisions were patterned on existing EPA and NHTSA ABT programs (including the light-duty GHG and fuel economy standards) and will allow a vehicle manufacturer to reduce CO_2 emission and fuel consumption levels further than the level of the standard for one or more vehicles to generate ABT credits. The manufacturer can use those credits to offset higher emission or fuel consumption levels in the same averaging set, ''bank'' the credits for later use, or ''trade'' the credits to another manufacturer. As also noted above, for HD pickups and vans, we adopted a fleet averaging system very similar to the light-duty GHG and CAFE fleet averaging system. In both programs, manufacturers are allowed to carry-forward deficits for up to three years without penalty. The agencies provided in the ABT programs flexibility for situations in which a manufacturer is unable to avoid a negative credit balance at the end of the year. In such cases, manufacturers are not considered to be out of compliance unless they are unable to make up the difference in credits by the end of the third subsequent model year.

In total, the Phase 1 program divides the heavy-duty sector into 14 subcategories of vehicles and 4 subcategories of engines. These subcategories are grouped into 4 vehicle averaging sets and 4 engine averaging sets in the ABT program. For tractors and vocational vehicles, the fleet averaging sets are: Light heavy-duty (Classes 2b–5); medium heavy-duty (Class 6–7); and heavy heavy-duty (Class 8). Complete HD pickups and vans (both spark-ignition and compression-ignition) are the final vehicle averaging set. For engines, the fleet averaging sets are spark-ignition engines, compression-ignition light heavy-duty engines, compression-ignition medium heavy-duty engines, and compression-ignition heavy heavy-duty engines. ABT allows the exchange of credits within an averaging set. This means that a Class 8 day cab tractor can exchange credits with a Class 8 sleeper tractor but not with a smaller Class 7 tractor. Also, a Class 8 vocational vehicle can exchange credits with a Class 8 tractor. However, we did not allow trading between engines and chassis (*i.e.* vehicles).

In addition to ABT, the other primary flexibility provisions in the Phase 1 program involve opportunities to generate early credits, advanced technology credits (including for use of hybrid powertrains), and innovative technology credits.[55] For the early credits and advanced technology credits, the agencies adopted a 1.5x multiplier, meaning that manufacturers would get 1.5 credits for each early credit and each advanced technology credit. In addition, advanced technology credits for Phase 1 can be used anywhere within the heavy-duty sector (including both vehicles and engines). Put another way, as a means of promoting these promising technologies, the Phase 1 rule does not restrict averaging or trading by averaging set in this instance.

For other vehicle or engine technologies that can reduce CO_2 and fuel consumption, but whose benefits are not reflected if measured using the Phase 1 test procedures, the agencies wanted to encourage the development of such innovative technologies, and therefore adopted special ''innovative technology'' credits. These innovative technology credits apply to technologies that are shown to produce emission and fuel consumption reductions that are not adequately recognized on the Phase 1 test procedures and that were not yet in widespread use in the heavy-duty sector before MY 2010. Manufacturers

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[52] These thresholds were revised in early 2016. See *http://www.regulations.gov/#!documentDetail;D=SBA-2014-0011-0031.*

[53] Note: These calendar year benefits do not represent the same time frame as the model year lifetime benefits described above, so they are not additive.

[54] NHTSA explained that it has greater flexibility in the HD program to include consideration of credits and other flexibilities in determining appropriate and feasible levels of stringency than it does in the light-duty CAFE program. *Cf.* 49 U.S.C. 32902(h), which applies to light-duty CAFE but not heavy-duty fuel efficiency under 49 U.S.C. 32902(k).

[55] Early credits are for engines and vehicles certified before EPA standards became mandatory, advanced technology credits are for hybrids and/or Rankine cycle engines, and innovative technology credits are for other technologies not in the 2010 fleet whose benefits are not reflected using the Phase 1 test procedures.

need to quantify the reductions in fuel consumption and CO_2 emissions that the technology is expected to achieve, above and beyond those achieved on the Phase 1 test procedures. As with ABT, the use of innovative technology credits is allowed only among vehicles and engines of the same defined averaging set generating the credit, as described above. The credit multiplier likewise does not apply for innovative technology credits.

(4) Implementation of Phase 1

Manufacturers have already begun complying with the Phase 1 standards. In some cases manufacturers voluntarily chose to comply early, before compliance was mandatory. The Phase 1 rule allowed manufacturers to generate credits for such early compliance. The market appears to be very accepting of the new technologies, and the agencies have seen no evidence of ''pre-buy'' effects in response to the standards. In fact sales have been higher in recent years than they were before Phase 1. Moreover, manufacturers' compliance plans indicate intention to utilize the Phase 1 flexibilities, and we have yet to see significant non-compliance with the standards.

(5) Litigation on Phase 1 Rule

The D.C. Circuit rejected all challenges to the agencies' Phase 1 regulations. The court did not reach the merits of the challenges, holding that none of the petitioners had standing to bring their actions, and that a challenge to NHTSA's denial of a rulemaking petition could only be brought in District Court. See *Delta Construction* v. *EPA,* 783 F. 3d 1291 (D.C. Cir. 2015).

C. Summary of the Phase 2 Standards and Requirements

The agencies are adopting new standards that build on and enhance existing Phase 1 standards, and are adopting as well the first-ever standards for certain trailers used in combination with heavy-duty tractors. Taken together, the Phase 2 program comprises a set of largely technology-advancing standards that will achieve greater GHG and fuel consumption savings than the Phase 1 program. As described in more detail in the following sections, the agencies are adopting these standards because, based on the information available at this time and careful consideration of all comments, we believe they best fulfill our respective statutory authorities when considered in the context of available technology, feasible reductions of emissions and fuel consumption, costs, lead time, safety, and other relevant factors.

The Phase 2 standards represent a more technology-forcing[56] approach than the Phase 1 approach, predicated on use of both off-the-shelf technologies and emerging technologies that are not yet in widespread use. The agencies are adopting standards for MY 2027 that we project will require manufacturers to make extensive use of these technologies. The standards increase in stringency incrementally beginning in MY 2018 for trailers and in MY 2021 for other segments, ensuring steady improvement to the MY 2027 stringency levels. For existing technologies and technologies in the final stages of development, we project that manufacturers will likely apply them to nearly all vehicles, excluding those specific vehicles with applications or uses that prevent the technology from functioning properly. We also project as one possible compliance pathway that manufacturers could apply other more advanced technologies such as hybrids and waste engine heat recovery systems, although at lower application rates than the more conventional technologies. Comments on the overall stringency of the proposed Phase 2 program were mixed. Many commenters, including most non-governmental organizations, supported more stringent standards with less lead time. Many technology and component suppliers supported more stringent standards but with the proposed lead time. Vehicle manufacturers did not support more stringent standards and emphasized the importance of lead time. To the extent these commenters provided technical information to support their comments on stringency and lead time, it is discussed in Sections II through VI.

The standards being adopted provide approximately ten years of lead time for manufacturers to meet these 2027 standards, which the agencies believe is appropriate to implement the technologies industry could use to meet these standards. For some of the more advanced technologies production prototype parts are not yet available, though they are in the research stage with some demonstrations in actual vehicles.[57] In the respective sections of Chapter 2 of the RIA, the agencies explain what further steps are needed to successfully and reliably commercialize these prototypes in the lead time afforded by the Phase 2 standards. Additionally, even for the more developed technologies, phasing in more stringent standards over a longer timeframe will help manufacturers to ensure better reliability of the technology and to develop packages to work in a wide range of applications.

As discussed later, the agencies are also adopting new standards in MYs 2018 (trailers only), 2021, and 2024 to ensure that manufacturers make steady progress toward the 2027 standards, thereby achieving steady and feasible reductions in GHG emissions and fuel consumption in the years leading up to the MY 2027 standards.

Providing additional lead time can often enable manufacturers to resolve technological challenges or to find lower cost means of meeting new regulatory standards, effectively making them more feasible in either case. See generally *NRDC* v. *EPA,* 655 F. 2d 318, 329 (D.C. Cir. 1981). On the other hand, manufacturers and/or operators may incur additional costs if regulations require them to make changes to their products with less lead time than manufacturers would normally have when bringing a new technology to the market or expanding the application of existing technologies. After developing a new technology, manufacturers typically conduct extensive field tests to ensure its durability and reliability in actual use. Standards that accelerate technology deployment can lead to manufacturers incurring additional costs to accelerate this development work, or can lead to manufacturers beginning production before such testing can be completed. Some industry stakeholders have informed EPA that when manufacturers introduced new emission control technologies (primarily diesel particulate filters) in response to the 2007 heavy-duty engine standards they did not perform sufficient product development validation, which led to additional costs for operators when the technologies required repairs or resulted in other operational issues in use. Thus, the issues of costs, lead time, and reliability are intertwined for the

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[56] In this context, the term ''technology-forcing'' has a specific legal meaning and is used to distinguish standards that will effectively require manufacturers to develop new technologies (or to significantly improve technologies) from standards that can be met using off-the-shelf technology alone. *See, e.g., NRDC* v. *EPA,* 655 F. 2d 318, 328 (D.C. Cir. 1981). Technology-forcing standards do not require manufacturers to use any specific technologies. See also 76 FR 57130 (explaing that section 202(a)(2) allows EPA to adopt such technology-forcing standards, although it does not compell such standards).

[57] ''Prototype'' as it is used here refers to technologies that have a potentially production-feasible design that is expected to meet all performance, functional, reliability, safety, manufacturing, cost and other requirements and objectives that is being tested in laboratories and on highways under a full range of operating conditions, but is not yet available in production vehicles already for sale in the market.

agencies' determination of whether standards are reasonable and maximum feasible, respectively.

Another important consideration was the possibility of disrupting the market, which would be a risk if compliance required application of new technologies too suddenly. Several of the heavy-duty vehicle manufacturers, fleets, and commercial truck dealerships informed the agencies that for fleet purchases that are planned more than a year in advance, *expectations* of reduced reliability, increased operating costs, reduced residual value, or of large increases in purchase prices can lead the fleets to pull-ahead by several months planned future vehicle purchases by pre-buying vehicles without the newer technology. In the context of the Class 8 tractor market, where a relatively small number of large fleets typically purchase very large volumes of tractors, such actions by a small number of firms can result in large swings in sales volumes. Such market impacts would be followed by some period of reduced purchases that can lead to temporary layoffs at the factories producing the engines and vehicles, as well as at supplier factories, and disruptions at dealerships. Such market impacts also can reduce the overall environmental and fuel consumption benefits of the standards by delaying the rate at which the fleet turns over. See *International Harvester* v. *EPA,* 478 F. 2d 615, 634 (D.C. Cir. 1973). A number of commenters stated that the 2007 EPA heavy-duty engine criteria pollutant standard precipitated pre-buy for the Class 8 tractor market.[58] The agencies understand the potential impact that fleets pulling ahead purchases can have on American manufacturing and labor, dealerships, truck purchasers, and on the program's environmental and fuel savings goals, and have taken steps in the design of the program to avoid such disruption (see also our discussion in RTC Section 11.7). These steps include the following:

- Providing considerable lead time
- Adopting standards that will result in significantly lower operating costs for vehicle owners (unlike the 2007 standard, which increased operating costs)
- Phasing in the standards
- Structuring the program so the industry will have a significant range of technology choices to be considered for compliance, rather than the one or two new technologies the OEMs pursued to comply with EPA's 2007 criteria pollutant standard
- Allowing manufacturers to use emissions averaging, banking and trading to phase in the technology even further

As discussed in the Phase 1 final rule, NHTSA has certain statutory considerations to take into account when determining feasibility of the preferred alternative.[59] EISA states that NHTSA (in consultation with EPA and the Secretary of Energy) will develop a commercial medium- and heavy-duty fuel efficiency program designed ''to achieve the maximum feasible improvement.''[60] Although there is no definition of maximum feasible standards in EISA, NHTSA is directed to consider three factors when determining what the maximum feasible standards are. Those factors are, appropriateness, cost-effectiveness, and technological feasibility,[61] which modify ''feasible'' beyond its plain meaning.

NHTSA has the broad discretion to weigh and balance the aforementioned factors in order to accomplish EISA's mandate of determining maximum feasible standards. The fact that the factors may often be at odds gives NHTSA significant discretion to decide what weight to give each of the competing factors, policies and concerns and then determine how to balance them—as long as NHTSA's balancing does not undermine the fundamental purpose of the EISA: Energy conservation, and as long as that balancing reasonably accommodates ''conflicting policies that were committed to the agency's care by the statute.''[62]

EPA also has significant discretion in assessing, weighing, and balancing the relevant statutory criteria. Section 202(a)(2) of the Clean Air Act (42 U.S.C. 7521(a)(2)) requires that the standards ''take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period.'' This language affords EPA considerable discretion in how to weight the critical statutory factors of emission reductions, cost, and lead time (76 FR 57129–57130). Section 202(a)(2) also allows (although it does not compel) EPA to adopt technology-forcing standards. Id. at 57130.

Sections II through VI of this Preamble explain the consideration that the agencies took into account based on careful assessment and balancing of the statutory factors under Clean Air Act section 202(a)(1) and (2), and under 49 U.S.C. 32902(k).

(1) Carryover From Phase 1 Program and Compliance Changes

Phase 2 is carrying over many of the compliance approaches developed for Phase 1, with certain changes as described below. Readers are referred to the regulatory text for much more detail. Note that the agencies have adapted some of these Phase 1 provisions in order to address new features of the Phase 2 program, notably provisions related to trailer compliance. The agencies have also reevaluated all of the compliance provisions to ensure that they will be effective in achieving the projected reductions without placing an undue burden on manufacturers.

The agencies received significant comments from vehicle manufacturers emphasizing the potential for the structure of the compliance program to impact stringency. Although the agencies do not agree with all of these comments (which are discussed in more detail in later sections), we do agree that it is important to structure the compliance program so that the effective stringency of standards is consistent with levels established by regulation. The agencies have made appropriate improvements to the compliance structure in response to these comments.

(a) Certification

EPA and NHTSA are applying the same general certification procedures for Phase 2 as are currently being used for certifying to the Phase 1 standards. Tractors and vocational vehicles will continue to be certified using the vehicle simulation tool (GEM). The agencies, however, revised the Phase 1 GEM simulation tool to develop a new version, Phase 2 GEM, that more specifically reflects improvements to engines, transmissions, and drivetrains.[63] Rather than the GEM simulation tool using default values for engines, transmissions and drivetrains, most manufacturers will enter measured or tested values as inputs reflecting performance of the actual engine, transmission and drivetrain technologies.

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[58] For example, see the public comments of The International Union, Volvo Trucks North America, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW).

[59] 75 FR 57198.

[60] 49 U.S.C. 32902(k).

[61] *Id.*

[62] *Center for Biological Diversity* v. *National Highway Traffic Safety Admin.,* 538 F.3d 1172, 1195 (9th Cir. 2008).

[63] As described in Section IV, although the trailer standards were developed using the simulation tool, the agencies are adopting a compliance structure that does not require trailer manufacturers to use it.

The Phase 1 certification process for engines used in tractors and vocational vehicles was based on EPA's process for showing compliance with the heavy-duty engine criteria pollutant standards using engine dynamometer testing, and the agencies are continuing it for Phase 2. We also will continue certifying HD pickups and vans using the Phase 1 chassis dynamometer testing results and vehicle certification process, which is very similar to the light-duty vehicle certification process. The Phase 2 trailer certification process will resemble the Phase 2 tractor certification approach, but with a simplified version of Phase 2 GEM. The trailer certification process allows trailer manufacturers to use a simple equation to determine GEM-equivalent g/ton-mile emission rates without actually running GEM.

EPA and NHTSA are also clarifying provisions related to confirming a manufacturer's test data during certification (*i.e.,* confirmatory testing) and verifying a manufacturer's vehicles are being produced to perform as described in the application for certification (*i.e.,* selective enforcement audits or SEAs). The EPA confirmatory testing provisions for engines, vehicles, and components are in 40 CFR 1036.235 and 1037.235. The SEA provisions are in 40 CFR 1036.301 and 1037.301–1037.320. The NHTSA provisions are in 49 CFR 535.9(a). As we proposed, these clarifications will also apply for Phase 1 engines and vehicles.

In response to comments, we are making several changes to the proposed EPA confirmatory testing provisions. First, the regulations being adopted specify that EPA will conduct triplicate tests for engine fuel maps to minimize the impact of test-to-test variability. The final regulations also state that we will consider entire fuel maps rather than individual points. Engine manufacturers objected to EPA's proposal that individual points could be replaced based on a single test, arguing that it effectively made the vehicle standards more stringent due to point-to-point and test-to-test variability. We believe that the changes being adopted largely address these concerns. We are also applying this approach for axle and transmission maps for similar reasons.

As described in Sections III and IV, EPA has also modified the SEA regulations for verifying aerodynamic performance. These revised regulations differ somewhat from the standard SEA regulations to address the unique challenges of measuring aerodynamic drag. In particular EPA recognizes that for coastdown testing, test-to-test variability is expected to be large relative to production variability. This differs fundamentally from traditional compliance testing, in which test-to-test variability is expected to be *small* relative to production variability. To address this difference, the modified regulations call for more repeat testing of the same vehicle, but fewer test samples. These revisions were generally supported by commenters. See Section III and IV for additional discussion.

Some commenters suggested that the agencies should apply a compliance margin to confirmatory and SEA test results to account for test variability. However, other commenters supported following EPA's past practice, which has been to base the standards on technology projections that assume manufacturers will apply compliance margins to their test results for certification. In other words, they design their products to have emissions below the standards by some small margin so that test-to-test or lab-to-lab variability would not cause them to exceed any applicable standards. Consequently, EPA has typically not set standards precisely at the lowest levels achievable, but rather at slightly higher levels—expecting manufacturers to target the lower levels to provide compliance margins for themselves. As discussed in Sections II through VI, the agencies have applied this approach to the Phase 2 standards.

(b) Averaging, Banking and Trading (ABT)

The Phase 1 ABT provisions were patterned on established EPA ABT programs that have proven to work well. In Phase 1, the agencies determined this flexibility would provide an opportunity for manufacturers to make necessary technological improvements and reduce the overall cost of the program without compromising overall environmental and fuel economy objectives. Commenters generally supported this approach for engines, pickups/vans, tractors, and vocational vehicles. Thus, we are generally continuing this Phase 1 approach with few revisions to the engine and vehicle segments. However, as described in Section IV, in response to comments, we are finalizing a much more limited averaging program for trailers that will not go into effect until 2027. We are adopting some other provisions for certain vocational vehicles, which are discussed in Section V.

The agencies see the overall ABT program as playing an important role in making the technology-advancing standards feasible, by helping to address many issues of technological challenges in the context of lead time and costs. It provides manufacturers flexibilities that assist the efficient development and implementation of new technologies and therefore enable new technologies to be implemented at a more aggressive pace than without ABT.

ABT programs are more than just add-on provisions included to help reduce costs. They can be, as in EPA's Title II programs generally, an integral part of the standard setting itself. A well-designed ABT program can also provide important environmental and energy security benefits by increasing the speed at which new technologies can be implemented (which means that more benefits accrue over time than with later-commencing standards) and at the same time increase flexibility for, and reduce costs to, the regulated industry and ultimately consumers. Without ABT provisions (and other related flexibilities), standards would typically have to be numerically less stringent since the numerical standard would have to be adjusted to accommodate issues of feasibility and available lead time. See 75 FR 25412–25413. By offering ABT credits and additional flexibilities the agencies can offer progressively more stringent standards that help meet our fuel consumption reduction and GHG emission goals at a faster and more cost-effective pace.[64]

(i) Carryover of Phase 1 Credits and Credit Life

The agencies proposed to continue the five-year credit life provisions from Phase 1, and not to adopt any general restriction on the use of banked Phase 1 credits in Phase 2. In other words, Phase 1 credits in MY 2019 could be used in Phase 1 or in Phase 2 in MYs 2021–2024. CARB commented in support of a more restrictive approach for Phase 1 credits, based on the potential for manufacturers to delay implementation of technology in Phase 2 by using credits generated under Phase 1. We also received comments asking the agencies to provide a path for manufacturers to generate credits for applying technologies not explicitly included in the Phase 1 program. In response to these comments, the agencies have analyzed the potential impacts of Phase 1 credits on the Phase 2 program for each sector and made appropriate adjustments in the program. For example, as described in Section II.D.(5), the agencies are adopting some restrictions on the carryover of windfall Phase 1 engine credits that result from the Phase 1 vocational engine standards.

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[64] See *NRDC* v. *Thomas,* 805 F. 2d 410, 425 (D.C. Cir. 1986) (upholding averaging as a reasonable and permissible means of implementing a statutory provision requiring technology-forcing standards).

Also, as described in Section III, the agencies are projecting that Phase 1 credit balances for tractor manufacturers will enable them to meet more stringent standards for MY 2021–2023, so the agencies have increased the stringency of these standards accordingly.

In contrast to the Phase 1 tractor program, the Phase 1 vocational chassis program currently offers fewer opportunities to generate credits for potential carryover into Phase 2. To address comments related to this particular situation and also to provide a new Phase 1 incentive to voluntarily apply certain Phase 2 technologies, which are available today but currently not being adopted, the agencies are finalizing a streamlined Phase 1 off-cycle credit approval process for these Phase 2 technologies. For vocational chassis, these technologies include workday idle reduction technologies such as engine stop-start systems, automatic engine shutdown systems, shift-to-neutral at idle automatic transmissions, automated manual transmissions, and dual-clutch transmissions. The agencies are also finalizing a streamlined Phase 1 off-cycle credit approval process for Phase 2 automatic tire inflation systems (ATIS), for both tractors and vocational chassis. The purpose for offering these streamlined off-cycle approval processes for Phase 1 is to encourage more early adoption of these Phase 2 technologies during the remaining portion of the Phase 1 program (*e.g.,* model years 2018, 2019, 2020). Earlier adoption of these technologies would help demonstrate that these newer, but not advanced, technologies are effective, reliable and well-accepted into the marketplace by the time the agencies project that they would be needed for compliance with the Phase 2 standards.

The agencies are also including a provision allowing exempt small business manufacturers of vocational chassis to opt into the Phase 1 program for the purpose of generating credits which can be used throughout the Phase 2 program, as just described.

In conjunction with this provision allowing manufacturers to receive credit in Phase 1 for pulling ahead certain Phase 2 technologies, the agencies are providing an extended credit life for the Light and Medium heavy-duty vocational vehicle averaging sets (see next subsection) to provide additional Phase 2 transition flexibility for these vehicles. Unlike the HD Phase 1 pickup/van and tractor programs, where the averaging sets are broad; where manufacturers have many technology choices from which to earn credits (*e.g.,* tractor aerodynamic and idle reduction technologies, pickup/van engine and transmission technologies); and where we project manufacturers to have sufficient pickup/van and tractor credits to manage the transition to the Phase 2 standards, transitioning to the new Light and Medium vocational vehicle standards may be more challenging. Manufacturers selling lower volumes of these lighter vehicles may find themselves with fewer overall credits to manage the transition to the new standards, especially the 2027 standards. To facilitate this transition and better assure adequate lead time, the agencies are extending the credit life for the Light and Medium heavy-duty vehicle averaging sets (typically vehicles in Classes 2b through 7) so that all credits generated in 2018 and later will last at least until 2027. We are not doing this for the Heavy heavy-duty vocational vehicle category (typically Class 8) because tractor credits may be used within this averaging set. Because we project that manufacturers will have sufficient tractor credits, we believe that they will be able to manage the Heavy vocational transition to each set of new standards, without the extended credit life that we are finalizing for Light and Medium vocational averaging sets. Nevertheless, we will continue to monitor the manufacturers' progress in transitioning to the Phase 2 standards for each category, and we may reconsider the need for additional transitional flexibilities, such as extending other categories' credit lives.

Although, as we have already noted, the numerical values of Phase 2 standards are not directly comparable in an absolute sense to the existing Phase 1 standards (in other words, a given vehicle would have a different g/ton-mile emission rate when evaluated using Phase 1 GEM than it would when evaluated using Phase 2 GEM), we believe that the Phase 1 and Phase 2 credits are largely equivalent. Because the standards and emission levels are included in a relative sense (as a difference), it is not necessary for the Phase 1 and Phase 2 standards to be directly equivalent in an absolute sense in order for the credits to be equivalent.

This is best understood by examining the way in which credits are calculated. For example, the credit equations in 40 CFR 1037.705 and 49 CFR 535.7 calculate credits as the product of the difference between the standard and the vehicle's emission level (g/ton-mile or gallon/1,000 ton-mile), the regulatory payload (tons), production volume, and regulatory useful life (miles). The Phase 2 payloads, production volumes, and useful lives for tractors, medium and heavy heavy-duty engines, or medium and heavy heavy-duty vocational vehicles are equivalent to those of Phase 1. However, EPA is changing the regulatory useful lives of HD pickups and vans, light heavy-duty vocational vehicles, spark-ignited engines, and light heavy-duty compression-ignition engines. Because useful life is a factor in determining the value of a credit, the agencies proposed to apply interim adjustment factors to ensure banked credits maintain their value in the transition from Phase 1 to Phase 2.

For Phase 1, EPA aligned the useful life for GHG emissions with the useful life already in place for criteria pollutants. After the Phase 1 rules were finalized, EPA updated the useful life for criteria pollutants as part of the Tier 3 rulemaking.[65] The new useful life implemented for Tier 3 is 150,000 miles or 15 years, whichever occurs first. This same useful life is being adopted in Phase 2 for HD pickups and vans, light heavy-duty vocational vehicles, spark-ignited engines, and light heavy-duty compression-ignition engines.[66] The numeric value of the adjustment factor for each of these regulatory categories depends on the Phase 1 useful life. These are described in detail below in this Preamble in Sections II, V, and VI. Without these adjustment factors the changes in useful life would effectively result in a discount of banked credits that are carried forward from Phase 1 to Phase 2, which is not the intent of the changes in the useful life. With the relatively flat deterioration generally associated with CO_2, EPA does not believe the changes in useful life will significantly affect the feasibility of the Phase 2 standards.

We note that the primary purpose of allowing manufacturers to bank credits is to provide flexibility in managing transitions to new standards. The five-year credit life is substantial, and allows credits generated in either Phase 1 or early in Phase 2 to be used for the intended purpose. The agencies believe a credit life longer than five years is unnecessary to accomplish this transition. Restrictions on credit life serve to reduce the likelihood that any manufacturer will be able to use banked credits to disrupt the heavy-duty vehicle market in any given year by effectively limiting the amount of credits that can be held. Without this limit, one manufacturer that saved enough credits over many years could achieve a significant cost advantage by using all the credits in a single year. The agencies

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[65] 79 FR 23492, April 28, 2014 and 40 CFR 86.1805–17.

[66] NHTSA's useful life is based on mileage and years of duration.

believe that allowing a five-year credit life for all credits, and as a consequence allowing use of Phase 1 credits in Phase 2, creates appropriate flexibility and appropriately facilitates a smooth transition to each new level of standards.

(ii) Averaging Sets

EPA has historically restricted averaging to some extent for its HD emission standards to avoid creating unfair competitive advantages or environmental risks due to credits being inconsistent. It also helps to ensure a robust and manageable compliance program. Under Phase 1, averaging, banking and trading can only occur within and between specified ''averaging sets'' (with the exception of credits generated through use of specified advanced technologies). As proposed, we will continue this regime in Phase 2, retaining the existing vehicle and engine averaging sets, and creating new trailer averaging sets. We are also continuing the averaging set restrictions from Phase 1 in Phase 2. (See Section V for certain other provisions applicable to vehicles certified to special standards.) These general averaging sets for vehicles are:

- Complete pickups and vans
- Other light heavy-duty vehicles (Classes 2b–5)
- Medium heavy-duty vehicles (Class 6–7)
- Heavy heavy-duty vehicles (Class 8)
- Long dry and refrigerated van trailers[67]
- Short dry and refrigerated van trailers

We are not allowing trading between engines and chassis, even within the same vehicle class. Such trading would essentially result in double counting of emission credits, because the same engine technology would likely generate credits relative to both standards (and indeed, certain engine improvements are reflected exclusively in the vehicle standards the agencies are adopting). We similarly limit trading among engine categories to trades within the designated averaging sets:

- Spark-ignition engines
- Compression-ignition light heavy-duty engines
- Compression-ignition medium heavy-duty engines
- Compression-ignition heavy heavy-duty engines

The agencies continue to believe that maintaining trading to be only within the classes listed above will provide adequate opportunities for manufacturers to make necessary technological improvements and to reduce the overall cost of the program without compromising overall environmental and fuel efficiency objectives, and it is therefore appropriate and reasonable under EPA's authority and maximum feasible under NHTSA's authority, respectively. We do not expect emissions from engines and vehicles—when restricted by weight class—to be dissimilar. We therefore expect that the lifetime vehicle performance and emissions levels will be very similar across these defined categories, and the credit calculations will fairly ensure the expected fuel consumption and GHG emission reductions.

These restrictions have generally worked well for Phase 1, and we continue to believe that these averaging sets create flexibility without creating an unfair advantage for manufacturers with integrated portfolios, including engines and vehicles. See 76 FR 57240.

(iii) Credit Deficits

The Phase 1 regulations allow manufacturers to carry-forward deficits for up to three years. This is an important flexibility because the program is designed to address the diversity of the heavy-duty industry by allowing manufacturers to sell a mix of engines or vehicles that have very different emission levels and fuel efficiencies. Under this construct, manufacturers can offset sales of engines or vehicles not meeting the standards by selling others (within the same averaging set) that perform better than the standards require. However, in any given year it is possible that the actual sales mix will not balance out, and the manufacturer may be short of credits for that model year. The three-year provision allows for this possibility and creates additional compliance flexibility to accommodate it.

(iv) Advanced Technology Credits

At the time of the proposal, the agencies believed it was no longer appropriate to provide extra credit for any of the technologies identified as advanced technologies for Phase 1, although we requested comment on this issue. The Phase 1 advanced technology credits were adopted to promote the implementation of advanced technologies that were not included in our basis of the feasibility of the Phase 1 standards. Such technologies included hybrid powertrains, Rankine cycle waste heat recovery systems on engines, all-electric vehicles, and fuel cell vehicles (see 40 CFR 86.1819–14(k)(7), 1036.150(h), and 1037.150(p)). The Phase 2 heavy-duty engine and vehicle standards are premised on the use of some of these technologies, making them equivalent to other fuel-saving technologies in this context. We believe the Phase 2 standards themselves will provide sufficient incentive to develop those specific technologies.

Although the agencies proposed to eliminate all advanced technology incentives, we remained open to targeted incentives that would address truly advanced technology. We specifically requested comment on this issue with respect to electric vehicle, plug-in hybrid, and fuel cell technologies. Although the Phase 2 standards are premised on some use of Rankine cycle waste heat recovery systems on engines and hybrid powertrains, none of these standards are based on projected utilization of these other even more-advanced technologies (*e.g.,* all-electric vehicles, fuel cell vehicles). 80 FR 40158. Commenters generally supported providing credit multipliers for these advanced technologies. However, Allison supported ending the incentives for hybrids, fuel cells, and electric vehicles in Phase 2. ATA, on the other hand, commented that the agencies should preserve the advanced technology credits which provide a credit multiplier of 1.5 in order to promote the use of hybrid and electric vehicles in larger vocational vehicles and tractors. ARB supported the use of credit multipliers even more strongly and provided suggestions for values larger than 1.5 that could be used to incentivize plug-in hybrids, electric vehicles, and fuel cell vehicles. Eaton recommended the continuation of advanced technology credits for hybrid powertrains until a sufficient number are in the market. Overall, the comments indicated that there is support for such incentives among operators, suppliers, and states. Upon further consideration, the agencies are adopting advanced technology credits for these three types of advanced technologies, as shown in Table I–2 below.

TABLE I–2—ADVANCED TECHNOLOGY MULTIPLIERS

Technology	Multiplier
Plug-in hybrid electric vehicles	3.5
All-electric vehicles	4.5
Fuel cell vehicles	5.5

Our intention in adopting these multipliers is to create a meaningful incentive to those considering adopting these qualifying advanced technologies into their vehicles. The values being

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[67] Averaging for trailers does not begin until 2027.

adopted are consistent with values recommended by CARB in their supplemental comments.[68] CARB's values were based on a cost analysis that compared the costs of these technologies to costs of other conventional technologies. Their costs analysis showed that adopting multipliers in this range would make these technologies much more competitive with the conventional technologies and could allow manufacturers to more easily generate a viable business case to develop these technologies for heavy-duty and bring them to market at a competitive price.

Another important consideration in the adoption of these larger multipliers is the tendency of the heavy-duty sector to significantly lag the light-duty sector in the adoption of advanced technologies. There are many possible reasons for this, such as:

- Heavy-duty vehicles are more expensive than light-duty vehicles, which makes it a greater monetary risk for purchasers to invest in unproven technologies.
- These vehicles are work vehicles, which makes predictable reliability even more important than for light-duty vehicles.
- Sales volumes are much lower for heavy-duty vehicles, especially for specialized vehicles.

As a result of factors such as these, adoption rates for these advanced technologies in heavy-duty vehicles are essentially non-existent today and seem unlikely to grow significantly within the next decade without additional incentives.

The agencies believe it is appropriate to provide such large multipliers for these very advanced technologies at least in the short term, because they have the potential to provide very large reductions in GHG emissions and fuel consumption and advance technology development substantially in the long term. However, because they are so large, we also believe that we should not necessarily allow them to continue indefinitely. Therefore, the agencies are adopting them as an interim program that will continue through MY 2027. If the agencies determine that these credit multipliers should be continued beyond MY 2027, we could do so in a future rulemaking.

As discussed in Section I.C.(1)(d), the agencies are not specifically accounting for upstream emissions that might occur from production of electricity to power these advanced vehicles. This approach is largely consistent with the incentives offered for electric vehicles in the light-duty National Program. 77 FR 62810. For light-duty vehicles, the agencies also did not require manufacturers to account for upstream emissions during the initial years, as the technologies are being developed. While we proactively sunset this allowance for light-duty due to concerns about potential impacts from very high sales volumes, we do not have similar concerns for heavy-duty. Nevertheless, in this program we are only adopting these credit multipliers through MY 2027, and should we not promulgate a future rulemaking to extend them beyond MY 2027, these multipliers would essentially sunset in MY 2027.

One feature of the Phase 1 advanced technology program that is not being continued in Phase 2 is the allowance to use advanced technology credits across averaging sets. We believe that combined with the very large multipliers being adopted, there could be too large a risk of market distortions if we allowed the use of these credits across averaging sets.

(v) Transition Flexibility for Meeting the Engine Standards

Some manufacturers commented that the proposed engine regulations did not offer sufficient flexibility. Although these commenters acknowledge that the tractor and vocational *vehicle* standards will separately drive engine improvements, they nonetheless maintain that the MY 2024 *engine* standards may constrain potential compliance paths too much. Some commented that advanced technologies (such as waste heat recovery) may need to be deployed before the technologies are fully reliable for every engine manufacturer, and may lead to the development and implementation of additional engine technologies outside of scheduled engine redesign cycles, which could cause manufacturers to incur costs which were not accounted for in the agencies' analyses. These costs could include both product development and equipment costs for the engine manufacturer, and potential increased costs for vehicle owners associated with potential reliability issues in-the-field.

The agencies have considered these comments carefully. See, *e.g.,* RIA Section 2.3.9 and RTC Section 3.4. The agencies recognize the importance of ensuring that there is adequate lead time to develop, test, and otherwise assure reliability of the technologies projected to be needed to meet the standards and for the advanced engine technologies in particular. See Section I.C above; see also responses regarding waste heat recovery technology in RTC Section 3.4, and Response 3.4.1. The agencies are therefore adopting an alternative, optional ABT flexibility for heavy-heavy and medium-heavy engines in partial response to these comments. This optional provision would affect only the MYs 2021 and 2024 standards for these engines, not the final MY 2027 engine standards, and to the extent manufacturers elect the provision would increase fuel consumption and GHG reduction benefits, as explained below.

This optional provision has three aspects:

- A pull ahead of the engine standards to MY 2020
- Extended credit life for engine credits generated against MYs 2018–2019 Phase 1 standards, the MY 2020 pull-ahead Phase 2 engine standards, and the MYs 2021–2024 Phase 2 engine standards
- Slightly relaxed engine standards for MYs 2024–2026 tractor engine standards[69]

Thus, the final rule provides the option of an extended credit life for the medium heavy-duty and heavy heavy-duty engines so that all credits generated in MY 2018 and later will last at least until MY 2030.[70] To be eligible for this allowance, manufacturers would need to voluntarily certify all of their HHD and/or MHD MY 2020 engines (tractor and vocational) to MY 2021 standards.[71] Manufacturers could elect to apply this provision separately to medium heavy-duty and heavy heavy-duty engines, since these remain separate averaging sets. Credits banked by the manufacturer in Phase 1 for model year 2018 and 2019 engines would be eligible for the extended credit life for manufacturers satisfying the pull ahead requirement. Such credits could be used in any model year 2021 through

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[68] Letter from Michael Carter, ARB, to Gina McCarthy, Administrator, EPA and Mark Rosekind, Administrator, NHTSA, June 16, 2016.

[69] Credits can be generated against these standards as well, but the life of credits generated for 2025 and 2026 would be five years. The pull ahead of the MY 2021 standards should more than balance out any slight decreases in benefits attributable to such credits.

[70] The final rule (40 CFR 1036.150(p)) provides that for engine manufacturers choosing this alternative option, credits generated with MY 2018–2024 engines can be used until MY 2030. Credits from later model years can be used for five years from generation under 40 CFR 1037.740(c).

[71] Compliance with this requirement would be evaluated at the time of certification and when end of year ABT reports are submitted. Manufacturers that show a net credit deficit for the averaging set at the end of the year would not meet this requirement.

2030. Manufacturers that voluntarily certify their engines to MY 2021 standards early would then also be eligible for slightly less stringent engine tractor standards in MYs 2024–2026, as shown in the following table.

TABLE I–3—OPTIONAL ABT FLEXIBILITY STANDARDS FOR HEAVY-HEAVY AND MEDIUM-HEAVY ENGINES

Model years	Medium heavy-duty—tractor		Heavy heavy-duty—tractor	
	EPA CO_2 standard (g/bhp-hr)	NHTSA fuel consumption standard (gal/100bhp-hr)	EPA CO_2 standard (g/bhp-hr)	NHTSA fuel consumption standard (gal/100bhp-hr)
2020–2023	473	4.6464	447	4.3910
2024–2026	467	4.5874	442	4.3418

Once having opted into this alternative compliance path, engine manufacturers would have to adhere to that path for the remainder of the Phase 2 program. The choice would be made when certifying MY 2020 engines. Instead of certifying engines to the final year of the Phase 1 engine standards, manufacturers electing the alternative would indicate that they are instead certifying to the MY 2021 Phase 2 engine standard.

Because these engine manufacturers would be reducing emissions of engines otherwise subject to the MY 2020 Phase 1 engine standards (and because engine reductions were not reflected in the Phase 1 *vehicle* program), there would be a net benefit to the environment. These engines would not generate credits relative to the Phase 1 standards (that is, MY 2020 engines would only use or generate credits relative to the pulled ahead MY 2021 Phase 2 engines standards) which would result in net reductions of CO_2 and fuel consumption of about 2 percent for each engine. Thus, if every engine manufacturer chooses to use this flexibility, there could be resulting reductions of an additional 12MMT of CO_2 and saving of nearly one billion gallons of diesel fuel.

This alternative also does not have adverse implications for the vehicle standards. As just noted, the vehicle standards themselves are unaffected. Thus, these voluntary standards would not reduce the GHG reductions or fuel savings of the program. Vehicle manufacturers using the alternative MYs 2024–2026 engines would need to adopt additional vehicle technology (*i.e.* technology beyond that projected to be needed to meet the standard) to meet the vehicle standards. This means the vehicles would still achieve the same fuel efficiency in use.[72]

In sum, the agencies view this alternative as being positive from the environmental and energy conservation perspectives, and believe it will provide significant flexibility for manufacturers that may reduce their compliance costs. It also provides a hedge against potential premature introduction of advanced engine technologies, providing more lead time to assure in-use reliability.

(c) Innovative Technology and Off-Cycle Credits

The agencies are continuing the Phase 1 innovative technology program (reflecting certain streamlining features as just discussed), but re-designating it as an off-cycle program for Phase 2. In other words, beginning in MY 2021 technologies that are not accounted for in the GEM simulation tool, or by compliance dynamometer testing (for engines or chassis certified vehicles) will be considered ‘‘off-cycle,’’ including those technologies that may no longer be considered innovative technologies.

The final rules provide that in order for a manufacturer to receive these credits for Phase 2, the off-cycle technology will still need to meet the requirement that it was not in common use prior to MY 2010. Although we have not identified specific off-cycle technologies at this time that should be excluded, we believe it is prudent to continue this requirement to avoid the potential for manufacturers to receive windfall credits for technologies that they were already using before MY 2010, and that are therefore reflected in the Phase 2 (and possibly Phase 1) baselines. However, because the Phase 2 program will be implemented in MY 2021 and extend at least through MY 2027, the agencies and manufacturers may have difficulty in the future determining whether an off-cycle technology was in common use prior to MY 2010. In order to avoid this approach becoming an unnecessary hindrance to the off-cycle program, the agencies will presume that off-cycle technologies were not in common use in 2010 unless we have clear evidence to the contrary. Neither the agencies nor manufacturers will be required to demonstrate that the technology meets this 2010 criteria. Rather, the agencies will simply retain the authority to deny a request for off-cycle credits if it is clear that the technology was in common use in 2010 and thus part of the baseline.

Manufacturers will be able to carry over innovative technology credits from Phase 1 into Phase 2, subject to the same restrictions as other credits. Manufacturers will also be able to carry over the improvement factor (not the credit value) of a technology, if certain criteria are met. The agencies will require documentation for all off-cycle requests similar to those required by EPA for its light-duty GHG program.

Additionally, the agencies will not grant any off-cycle credits for crash avoidance technologies. The agencies will also require manufacturers to consider the safety of off-cycle technologies and will request a safety assessment from the manufacturer for all off-cycle technologies.

Similar principles apply to off-cycle credits in this heavy-duty Phase 2 program as under the light-duty vehicle rules. Thus, technologies which are part of the basis of a Phase 2 standard would not be eligible for off-cycle credits. Their benefits have been accounted for in developing the stringency of the Phase 2 standard, as have their costs. See 77 FR 62835 (October 15, 2012). In addition, technologies which are integral or inherent to the basic vehicle design and are recognized in GEM or under the FTP (for pickups and vans), including engine, transmission, mass reduction, passive aerodynamic design, and base tires, will not be eligible for off-cycle credits. 77 FR 62836.

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[72] The agencies view this alternative as of reasonable cost with respect to the vehicle standards. First, where engine manufacturers and vehicle manufacturers are vertically integrated, that manufacturer would choose the alternative which is most cost advantageous. Second, where engine manufacturers and vehicle manufacturers are not vertically integrated, the agencies anticipate that engines certified to the alternative and the main standards will both be available for the vehicle manufacturer to purchase, so that the vehicle manufacturer would not need to incur any costs attributable to the alternative engine standard.

Technologies integral or inherent to basic vehicle design are fully functioning and are thus recognized in GEM, or operate over the entirety of the FTP/HFET and therefore are adequately captured by the test procedure.

Just as some technologies that were considered off-cycle for Phase 1 are being adopted as primary technologies in Phase 2 on whose performance standard stringency is calculated, the agencies may revise the regulation in a future rulemaking to create a more direct path to recognize technologies currently considered off-cycle. For example, although we are including specific provisions to recognize certain electrified accessories, recognizing others would require the manufacturer to go through the off-cycle process. However, it is quite possible that the agencies could gather sufficient data to allow us to adopt specific provisions in a future rulemaking to recognize other accessories in a simpler manner. Because such a change would merely represent a simpler way to receive the same credit as could be obtained under the regulations being adopted today (rather than a change in stringency), it would not require us to reconsider the standards.

(d) Alternative Fuels and Electric Vehicles

The agencies will largely continue the Phase 1 approach for engines and vehicles fueled by fuels other than gasoline and diesel.[73] Phase 1 engine emission standards applied uniquely for gasoline-fueled and diesel-fueled engines. The regulations in 40 CFR part 86 implement these distinctions for alternative fuels by dividing engines into Otto-cycle and Diesel-cycle technologies based on the combustion cycle of the engine. However, as proposed, the agencies are making a small change that is described in Section II. Under this change, we will require manufacturers to divide their natural gas engines into primary intended service classes, like the current requirement for compression-ignition engines. Any alternative fuel-engine qualifying as a heavy heavy-duty engine will be subject to all the emission standards and other requirements that apply to compression-ignition engines. Note that this small change in approach will also apply with respect to EPA's criteria pollutant program.

We are also applying the Phase 2 standards at the vehicle tailpipe. That is, compliance is based on vehicle fuel consumption and GHG emission reductions, and does not reflect any so-called lifecycle emission properties. The agencies have explained why it is reasonable that the heavy-duty standards be fuel neutral in this manner and adhere to this reasoning here. See 76 FR 57123; see also 77 FR 51705 (August 24, 2012) and 77 FR 51500 (August 27, 2012). In particular, EPA notes that there is a separate, statutorily-mandated program under the Clean Air Act which encourages use of renewable fuels in transportation fuels, including renewable fuel used in heavy-duty diesel engines. This program considers lifecycle greenhouse gas emissions compared to petroleum fuel. NHTSA notes that the fuel efficiency standards are necessarily tailpipe-based, and that a lifecycle approach would likely render it impossible to harmonize the fuel efficiency and GHG emission standards, to the great detriment of our goal of achieving a coordinated program. 77 FR 51500–51501; see also 77 FR 51705 (similar finding by EPA); see also Section I.F.(1)(a) below, Section 1.8 of the RTC, and Section XI.B.

The agencies received mixed comments on this issue. Many commenters supported the proposed approach, generally agreeing with the agencies' arguments. However, some other commenters opposed this approach. Opposing commenters generally fell into two categories:

- Commenters concerned that upstream emissions of methane occurring during the production and distribution of natural gas would offset some or all of the GHG emission reductions observed at the tailpipe.
- Commenters concerned that tailpipe-only standards ignore the GHG benefits of using renewable fuels.

The agencies are not issuing rules that effectively would turn these rules into a fuel program, rather than an emissions reduction and fuel efficiency program. Nor will the agencies disharmonize the program by having GHG standards reflect upstream emissions having no relation to fuel efficiency. See *e.g.* 77 FR 51500–51501; see also 77 FR 51705. We thus will continue to measure compliance at the tailpipe. Issues relating to whether to consider in the emission standards upstream emissions related to natural gas exploration and production are addressed in detail in Section XI below. It is sufficient to state here that the agencies carefully investigated the potential use of natural gas in the heavy-duty sector and the impacts of such use. We do not believe that the use of natural gas is likely to become a major fuel source for heavy-duty vehicles during the Phase 2 time frame. Thus, since we project natural gas vehicles to have little impact on both overall GHG emissions and fuel consumption during the Phase 2 time frame, the agencies see no need to make fundamental changes to the Phase 1 approach for natural gas engines and vehicles.

The agencies note further that a consequence of the tailpipe-based approach is that the agencies will treat vehicles powered by electricity the same as in Phase 1. In Phase 1, EPA treated all electric vehicles as having zero tailpipe emissions of CO_2, CH_4, and N_2O (see 40 CFR 1037.150(f)). Similarly, NHTSA adopted regulations in Phase 1 that set the fuel consumption standards based on the fuel consumed by the vehicle. The agencies also did not require emission testing for electric vehicles in Phase 1. The agencies considered the potential unintended consequence of not accounting for upstream emissions from the charging of heavy-duty electric vehicles. In our reassessment for Phase 2, we have found only one all-electric heavy-duty vehicle manufacturer that has certified through 2016. As we look to the future, we project limited adoption of all-electric vehicles into the market. Therefore, we believe that this provision is still appropriate. Unlike the 2017–2025 light-duty rule, which included a cap whereby upstream emissions would be counted after a certain volume of sales (see 77 FR 62816–62822), we believe there is no need to establish a cap for heavy-duty vehicles because of the small likelihood of significant production of EV technologies in the Phase 2 timeframe. Commenters specifically addressing electric vehicles generally supported the agencies' proposal. However, some commenters did support accounting for emissions from the generation of electricity in the broader context of supporting full life-cycle analysis. As noted above, and in more detail in Section I.F.(2)(f) as well as Section 1.8 of the RTC, the agencies are not predicating the standards on a full life-cycle approach.

(e) Phase 1 Interim Provisions

EPA adopted several flexibilities for the Phase 1 program (40 CFR 86.1819–14(k), 1036.150 and 1037.150) as interim provisions. Because the existing regulations do not have an end date for Phase 1, most of these provisions did not have an explicit end date. NHTSA adopted similar provisions. With few exceptions, the agencies are not continuing these provisions for Phase 2. These will generally remain in effect for the Phase 1 program. In particular, the agencies note that we are not continuing the blanket exemption for small

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[73] See Section XI for additional discussion of natural gas engines and vehicles.

manufacturers. Instead, in Phase 2 the agencies are providing more targeted relief for these entities.

(f) In-Use Standards and Recall

Section 202(a)(1) of the CAA specifies that EPA is to adopt emissions standards that are applicable for the useful life of the vehicle and for the engine. EPA finalized in-use standards for the Phase 1 program, whereas NHTSA's rules do not include these standards. For the Phase 2 program, EPA will carry-over its in-use provisions, and NHTSA is adopting EPA's useful life requirements for its vehicle and engine fuel consumption standards to ensure manufacturers consider in the design process the need for fuel efficiency standards to apply for the same duration and mileage as EPA standards. If EPA determines a manufacturer fails to meet its in-use standards, civil penalties may be assessed.

CAA section 207(c)(1) requires ''the manufacturer'' to remedy certain in-use problems. The remedy process is to recall the nonconforming vehicles and bring them into conformity with the standards and the certificate. The regulations for this process are in 40 CFR part 1068, subpart F. EPA is also adopting regulatory text addressing recall obligations for component manufacturers and other non-certifying manufacturers. We note that the CAA does not limit this responsibility to certificate holders, consistent with the definition of a ''manufacturer'' as ''any person engaged in the manufacturing or assembling of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, or importing such vehicles or engines for resale, or who acts for and is under the control of any such person in connection with the distribution of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, but shall not include any dealer with respect to new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines received by him in commerce.''

As discussed in Section I.E.(1) below, this definition was not intended to restrict the definition of ''manufacturer'' to a single person per vehicle. Under EPA regulations, we can require any person meeting the definition of manufacturer for a nonconforming vehicle to participate in a recall. However, we would normally presume the certificate holder to have the primary responsibility.

EPA requested comment on adding regulatory text that would explicitly apply these provisions to tire manufacturers. Comments from the tire industry generally opposed this noting that they are not the manufacturer of the vehicle. These comments are correct that tires are not incomplete vehicles and hence that the recall authority does not apply for companies that only manufacture the tires. However, EPA remains of the view that in the event that vehicles (*e.g.* trailers) do not conform to the standards in-use due to nonconforming tires, tire manufacturers would have a role to play in remedying the problem. In this (hypothetical) situation, a tire manufacturer would not only have produced the part in question, but in the case of a trailer manufacturer or other small vehicle manufacturer, would have significantly more resources and knowledge regarding how to address (and redress) the problem. Accordingly, EPA would likely require that a component manufacturer responsible for the nonconformity assist in the recall to an extent and in a manner consistent with the provisions of CAA section 208(a). This section specifies that component and part manufacturers ''shall establish and maintain records, perform tests where such testing is not otherwise reasonably available under this part and part C of this subchapter (including fees for testing), make reports and provide information the Administrator may reasonably require to determine whether the manufacturer or other person has acted or is acting in compliance with this part and part C of this subchapter and regulations thereunder, or to otherwise carry out the provision of this part and part C of this subchapter. . .''. Any such action would be considered on a case-by-case basis, adapted to the particular circumstances at the time.

(g) Vehicle Labeling

EPA proposed to largely continue the Phase 1 engine and vehicle labeling requirements, but to eliminate the requirement for tractor and vocational vehicle manufacturers to list emission control on the label. The agencies consider it crucial that authorized compliance inspectors are able to identify whether a vehicle is certified, and if so whether it is in its certified condition. To facilitate this identification in Phase 1, EPA adopted labeling provisions for tractors that included several items. The Phase 1 tractor label must include the manufacturer, vehicle identifier such as the Vehicle Identification Number (VIN), vehicle family, regulatory subcategory, date of manufacture, compliance statements, and emission control system identifiers (see 40 CFR 1037.135). EPA proposed to apply parallel requirements for trailers.

In Phase 1, the emission control system identifiers are limited to vehicle speed limiters, idle reduction technology, tire rolling resistance, some aerodynamic components, and other innovative and advanced technologies. However, the number of emission control systems for greenhouse gas emissions in Phase 2 has increased significantly for tractors and vocational vehicles. For example, all aspects of the engine transmission and drive axle; accessories; tire radius and rolling resistance; wind averaged drag; predictive cruise control; idle reduction technologies; and automatic tire inflation systems are controls which can be evaluated on-cycle in Phase 2 (*i.e.* these technologies' performance can now be input to GEM), but could not be in Phase 1. Due to the complexity in determining greenhouse gas emissions in Phase 2, the agencies do not believe that we can unambiguously determine whether or not a vehicle is in a certified condition through simply comparing information that could be made available on an emission control label with the components installed on a vehicle. Therefore, EPA proposed to remove the requirement to include the emission control system identifiers required in 40 CFR 1037.135(c)(6) and in Appendix III to 40 CFR part 1037 from the emission control labels for vehicles certified to the Phase 2 standards. The agencies received comments on the emission control labels from Navistar, which supported the elimination of the emission control information from the vehicle GHG label.

Although we are largely finalizing the proposed labeling requirements, we remain interested in finding a better approach for labeling. Under the agencies' existing authorities, manufacturers must provide detailed build information for a specific vehicle upon our request. Our expectation is that this information should be available to us via email or other similar electronic communication on a same-day basis, or within 24 hours of a request at the latest. The agencies have started to explore ideas that would provide inspectors with an electronic method to identify vehicles and access on-line databases that would list all of the engine-specific and vehicle-specific emissions control system information. We believe that electronic and Internet technology exists today for using scan tools to read a bar code or radio frequency identification tag affixed to a vehicle that could then lead to secure on-line access to a database of manufacturers' detailed vehicle and engine build information. Our exploratory work on these ideas has raised questions about the level of effort that would be required to develop, implement and maintain an information technology system to provide inspectors real-time access to this information. We have also considered questions about privacy and data security. We requested comment on the concept of electronic labels and database access, including any available information on similar systems that exist today and on burden estimates and approaches that could address concerns about privacy and data security.

Although we are not finalizing such a program in this rulemaking, we remain very interested in the use of electronic labels that could be used by the agencies to access vehicle information and may pursue these in a future rulemaking. Such a rulemaking would likely consider the feasibility of accessing dynamic link libraries in real-time to view each manufacturer's build records (and perhaps pending orders). The agencies envision that this could be very useful for our inspectors by providing them access to the build information by VIN to confirm that each vehicle has the proper emission control features.

(h) Model Year Definition

The agencies proposed to continue the Phase definitions of ''model year'' for compliance with GHG emissions and fuel efficiency standards. However, in response to comments, the agencies are revising the definition slightly for Phase 2 tractors and vocational vehicles to match the model years of the engines installed in them. The revised definition generally sets the vehicle model year to be the calendar year of manufacture, but allows the vehicle manufacturer the option to select the prior year if the vehicle uses an engine manufactured in the prior model year.[74] Because Phase 2 vehicle standards are based in part on engine performance, some commenters stated that the engine model year should dictate the vehicle's GHG and fuel efficiency compliance model year, and that the emissions and fuel efficiency compliance model year should be presented on the vehicle emissions label. This would allow manufacturers to market a vehicle and certify it to NHTSA's safety standards based on the standards applicable on the date of manufacture, but certify the vehicle for GHG emissions and fuel efficiency purposes based on the engine model compliance year. For example, a 2023 model year tractor might have a 2022 model year engine in it. The tractor would be marketed as a model year 2023 tractor, certified as complying with NHTSA's safety standards applicable at the time when certifying the vehicle, but would have an ''emissions and fuel efficiency compliance model year'' of 2022 for purposes of emissions and fuel efficiency standards. In today's action, NHTSA and EPA are finalizing standards that allow for the use of an ''emissions and fuel efficiency compliance model year.'' This is consistent with past program practice, in which certain manufacturers have been able to reclassify tractors to the previous model year for emissions purposes when the tractors use engines from the previous model year.

(2) Phase 2 Standards

This section briefly summarizes the Phase 2 standards for each category and identifies the technologies that the agencies project will be needed to meet the standards. Given the large number of different regulatory categories and model years for these standards, the actual numerical standards are not listed. Readers are referred to Sections II through IV for the tables of standards.

(a) Summary of the Engine Standards

The agencies are continuing the basic Phase 1 structure for the Phase 2 engine standards. There will be separate standards and test cycles for tractor engines, vocational diesel engines, and vocational gasoline engines. However, as described in Section II, we are adopting a revised test cycle for tractor engines to better reflect actual in-use operation. After consideration of comments, including those specifically addressing whether the agencies should adopt an alternative with accelerated stringency targets, the agencies are adopting engine standards that can generally be characterized as more stringent than the proposed alternative.

Specifically, for diesel tractor engines, the agencies are adopting standards for MY 2027 that are more stringent than the preferred alternative from the proposal, and require reductions in CO_2 emissions and fuel consumption that are 5.1 percent better than the 2017 baseline for tractor engines.[75] We are also adopting standards for MY 2021 and MY 2024, requiring reductions in CO_2 emissions and fuel consumption of 1.8 to 4.2 percent better than the 2017 baseline tractor engines. For vocational diesel engines, the new standards will require reductions of 2.3, 3.6, and 4.2 percent in MYs 2021, 2024, and 2027, respectively. These levels are more stringent than the proposed standards for these same MYs, and approximately as stringent in MY 2021 and MY 2024 as the Alternative 4 standards discussed at proposal.[76]

The agencies project that these reductions will be maximum feasible and reasonable for diesel engines based on technological changes that will improve combustion and reduce energy losses. For most of these improvements, the agencies project (*i.e.*, the agencies have set out a potential, but by no means mandatory, compliance path) that manufacturers will begin applying improvements to about 45 percent of their heavy-duty engines by 2021, and ultimately apply them to about 95 percent of their heavy-duty engines by 2024. However, for some of these improvements we project more limited application rates. In particular, we project a more limited use of waste exhaust heat recovery systems in 2027, projecting that about 10 percent of tractor engines will have turbo-compounding systems, and an additional 25 percent of tractor engines will employ Rankine-cycle waste heat recovery. We do not project that turbo-compounding or Rankine-cycle waste heat recovery technology will be utilized in vocational engines due to vocational vehicle drive cycles under which these technologies would not show significant benefit, and also due to low sales volumes, limiting the ability to invest in newer technologies for these vehicles.

As described in Section III.D.(1)(b)(i), the agencies project that some engine manufacturers will be able to achieve larger reductions for at least some of their tractor engines. So in developing the tractor *vehicle* standards, we projected slightly better fuel efficiency for the *average* tractor engine than is required by the engine standards. We are projecting that similar over-compliance will occur for heavy heavy-duty vocational engines.

For gasoline vocational engines, we are not adopting more stringent *engine* standards. Gasoline engines used in

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[74] Anti-stockpiling provisions will generally prevent vehicle manufacturers from using new engines older than the prior model year. See Section XIII.B for a discussion of EPA requirements for installing older used engines into new vehicles.

[75] For the flat baseline referenec case, the agencies project that tractors engines will meet the Phase 1 engine standards with a small compliancee margin. The Phase 1 standards for diesel engines will be fully phased-in by MY 2017, so we use MY 2017 as the baseline engine for tractors. Note that we project that vocational engines will achieve additioanl overcompliance with the Phase 1 vocational engine standards.

[76] As noted in Section II, the numerical levels of the vocational engine standards also reflect an updated baseline in which Phase 1 vocational engines are more efficient than assumed for the proposal. In addition, the numerical levels of the tractor engine standards reflect an updated baseline to reflect the changes to the test cycle.

vocational vehicles are generally the same engines as are used in the complete HD pickups and vans in the Class 2b and 3 weight categories, although the operational demands of vocational vehicles often require use of the largest, most powerful SI engines, so that some engines fitted in complete pickups and vans are not appropriate for use in vocational vehicles. Given the relatively small sales volumes for gasoline-fueled vocational vehicles, manufacturers typically cannot afford to invest significantly in developing separate technology for these vocational vehicle engines. Thus, we project that in general, vocational gasoline engines will incorporate much of the technology that will be used to meet the pickup and van chassis standards, and this will result in some real world reductions in CO_2 emissions and fuel consumption. The agencies received many comments suggesting that technologies be applied to increase the stringency of the SI engine standard, which technologies in fact are already presumed to be adopted at 100 percent to meet the MY 2016 engine standard. The commenters did not identify any additional engine technologies that are not already fully considered by the agencies in setting the MY 2016 engine standard, that could be recognized over the HD SI Engine FTP test cycle. We did, however, consider some additional technologies recommended by commenters, which can be recognized over the GEM vehicle cycles. As a result, the Phase 2 *vehicle* standards for gasoline-fueled vocational vehicles are predicated on adoption of engine technologies beyond what is required to meet the separate engine standard, those additional technologies being advanced engine friction reduction and cylinder deactivation. As described in Section V, we are projecting these technologies to improve fuel consumption over the GEM cycles by nearly one percent in MY 2021, MY 2024, and MY 2027. In other words, this improvement is reflected in the vehicle standards rather than in the engine standards. To the extent any SI engines do not incorporate the projected engine technologies, manufacturers of gasoline-fueled vocational vehicles would need to achieve equivalent reductions from some other technology to meet the GEM-based vehicle standards. The engine standards are summarized in Table I–4.

TABLE I–4—SUMMARY OF PHASE 1 AND PHASE 2 REQUIREMENTS FOR ENGINES IN COMBINATION TRACTORS AND VOCATIONAL VEHICLES

	Phase 1 program	Final 2027 standards
Covered in this category	Engines installed in tractors and vocational chassis.	
Share of HDV fuel consumption and GHG emissions.	Combination tractors and vocational vehicles account for approximately 85 percent of fuel use and GHG emissions in the heavy duty truck sector.	
Per vehicle fuel consumption and CO_2 improvement.	5%–9% improvement over MY 2010 baseline, depending vehicle application. Improvements are in addition to improvements from tractor and vocational vehicle standards.	4%–5% improvement over MY 2017 for diesel engines. Note that improvements are captured in complete vehicle tractor and vocational vehicle standards, so that engine improvements and the vehicle improvement shown below are not additive.
Form of the standard	EPA: CO_2 grams/horsepower-hour and NHTSA: Gallons of fuel/horsepower-hour.	
Example technology options available to help manufacturers meet standards.	Combustion, air handling, friction and emissions aftertreatment technology improvements.	Further technology improvements and increased use of all Phase 1 technologies, plus waste heat recovery systems for tractor engines (*e.g.*, turbo-compound and Rankine-cycle).
Flexibilities	ABT program which allows emissions and fuel consumption credits to be averaged, banked, or traded (five year credit life). Manufacturers allowed to carry-forward credit deficits for up to three model years. Interim incentives for advanced technologies, recognition of innovative (off-cycle) technologies not accounted for by the HD Phase 1 test procedures, and credits for certifying early.	Same ABT and off-cycle program as Phase 1. Adjustment factor of 1.36 for credits carried forward from Phase 1 to Phase 2 for SI and LHD CI engines due to change in useful life. Revised multipliers for Phase 2 advanced technologies. No Phase 2 early credit multipliers.

(b) Summary of the Tractor Standards

As explained in Section III, the agencies will largely continue the structure of the Phase 1 tractor program, but adopt new standards and update test procedures, as summarized in Table I–6. The tractor standards for MY 2027 will achieve up to 25 percent lower CO_2 emissions and fuel consumption than a 2017 model year Phase 1 tractor. The agencies project that the 2027 tractor standards could be met through improvements in the:

- Engine[77] (including some use of waste heat recovery systems)
- Transmission
- Driveline
- Aerodynamic design
- Tire rolling resistance
- Idle performance
- Other accessories of the tractor.

The agencies have enhanced the Phase 2 GEM vehicle simulation tool to recognize these technologies, as described in Section II.C. The agencies' evaluation shows that some of these technologies are available today, but have very low adoption rates on current vehicles, while others will require some lead time for development and deployment. In addition to the proposed alternative for tractors, the agencies solicited comment on an alternative that reached similar ultimate stringencies, but at an accelerated pace.

We have also determined that there is sufficient lead time to introduce many of these tractor and engine technologies into the fleet at a reasonable cost starting in the 2021 model year. The

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[77] Although the agencies are adopting new engine standards with separate engine certification, engine improvements will also be reflected in the vehicle certification process. Thus, it is appropriate to also consider engine improvements in the context of the vehicle standards.

2021 model year standards for combination tractors and engines will achieve up to 14 percent lower CO_2 emissions and fuel consumption than a 2017 model year Phase 1 tractor, the 2024 model year standards will achieve up to 20 percent lower CO_2 emissions and fuel consumption, and as already noted, the 2027 model year standards will achieve up to 25 percent lower CO_2 emissions and fuel consumption.

In addition to the CO_2 emission standards for tractors, EPA is adopting new particulate matter (PM) standards which effectively limit which diesel fueled auxiliary power units (APUs) can be used as emission control devices to reduce main engine idling in tractors, as shown in Table I–5. Additional details are discussed in Section III.C.3.

TABLE I–5—PM STANDARDS RELATED TO DIESEL APUs

Tractor MY	PM emission standard (g/kW-hr)	Expected control technology
2018–2023	0.15	In-cylinder PM control.
2024	0.02	DPF.

TABLE I–6—SUMMARY OF PHASE 1 AND PHASE 2 REQUIREMENTS FOR CLASS 7 AND CLASS 8 COMBINATION TRACTORS

	Phase 1 program	Final 2027 standards
Covered in this category	Tractors that are designed to pull trailers and move freight.	
Share of HDV fuel consumption and GHG emissions.	Combination tractors and their engines account for approximately sixty percent of fuel use and GHG emissions in the heavy duty vehicle sector.	
Per vehicle fuel consumption and CO_2 improvement.	10%–23% improvement over MY 2010 baseline, depending on tractor category. Improvements are in addition to improvements from engine standards.	19%–25% improvement over tractors meeting the MY 2017 standards.
Form of the standard	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons of fuel/1,000 ton payload mile.	
Example technology options available to help manufacturers meet standards.	Aerodynamic drag improvements; low rolling resistance tires; high strength steel and aluminum weight reduction; extended idle reduction; and speed limiters.	Further technology improvements and increased use of all Phase 1 technologies, plus engine improvements, improved transmissions and axles, tire pressure systems, and predictive cruise control (depending on tractor type).
Flexibilities	ABT program which allows emissions and fuel consumption credits to be averaged, banked, or traded (five year credit life). Manufacturers allowed to carry-forward credit deficits for up to three model years. Interim incentives for advanced technologies, recognition of innovative (off-cycle) technologies not accounted for by the HD Phase 1 test procedures, and credits for certifying early.	Same ABT and off-cycle program as Phase 1. Revised multipliers for Phase 2 advanced technologies.

(c) Summary of the Trailer Standards

The final rules contain a set of GHG emission and fuel consumption standards for manufacturers of new trailers that are used in combination with tractors. These standards will significantly reduce CO_2 and fuel consumption from combination tractor-trailers nationwide over a period of several years. As described in Section IV, there are numerous aerodynamic and tire technologies available to manufacturers to achieve these standards. Many of these technologies have already been introduced into the market through EPA's voluntary SmartWay program and California's tractor-trailer greenhouse gas requirements.

The agencies are adopting Phase 2 standards that will phase-in beginning in MY 2018 and be fully phased-in by 2027. These standards are predicated on use of aerodynamic and tire improvements, with trailer OEMs making incrementally greater improvements in MYs 2021 and 2024 as standard stringency increases in each of those model years. EPA's GHG emission standards will be mandatory beginning in MY 2018, while NHTSA's fuel consumption standards will be voluntary beginning in MY 2018, and be mandatory beginning in MY 2021. In general, the trailer standards being finalized apply only for box vans, flatbeds, tankers, and container chassis.

As described in Section XIV.D and Chapter 12 of the RIA, the agencies are adopting special provisions to minimize the impacts on small business trailer manufacturers. These provisions have been informed by and are largely consistent with recommendations from the SBAR Panel that EPA conducted pursuant to section 609(b) of the Regulatory Flexibility Act (RFA). Broadly, these provisions provide additional lead time for small business manufacturers, as well as simplified testing and compliance requirements. The agencies also are not finalizing standards for various trailer types, including most specialty types of non-box trailers. Excluding these specialty trailers also reduces the impacts on small businesses.

TABLE I–7—SUMMARY OF PHASE 2 REQUIREMENTS FOR TRAILERS

	Phase 1 program	Final 2027 standards
Covered in this category	All lengths of dry vans, refrigerated vans, tanks, flatbeds, and container chassis hauled by low, mid, and high roof day and sleeper cab tractors.	
Share of HDV fuel consumption and GHG emissions.	Trailers are modeled together with combination tractors and their engines. Together, they account for approximately sixty percent of fuel use and GHG emissions in the heavy duty truck sector.	
Per vehicle fuel consumption and CO_2 improvement.	N/A	Between 3% and 9% improvement over MY 2018 baseline, depending on the trailer type.
Form of the standard	N/A	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons/1,000 ton payload mile.
Example technology options available to help manufacturers meet standards.	N/A	Low rolling resistance tires and tire pressure systems for most trailers, plus weight reduction and aerodynamic improvements such as side and rear fairings, gap closing devices, and undercarriage treatment for box vans (*e.g.*, dry and refrigerated).
Flexibilities	N/A	One year delay in implementation for small businesses, trailer manufacturers may use pre-approved aerodynamic data in lieu of additional testing, averaging program available in MY 2027 for manufacturers of dry and refrigerated box vans.

(d) Summary of the Vocational Vehicle Standards

As explained in Section V, the agencies are adopting new vocational vehicle standards that expand upon the Phase 1 Program. These new standards reflect further subcategorization from Phase 1, with separate standards based on mode of operation: Urban, regional, and multi-purpose. The agencies are also adopting optional separate standards for emergency vehicles and other custom chassis vehicles.

The agencies project that the vocational vehicle standards could be met through improvements in the engine, transmission, driveline, lower rolling resistance tires, workday idle reduction technologies, weight reduction, and some application of hybrid technology. These are described in Section V of this Preamble and in Chapter 2.9 of the RIA. These MY 2027 standards will achieve up to 24 percent lower CO_2 emissions and fuel consumption than MY 2017 Phase 1 standards. The agencies are also making revisions to the compliance program for vocational vehicles. These include: The addition of two idle cycles that will be weighted along with the other drive cycles for each vocational vehicle; and revisions to Phase 2 GEM to recognize improvements to the engine, transmission, and driveline.

Similar to the tractor program, we have determined that there is sufficient lead time to introduce many of these new technologies into the fleet starting in MY 2021. Therefore, we are adopting new standards for MY 2021 and 2024. Based on our analysis, the MY 2021 standards for vocational vehicles will achieve up to 12 percent lower CO_2 emissions and fuel consumption than a MY 2017 Phase 1 vehicle, on average, and the MY 2024 standards will achieve up to 20 percent lower CO_2 emissions and fuel consumption.

In Phase 1, EPA adopted air conditioning (A/C) refrigerant leakage standards for tractors, as well as for heavy-duty pickups and vans, but not for vocational vehicles. For Phase 2, EPA believes that it will be feasible to apply similar A/C refrigerant leakage standards for vocational vehicles, beginning with the 2021 model year. The certification process for vocational vehicles to certify low-leakage A/C components is identical to that already required for tractors.

TABLE I–8—SUMMARY OF PHASE 1 AND PHASE 2 REQUIREMENTS FOR VOCATIONAL VEHICLE CHASSIS

	Phase 1 program	Final 2027 standard
Covered in this category	Class 2b—8 chassis that are intended for vocational services such as delivery vehicles, emergency vehicles, dump truck, tow trucks, cement mixer, refuse trucks, etc., except those qualified as off-highway vehicles. Because of sector diversity, vocational vehicle chassis are segmented into Light, Medium and Heavy Heavy-Duty vehicle categories and for Phase 2 each of these segments are further subdivided using three duty cycles: Regional, Multi-purpose, and Urban.	
Share of HDV fuel consumption and GHG emissions.	Vocational vehicles account for approximately 17 percent of fuel use and GHG emissions in the heavy duty truck sector categories.	
Per vehicle fuel consumption and CO_2 improvement.	2% improvement over MY 2010 baseline. Improvements are in addition to improvements from engine standards.	Up to 24% improvement over MY 2017 standards.
Form of the standard	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons of fuel/1,000 ton payload mile.	
Example technology options available to help manufacturers meet standards.	Low rolling resistance tires	Further technology improvements and increased use of Phase 1 technologies, plus improved engines, transmissions and axles, weight reduction, hybrids, and workday idle reduction systems.

TABLE I–8—SUMMARY OF PHASE 1 AND PHASE 2 REQUIREMENTS FOR VOCATIONAL VEHICLE CHASSIS—Continued

	Phase 1 program	Final 2027 standard
Flexibilities	ABT program which allows emissions and fuel consumption credits to be averaged, banked, or traded (five year credit life). Manufacturers allowed to carry-forward credit deficits for up to three model years. Interim incentives for advanced technologies, recognition of innovative (off-cycle) technologies not accounted for by the HD Phase 1 test procedures, and credits for certifying early.	Same ABT and off-cycle program as Phase 1. Adjustment factor of 1.36 for credits carried forward from Phase 1 to Phase 2 due to change in useful life. Revised multipliers for Phase 2 advanced technologies. No Phase 2 early credit multipliers. Chassis intended for emergency vehicles, cement mixers, coach buses, school buses, transit buses, refuse trucks, and motor homes may optionally use application-specific Phase 2 standards using a simplified version of GEM.

(e) Summary of the Heavy-Duty Pickup and Van Standards

The agencies are adopting new Phase 2 GHG emission and fuel consumption standards for heavy-duty pickups and vans that will be applied in largely the same manner as the Phase 1 standards. These standards are based on the extensive use of most known and proven technologies, and could result in some use of mild or strong hybrid powertrain technology. These standards will commence in MY 2021. By 2027, these standards are projected to be 16 percent more stringent than the 2018–2019 standards.

TABLE I–9—SUMMARY OF PHASE 1 AND PHASE 2 REQUIREMENTS FOR HD PICKUPS AND VANS

	Phase 1 program	Final 2027 standard
Covered in this category	Class 2b and 3 complete pickup trucks and vans, including all work vans and 15-passenger vans but excluding 12-passenger vans which are subject to light-duty standards.	
Share of HDV fuel consumption and GHG emissions.	HD pickups and vans account for approximately 23% of fuel use and GHG emissions in the heavy duty truck sector.	
Per vehicle fuel consumption and CO_2 improvement.	15% improvement over MY 2010 baseline for diesel vehicles, and 10% improvement for gasoline vehicles.	16% improvement over MY 2018–2019 standards.
Form of the standard	Phase 1 standards are based upon a "work factor" attribute that combines truck payload and towing capabilities, with an added adjustment for 4-wheel drive vehicles. There are separate target curves for diesel-powered and gasoline-powered vehicles. The Phase 2 standards are based on the same approach.	
Example technology options available to help manufacturers meet standards.	Engine improvements, transmission improvements, aerodynamic drag improvements, low rolling resistance tires, weight reduction, and improved accessories.	Further technology improvements and increased use of all Phase 1 technologies, plus engine stop-start, and powertrain hybridization (mild and strong).
Flexibilities	Two optional phase-in schedules; ABT program which allows emissions and fuel consumption credits to be averaged, banked, or traded (five year credit life). Manufacturers allowed to carry-forward credit deficits for up to three model years. Interim incentives for advanced technologies, recognition of innovative (off-cycle) technologies not accounted for by the HD Phase 1 test procedures, and credits for certifying early.	Same as Phase 1, with phase-in schedule based on year-over-year increase in stringency. Same ABT and off-cycle program as Phase 1. Adjustment factor of 1.25 for credits carried forward from Phase 1 to Phase 2 due to change in useful life. Revised multipliers for Phase 2 advanced technologies. No Phase 2 early credit multipliers.

Similar to Phase 1, the agencies are adopting for Phase 2 a set of continuous equation-based standards for HD pickups and vans. Please refer to Section VI for a description of these standards, including associated tables and figures.

D. Summary of the Costs and Benefits of the Final Rules

This section summarizes the projected costs and benefits of the NHTSA fuel consumption and EPA GHG emission standards. See Sections VII through IX and the RIA for additional details about these projections.

For these rules, the agencies used two analytical methods for the heavy-duty pickup and van segment by employing both DOT's CAFE model and EPA's MOVES model. The agencies used EPA's MOVES model to estimate fuel consumption and emissions impacts for tractor-trailers (including the engine that powers the tractor), and vocational vehicles (including the engine that powers the vehicle). Additional calculations were performed to determine corresponding monetized program costs and benefits. For heavy-duty pickups and vans, the agencies performed separate analyses, which we refer to as "Method A" and "Method B." In Method A, a new version of the CAFE model was used to project a pathway the industry could use to comply with each regulatory alternative and the estimated effects on fuel consumption, emissions, benefits and costs. In Method B, the CAFE model from the NPRM was used to project a pathway the industry could use to comply with each regulatory alternative, along with resultant impacts on per-vehicle costs. However, the MOVES model was used to calculate corresponding changes in total fuel consumption and annual emissions for pickups and vans in Method B. Additional calculations were performed to determine corresponding monetized program costs and benefits. NHTSA considered Method A as its central analysis and Method B as a supplemental analysis. EPA considered the results of Method B. The agencies concluded that these methods led the agencies to the same conclusions and the same selection of these standards. See Section VII for additional discussion of these two methods.

(1) Reference Case Against Which Costs and Benefits Are Calculated

The No Action Alternatives for today's analysis, alternatively referred to as the ''baselines'' or ''reference cases,'' assume that the agencies did not issue new rules regarding MD/HD fuel efficiency and GHG emissions. These are the baselines against which costs and benefits for these standards are calculated. The reference cases assume that model year 2018 engine, tractor, vocational vehicle, and HD pickup and van standards will be extended indefinitely and without change. They also assume that no new standards would be adopted for trailers.

The agencies recognize that if these Phase 2 standards had not been adopted, manufacturers would nevertheless continue to introduce new heavy-duty vehicles in a competitive market that responds to a range of factors, and manufacturers might have continued to improve technologies to reduce heavy-duty vehicle fuel consumption. Thus, as described in Section VII, both agencies fully analyzed these standards and the regulatory alternatives against two reference cases. The first case uses a baseline that projects no improvement in new vehicles in the absence of new Phase 2 standards, and the second uses a more dynamic baseline that projects some significant improvements in vehicle fuel efficiency. NHTSA considered its primary analysis to be based on the dynamic baseline, where certain cost-effective technologies are assumed to be applied by manufacturers to improve fuel efficiency beyond the Phase 1 requirements in the absence of new Phase 2 standards. EPA considered both reference cases. The results for all of the regulatory alternatives relative to both reference cases, derived via the same methodologies discussed in this section, are presented in Section X of the Preamble.

The agencies received limited comments on these reference cases. Some commenters expressed support for a flat baseline in the context of the need for the regulations, arguing that little improvement would occur without the regulations. Others supported the less dynamic baseline because they believe it more fully captures the costs. A number of commenters expressed that purchasers are willing to and do pay for fuel efficiency improving technologies, provided the cost for the technology is paid back through fuel savings within a certain period of time; this is the premise for a dynamic baseline. Some commenters thought it reasonable that the agencies consider both baselines given the uncertainty in this area. No commenters opposed the consideration of both baselines.

The agencies have continued to analyze two different baselines for the final rules because we recognize that there are a number of factors that create uncertainty in projecting a baseline against which to compare the future effects of this action and the remaining alternatives. The composition of the future fleet—such as the relative position of individual manufacturers and the mix of products they each offer—cannot be predicted with certainty at this time. Additionally, the heavy-duty vehicle market is diverse, as is the range of vehicle purchasers. Heavy-duty vehicle manufacturers have reported that their customers' purchasing decisions are influenced by their customers' own determinations of minimum total cost of ownership, which can be unique to a particular customer's circumstances. For example, some customers (*e.g.,* less-than-truckload or package delivery operators) operate their vehicles within a limited geographic region and typically own their own vehicle maintenance and repair centers within that region. These operators tend to own their vehicles for long time periods, sometimes for the entire service life of the vehicle. Their total cost of ownership is influenced by their ability to better control their own maintenance costs, and thus they can afford to consider fuel efficiency technologies that have longer payback periods, outside of the vehicle manufacturer's warranty period. Other customers (*e.g.,* truckload or long-haul operators) tend to operate cross-country, and thus must depend upon truck dealer service centers for repair and maintenance. Some of these customers tend to own their vehicles for about four to seven years, so that they typically do not have to pay for repair and maintenance costs outside of either the manufacturer's warranty period or some other extended warranty period. Many of these customers tend to require seeing evidence of fuel efficiency technology payback periods on the order of 18 to 24 months before seriously considering evaluating a new technology for potential adoption within their fleet (NAS 2010, Roeth et al. 2013, and Klemick et al. 2014). Purchasers of HD pickups and vans wanting better fuel efficiency tend to demand that fuel consumption improvements pay back within approximately one to three years, but some HD pickup and van owners accrue relatively few vehicle miles traveled per year, such that they may be less likely to adopt new fuel efficiency technologies, while other owners who use their vehicle(s) with greater intensity may be even more willing to pay for fuel efficiency improvements. Regardless of the type of customer, their determination of minimum total cost of ownership involves the customer balancing their own unique circumstances with a heavy-duty vehicle's initial purchase price, availability of credit and lease options, expectations of vehicle reliability, resale value and fuel efficiency technology payback periods. The degree of the incentive to adopt additional fuel efficiency technologies also depends on customer expectations of future fuel prices, which directly impacts customer payback periods. Purchasing decisions are not based exclusively on payback period, but also include the considerations discussed above and in Section X.A.1. For the baseline analysis, the agencies use payback period as a proxy for all of these considerations, and therefore the payback period for the baseline analysis is shorter than the payback period industry uses as a threshold for the further consideration of a technology. See Section X.A.1 of this Preamble and Chapter 11 of the RIA for a more detailed discussion of baselines. As part of a sensitivity analysis, additional baseline scenarios were also evaluated for HD pickups and vans, including baseline payback periods of 12, 18 and 24 months. See Section VI of this Preamble and Chapter 10 of the RIA for a detailed discussion of these additional scenarios.

(2) Costs and Benefits Projected for the Phase 2 Standards

The tables below summarize the benefits and costs for the program in two ways: First, from the perspective of a program designed to improve the Nation's energy security and to conserve energy by improving fuel efficiency and then from the perspective of a program designed to reduce GHG emissions. The individual categories of benefits and costs presented in the tables below are defined more fully and presented in more detail in Chapter 8 of the RIA.

Lifetime fuel savings, GHG reductions, benefits, costs and net benefits for model years 2018 through

2029 vehicles as presented below. This is consistent with the NPRM analysis and allows readers to compare the costs and benefits of the final program with those projected for the NPRM. It also includes for modeling purposes at least three model years for each standard.

Table I–10 shows benefits and costs for these standards from the perspective of a program designed to improve the Nation's energy security and conserve energy by improving fuel efficiency. From this viewpoint, technology costs occur when the vehicle is purchased. Fuel savings are counted as benefits that occur over the lifetimes of the vehicles produced during the model years subject to the Phase 2 standards as they consume less fuel.

TABLE I–10—LIFETIME FUEL SAVINGS, GHG REDUCTIONS, BENEFITS, COSTS, AND NET BENEFITS FOR MODEL YEARS 2018–2029 VEHICLES USING ANALYSIS METHOD A

[Billions of 2013$] [a] [b]

Category	3% discount rate	7% discount rate
Fuel Reductions (Billion Gallons)	71.1–77.7	
GHG reductions (MMT CO_2 eq)	959–1049	
Vehicle Program: Technology and Indirect Costs, Normal Profit on Additional Investments	23.7 to 24.4	16.1 to 16.6
Additional Routine Maintenance	1.7 to 1.7	0.9 to 0.9
Congestion, Crashes, Fatalities and Noise from Increased Vehicle Use [d]	3.1 to 3.2	1.8 to 1.9
Total Costs	28.5 to 29.3	18.8 to 19.4
Fuel Savings (valued at pre-tax prices)	149.1 to 163.0	79.7 to 87.0
Savings from Less Frequent Refueling	3.0 to 3.2	1.6 to 1.7
Economic Benefits from Additional Vehicle Use	5.4 to 5.5	3.4 to 3.5
Reduced Climate Damages from GHG Emissions [c]	33.0 to 36.0	
Reduced Health Damages from Non-GHG Emissions	27.1 to 30.0	14.6 to 16.1
Increased U.S. Energy Security	7.3 to 7.9	3.9 to 4.2
Total Benefits	225 to 246	136 to 149
Net Benefits	197 to 216	117 to 129

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] Range reflects two reference case assumptions 1a and 1b.

[c] Benefits and net benefits use the 3 percent global average SCC value applied only to CO_2 emissions; GHG reductions include CO_2, CH_4, N_2O and HFC reductions, and include benefits to other nations as well as the U.S. See Draft RIA Chapter 8.5 and Preamble Section IX.G for further discussion.

[d] "Congestion, Crashes, Fatalities and Noise from Increased Vehicle Use" includes NHTSA's monetized value of estimated reductions in the incidence of highway fatalities associated with mass reduction in HD pickup and vans, but this does not include these reductions from tractor-trailers or vocational vehicles. This likely results in a conservative overestimate of these costs.

Table I–11 shows benefits and cost from the perspective of reducing GHG. As shown below in terms of MY lifetime GHG reductions, and in RIA Chapter 5 in terms of year-by-year GHG reductions, the final program is expected to reduce more GHGs over the long run than the proposed program. In general, the greater reductions can be attributed to increased market penetration and effectiveness of key technologies, based on new data and comments, leading to increases in stringency such as with the diesel engine standards (Section I.C.(2)(a) above).

TABLE I–11—LIFETIME FUEL SAVINGS, GHG REDUCTIONS, BENEFITS, COSTS AND NET BENEFITS FOR MODEL YEARS 2018–2029 VEHICLES USING ANALYSIS METHOD B

[Billions of 2012$] [a] [b]

Category	3% discount rate	7% discount rate
Fuel Reductions (Billion Gallons)	73–82	
GHG reductions (MMT CO_2eq)	976–1,098	
Vehicle Program (e.g., technology and indirect costs, normal profit on additional investments)	−$26.5 to −$26.2	−$17.6 to −$17.4
Additional Routine Maintenance	−$1.9 to −$1.9	−$1.0 to −$1.0
Fuel Savings (valued at pre-tax prices)	$149.3 to $169.1	$76.8 to $87.2
Energy Security	$6.9 to $7.8	$3.5 to $4.0
Congestion, Crashes, and Noise from Increased Vehicle Use	−$3.2 to −$3.2	−$1.8 to −$1.8
Savings from Less Frequent Refueling	$3.4 to $4.0	$1.8 to $2.1
Economic Benefits from Additional Vehicle Use	$10.4 to $10.5	$5.7 to $5.7
Benefits from Reduced Non-GHG Emissions [c]	$28.3 to $31.9	$13.4 to $15.0

TABLE I–11—LIFETIME FUEL SAVINGS, GHG REDUCTIONS, BENEFITS, COSTS AND NET BENEFITS FOR MODEL YEARS 2018–2029 VEHICLES USING ANALYSIS METHOD B—Continued

[Billions of 2012$] [a] [b]

Category	3% discount rate	7% discount rate
Reduced Climate Damages from GHG Emissions [d]	$33.0 to $37.2	
Net Benefits	$200 to $229	$114 to $131

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] Range reflects two baseline assumptions 1a and 1b.

[c] Range reflects both the two baseline assumptions 1a and 1b using the mid-point of the low and high $/ton estimates for calculating benefits.

[d] Benefits and net benefits use the 3 percent average directly modeled SC–GHG values applied to direct reductions of CO_2, CH_4 and N_2O emissions; GHG reductions include CO_2, CH_4 and N_2O reductions.

Table I–12 breaks down by vehicle category the benefits and costs for these standards using the Method A analytical approach. For additional detail on per-vehicle break-downs of costs and benefits, please see RIA Chapter 10.

TABLE I–12—PER VEHICLE CATEGORY LIFETIME FUEL SAVINGS, GHG REDUCTIONS, BENEFITS, COSTS AND NET BENEFITS FOR MODEL YEARS 2018–2029 VEHICLES USING ANALYSIS METHOD A (BILLIONS OF 2013$), RELATIVE TO BASELINE 1b [a]

Key costs and benefits by vehicle category	3% discount rate	7% discount rate
Tractors, Including Engines, and Trailers		
Fuel Reductions (Billion Gallons)	50	
GHG Reductions (MMT CO_2 eq)	685	
Total Costs	13.8	9.0
Total Benefits	161.0	96.8
Net Benefits	147.2	85.5
Vocational Vehicles, Including Engines		
Fuel Reductions (Billion Gallons)	12	
GHG Reductions (MMT CO_2 eq)	162	
Total Costs	7.3	4.8
Total Benefits	37.8	22.7
Net Benefits	30.5	15.3
HD Pickups and Vans		
Fuel Reductions (Billion Gallons)	10	
GHG Reductions (MMT CO_2 eq)	111	
Total Costs	7.4	5.1
Total Benefits	26.0	16.7
Net Benefits	18.6	11.6

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE I–13—PER VEHICLE COSTS, USING METHOD A (2013$), RELATIVE TO BASELINE 1b

	MY 2021	MY 2024	MY 2027
Per Vehicle Cost ($): [a]			
Tractors	$6,400	$9,920	$12,160
Trailers	850	1,000	1,070
Vocational Vehicles	1,110	2,020	2,660
Pickups/Vans	750	760	1,340

Note:

[a] Per vehicle costs include new engine and vehicle technology only; costs associated with increased insurance, taxes and maintenance are included in the payback period values.

TABLE I–14—PER VEHICLE COSTS USING METHOD B RELATIVE TO BASELINE 1a

	MY 2021	MY 2024	MY 2027
Per Vehicle Cost ($):[a]			
Tractors	$6,484	$10,101	$12,442
Trailers	868	1,033	1,108
Vocational Vehicles	1,110	2,022	2,662
Pickups/Vans	524	963	1,364

Note:

[a] Per vehicle costs include new engine and vehicle technology only; costs associated with increased insurance, taxes and maintenance are included in the payback period values.

An important metric to vehicle purchasers is the payback period that can be expected on any new purchase. In other words, there is greater willingness to pay for new technology if that new technology ‘‘pays back’’ within an acceptable period of time. The agencies make no effort to define the acceptable period of time, but seek to estimate the payback period for others to make the decision themselves. The payback period is the point at which reduced fuel expenditures outpace increased vehicle costs, including increased maintenance, insurance premiums and taxes. The payback periods for vehicles meeting the standards considered for the final year of implementation are shown in Table I–15, and are similar for both Method A and Method B.

TABLE I–15—PAYBACK PERIODS FOR MY 2027 VEHICLES RELATIVE TO BASELINE 1a

[Payback cccurs in the year shown; using 7% discounting]

Tractors/Trailers	2nd.
Vocational Vehicles	4th.
Pickups/Vans	3rd.

TABLE I–16—PAYBACK PERIODS FOR MY 2027 VEHICLES RELATIVE TO BASELINE 1b

[Payback occurs in the year shown; using 7% discounting]

Tractors/Trailers	2nd.
Vocational Vehicles	4th.
Pickups/Vans	3rd.

(3) Cost Effectiveness

These regulations implement section 32902(k) of EISA and section 202(a)(1) and (2) of the Clean Air Act. Through the 2007 EISA, Congress directed NHTSA to create a medium- and heavy-duty vehicle fuel efficiency program designed to achieve the maximum feasible improvement by considering appropriateness, cost effectiveness, and technological feasibility to determine maximum feasible standards.[78] The Clean Air Act requires that any air pollutant emission standards for heavy-duty vehicles and engines take into account the costs of any requisite technology and the lead time necessary to implement such technology. Both agencies considered overall costs, overall benefits and cost effectiveness in developing the Phase 2 standards. Although there are different ways to evaluate cost effectiveness, the essence is to consider some measure of costs relative to some measure of impacts.

Considering that Congress enacted EPCA and EISA to, among other things, address the need to conserve energy, the agencies have evaluated these standards in terms of costs per gallon of fuel conserved. We also considered the similar metric of cost of technology per ton of CO_2e removed, consistent with the objective of CAA section 202(a)(1) and (2) to reduce emissions of air pollutants which contribute to air pollution which endangers public health and welfare. As described in the RIA, the agencies also evaluated these standards using the same approaches employed in HD Phase 1. Together, the agencies have considered the following three ratios of cost effectiveness:

1. Total social costs per gallon of fuel conserved
2. Technology costs per ton of GHG emissions reduced (CO_2eq)
3. Technology costs minus fuel savings per ton of GHG emissions reduced

By all three of these measures, the total heavy-duty program will be highly cost effective.

As discussed below, the agencies estimate that over the lifetime of heavy-duty vehicles produced for sale in the U.S. during model years 2018–2029, these standards will cost about $30 billion and conserve about 75 billion gallons of fuel, such that the first measure of cost effectiveness will be about 40 cents per gallon. Relative to fuel prices underlying the agencies' analysis, the agencies have concluded that today's standards will be cost effective.

With respect to the second measure, which is useful for comparisons to other GHG rules, these standards will have overall $/ton costs similar to the HD Phase 1 rule. As Chapter 7 of the RIA shows, social costs will amount to about $30 per metric ton of GHG (CO_2eq) for the entire HD Phase 2 program. This compares well to both the HD Phase 1 rule, which was also estimated to cost about $30 per metric ton of GHG (without fuel savings), and to the agencies' estimates of the social cost of carbon.[79] Thus, even without accounting for fuel savings, these standards will be cost-effective.

The following table include the overall per-unit costs of both gallons of fuel conserved and metric tons of GHG emissions abated using both a 3 percent and a 7 percent discount rate. Table I–16 gives these values under the Method A analysis.

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[78] This EISA requirement applies to regulation of medium- and heavy-duty vehicles. For many years, and as reaffirmed by Congress in 2007, ‘‘economic practicability'' has been among the factors EPCA requires NHTSA to consider when setting light-duty fuel economy standards at the (required) maximum feasible levels. NHTSA interprets ‘‘economic practicability'' as a factor involving considerations broader than those likely to be involved in ‘‘cost effectiveness.''

[79] As described in Section IX.G, the social cost of carbon is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year.

TABLE I–17—METHOD A COST PER-UNIT OF FUEL SAVINGS AND GHG EMISSION REDUCTIONS BY VEHICLE CLASS

[Relative to the dynamic baseline]

Per-unit costs (2013$/Unit) by vehicle category	3% Discount rate	7% Discount rate
Tractors, Including Engines, and Trailers		
Cost per Gallon of Fuel Saved	$0.28	$0.18
Cost per Ton of GHG Emissions Saved	20	13
Vocational Vehicles, Including Engines		
Cost per Gallon of Fuel Saved	0.61	0.40
Cost per Ton of GHG Emissions Saved	45	30
HD Pickups and Vans		
Cost per Gallon of Fuel Saved	0.76	0.52
Cost per Ton of GHG Emissions Saved	67	46
Total Program		
Cost per Gallon of Fuel Saved	0.40	0.26
Cost per Ton of GHG Emissions Saved	30	20

When considering these values, it is important to emphasize two points:

1. As is shown throughout this rulemaking, the Phase 2 standards represent the most stringent standards that are technologically feasible and reliably implementable within the lead time provided.

2. These are not the marginal cost-effectiveness values.

Without understanding these two points, some readers might assume that because the tractor-trailer standards are more cost-effective overall than the other standards that manufacturers would choose to over-comply with the more cost-effective tractor or trailer standards and do less for other vehicles. However, the agencies believe this is not a technologically feasible option. Because the tractor and trailer standards represent maximum feasible standards, they will effectively require manufacturers to deploy all available technology to meet the standards. The agencies do not project that manufacturers would be able to over-comply with the 2027 standards by a significant margin.

The third measure deducts fuel savings from costs, which also is useful for comparisons to other GHG rules. As shown in Table I–18, the agencies have also calculated the cost per metric ton of CO_2e emission reductions including the savings associated with reduced fuel consumption. The calculations presented here include all engine-related costs but do not include benefits associated with the final program such as those associated with criteria pollutant reductions or energy security benefits (discussed in Chapter 8 of this RIA). On this basis, net costs per ton of GHG emissions reduced will be negative under these standards. This means that the value of the fuel savings will be greater than the technology costs, and there will be a net cost saving for vehicle owners. In other words, the technologies will pay for themselves (indeed, more than pay for themselves) in fuel savings.

TABLE I–18—ANNUAL NET COST PER METRIC TON OF CO_2eq EMISSIONS REDUCED IN THE FINAL PROGRAM VS. THE FLAT BASELINE AND USING METHOD B FOR CALENDAR YEAR 2030

[Dollar values are 2013$] [a]

Calendar year	Vehicle & maintenance costs ($billions)	Fuel savings ($billions)	GHG reduced (MMT)	Net cost ($/metric ton) [b]
HDE Pickups and Vans	1.6	3.9	15	0
Vocational Vehicles	1.5	3.5	14	0
Tractor-Trailers	2.3	16	64	0
All Vehicles	5.5	23	94	0

Notes:

[a] For an explanation of analytical Methods A and B, please see the beginning of this Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1. GHG reductions include CO_2 and CO_2 equivalents of CH_4, and N_2O.

[b] For each category, fuel savings exceed cost so there is no net cost per ton of GHG reduced.

In addition, while the net economic benefits (*i.e.,* total benefits minus total costs) of these standards is not a traditional measure of their cost effectiveness, the agencies have concluded that the total costs of these standards are justified in part by their significant economic benefits. As discussed in the previous subsection and in Section IX, this rule will provide benefits beyond the fuel conserved and GHG emissions avoided. The rule's net benefits is a measure that quantifies each of its various benefits in economic terms, including the economic value of the fuel it saves and the climate-related damages it avoids, and compares their sum to the rule's estimated costs. The agencies estimate that these standards will result in net economic benefits exceeding $100 billion, making this a highly beneficial program.

EPA and NHTSA received many comments suggesting that more stringent standards were feasible because many cost effective technologies exist for future vehicle designs. While the agencies agree that many cost effective technologies exist, and indeed, we reflect the potential for many of those technologies to be applied in our analysis for today's final rule, commenters who focused on the cost-effectiveness of technologies did not consistently recognize certain real-world constraints on technology implementation. Manufacturers and suppliers have limited research and development capacities, and although they have some ability to expand (by adding staff or building new facilities), the process of developing and applying new technologies is inherently constrained by time. Adequate lead time is also necessary to complete durability, reliability, and safety testing and ramp up production to levels that might be necessary to meet future standards. If the agencies fail to account for lead time needs in determining the stringency of the standards, we could create unintended consequences, such as technologies that are applied before they are ready and lead to maintenance and repair problems. In addition to cost-effectiveness, then, lead time constraints can also be highly relevant to feasibility of more stringent standards.

E. EPA and NHTSA Statutory Authorities

This section briefly summarizes the respective statutory authority for EPA and NHTSA to promulgate the Phase 1 and Phase 2 programs. For additional details of the agencies' authority, see Section XV of this document as well as the Phase 1 rule.[80]

(1) EPA Authority

Statutory authority for the emission standards in this rule is found in CAA section 202(a)(1) and (2) (which requires EPA to establish standards for emissions of pollutants from new motor vehicles and engines which emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare), and in CAA sections 202(a)(3), 202(d), 203–209, 216, and 301 (42 U.S.C. 7521 (a)(1) and (2), 7521(d), 7522–7543, 7550, and 7601).

Title II of the CAA provides for comprehensive regulation of mobile sources, authorizing EPA to regulate emissions of air pollutants from all mobile source categories. When acting under Title II of the CAA, EPA considers such issues as technology effectiveness, its cost (both per vehicle, per manufacturer, and per consumer), the lead time necessary to implement the technology, and based on this the feasibility and practicability of potential standards; the impacts of potential standards on emissions reductions of both GHGs and non-GHG emissions; the impacts of standards on oil conservation and energy security; the impacts of standards on fuel savings by customers; the impacts of standards on the truck industry; other energy impacts; as well as other relevant factors such as impacts on safety.

This action implements a specific provision from Title II, section 202(a). Section 202(a)(1) of the CAA states that ''the Administrator shall by regulation prescribe (and from time to time revise) . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles . . ., which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.'' With EPA's December 2009 final findings that certain greenhouse gases may reasonably be anticipated to endanger public health and welfare and that emissions of GHGs from section 202(a) sources cause or contribute to that endangerment, section 202(a) requires EPA to issue standards applicable to emissions of those pollutants from new motor vehicles. See *Coalition for Responsible Regulation* v. *EPA,* 684 F. 3d at 116–125, 126–27 cert. granted by, in part *Util. Air Regulatory Group* v. *EPA,* 134 S. Ct. 418 (2013), affirmed in part and reversed in part on unrelated grounds by *Util. Air Regulatory Group* v. *EPA,* 134 S. Ct. 2427 (2014) (upholding EPA's endangerment and cause and contribute findings, and further affirming EPA's conclusion that it is legally compelled to issue standards under section 202(a) to address emission of the pollutant which endangers after making the endangerment and cause or contribute findings); see also id. at 127–29 (upholding EPA's light-duty GHG emission standards for MYs 2012–2016 in their entirety).

Other aspects of EPA's legal authority, including its authority under section 202(a), its testing authority under section 203 of the Act, and its enforcement authorities under sections 205 and 207 of the Act are discussed fully in the Phase 1 rule, and need not be repeated here. See 76 FR 57129–57130.

In this final rule, EPA is establishing first-time CO_2 emission standards for trailers hauled by tractors. 80 FR 40170. Certain commenters, notably the Truck Trailer Manufacturers Association (TTMA), maintained that EPA lacks authority to adopt requirements for trailer manufacturers, and that emission standards for trailers could be implemented, if at all, by requirements applicable to the entity assembling a tractor-trailer combination. The argument is that trailers by themselves are not ''motor vehicles'' as defined in section 216(2) of the Act, that trailer manufacturers therefore do not manufacture motor vehicles, and that standards for trailers can be imposed, if at all, only on ''the party that joined the trailer to the tractor.'' Comments of TTMA, p. 4; Comments of TTMA (March 31, 2016) p. 2.

EPA also proposed a number of changes and clarifications for rules respecting glider kits and glider vehicles. 80 FR 40527–40530. As shown in Figure I.1, a glider kit is a tractor chassis with frame, front axle, interior and exterior cab, and brakes.

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[80] 76 FR 57106–57129, September 15, 2011.

Figure I.1 Typical Incomplete Glider Kit Configuration

It is intended for self-propelled highway use, and becomes a glider vehicle when an engine, transmission, and rear axle are added. Engines are often salvaged from earlier model year vehicles, remanufactured, and installed in the glider kit. The final manufacturer of the glider vehicle, *i.e.* the entity that installs an engine, is typically a different manufacturer than the original manufacturer of the glider kit. The final rule contains emission standards for glider vehicles, but does not contain separate standards for glider kits.[81]

Many commenters to both the proposed rule and the NODA supported EPA's interpretation. However, a number of commenters, including Daimler, argued that glider kits are not motor vehicles and so EPA lacks the authority to impose any rules respecting their sale or configuration. Comments of Daimler, pp. 122–23; Comments of Daimler Trucks (April 1, 2016) pp. 2–3. We respond to these comments below, with a more detailed response appearing in RTC Section 1.3.1 and 14.2.

Under the Act, ''motor vehicle'' is defined as ''any self-propelled vehicle designed for transporting persons or property on a street or highway.'' CAA section 216(2). At proposal, EPA maintained that tractor-trailers are motor vehicles and that EPA therefore has the authority to promulgate emission standards for complete and incomplete vehicles—both the tractor and the trailer. 80 FR 40170. The same proposition holds for glider kits and glider vehicles. Id. at 80 FR 40528. The argument that a trailer, or a glider kit, standing alone, is not self-propelled, and therefore is not a motor vehicle, misses the key issues of authority under the Clean Air Act to promulgate emission standards for motor vehicles produced in discrete segments, and the further issue of the entities—namely ''manufacturers''—to which standards and certification requirements apply. Simply put, EPA is authorized to set emission standards for complete and incomplete motor vehicles, manufacturers of complete and incomplete motor vehicles can be required to certify to those emission standards, and there can be multiple manufacturers of a motor vehicle, each of which can be required to certify.

(a) Standards for Complete Vehicles—Tractor-Trailers and Glider Vehicles

Section 202(a)(1) authorizes EPA to set standards ''applicable to the emission of any air pollutant from any . . . new motor vehicles.'' There is no question that EPA is authorized to establish emission standards under this provision for complete new motor vehicles, and thus can promulgate emission standards for air pollutants emitted by tractor-trailers and by glider vehicles.

Daimler maintained in its comments that although a glider vehicle is a motor vehicle, it is not a ''new'' motor vehicle because ''glider vehicles, when constructed retain the identity of the donor vehicle, such that the title has already been exchanged, making the vehicles not 'new' under the CAA.'' Daimler Comments p. 121; see also the similar argument in Daimler Truck Comments (April 1, 2016), p. 4. Daimler maintains that because title to the powertrain from the donor vehicle has already been transferred, the glider vehicle to which the powertrain is added cannot be ''new.'' Comments of April 1, 2016 p. 4. Daimler also notes that NHTSA considers a truck to be ''newly manufactured'' and subject to Federal Motor Vehicle Safety Standards when a new cab is used in its assembly, ''unless the engine, transmission, and drive axle(s) (as a minimum) of the assembled vehicle are not new, and at least two of these components were taken from the same vehicle.'' 49 CFR 571.7(e). Daimler urges EPA to adopt a parallel provision here.

First, this argument appears to be untimely. In Phase 1, EPA already indicated that glider vehicles are new motor vehicles, at least implicitly, by

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[81] As discussed in sections (c) and (d) below, however, manufacturers of glider kits can, and typically are, responsible for obtaining a certificate of conformity before shipping a glider kit. This is because they are manufacturers of motor vehicles, in this case, an incomplete vehicle.

adopting an interim exemption for them. See 76 FR 57407 (adopting 40 CFR 1037.150(j) indicating that the general prohibition against introducing a vehicle not subject to current model year standards does not apply to MY 2013 or earlier engines). Assuming the argument that glider vehicles are not new can be raised in this rulemaking, EPA notes that the Clean Air Act defines ''new motor vehicle'' as ''a motor vehicle the equitable or legal title to which has never been transferred to an ultimate purchaser'' (section 216(3)). Glider vehicles are typically marketed and sold as ''brand new'' trucks. Indeed, one prominent assembler of glider kits and glider vehicles advertises that ''Fitzgerald Glider Kits offers customers the option to purchase a *brand new 2016 tractor,* in any configuration offered by the manufacturer . . . Fitzgerald Glider Kits has mastered the process of taking the 'Glider Kit' and installing the components to work seamlessly *with the new truck.*'' [82] The purchaser of a ''new truck'' necessarily takes initial title to that truck.[83] Daimler would have it that this 'new truck' terminology is a mere marketing ploy, but it obviously reflects reality. As shown in Figure I.1 above, the glider kit constitutes the major parts of the vehicle, lacking only the engine, transmission, and rear axle. The EPA sees nothing in the Act that compels the result that adding a used component to an otherwise new motor vehicle necessarily vitiates classification of the motor vehicle as ''new.'' See 80 FR 40528. Rather, reasonable judgments must be made, and in this case, the agency believes it reasonable that the tail need not wag the dog: Adding the engine and transmission to the otherwise-complete vehicle does not prevent the glider vehicle from being ''new''—as marketed. The fact that this approach is reasonable, if not mandated, is confirmed by the language of the Act's definition of ''new motor vehicle engine,'' which includes any ''engine in a new motor vehicle'' without regard to whether or not the engine was previously used. EPA has also previously addressed the issue of used components in new engines and vehicles explicitly in regulations in the context of locomotives and locomotive engines in 40 CFR part 1033. There we defined remanufactured locomotives and locomotive engines to be ''new'' locomotives and locomotive engines. See 63 FR 18980; see also Summary and Analysis of Comments on Notice of Proposed Rulemaking for Emission Standards for Locomotives and Locomotive Engines (EPA–420–R–97–101 (December 1997)) at pp. 10–14. This is a further reason that the model year of the engine is not determinative of whether a glider vehicle is ''new.'' As to the suggestion to adopt a provision parallel to the NHTSA definition, EPA notes that the NHTSA definition was developed for different purposes using statutory authority which differs from the Clean Air Act in language and intent. There consequently is no basis for requiring EPA to adopt such a definition, and doing so would impede meaningful control of both GHG emissions and criteria pollutant emissions from glider vehicles.

(b) Standards for Incomplete Vehicles

Section 202(a)(1) not only authorizes EPA to set standards ''applicable to the emission of any air pollutant from any . . . new motor vehicles,'' but states further that these standards are applicable ''whether such vehicles . . . are designed as complete systems or incorporate devices to prevent or control such pollution.'' The Act in fact thus not only contemplates, but in some instances, directly commands that EPA establish standards for incomplete vehicles and vehicle components. See CAA section 202(a)(6) (standards for onboard vapor recovery systems on ''new light-duty vehicles,'' and requiring installation of such systems); section 202(a)(5)(A) (standards to control emissions from refueling motor vehicles, and requiring consideration of, and possible design standards for, fueling system components); 202(k) (standards to control evaporative emissions from gasoline-fueled motor vehicles). Both TTMA and Daimler argued, in effect, that these provisions are the exceptions that prove the rule and that without this type of enumerated exception, only entire, complete vehicles can be considered to be ''motor vehicles.'' This argument is not persuasive. Congress did not indicate that these incomplete vehicle provisions were exceptions to the definition of motor vehicle. Just the opposite. Without amending the new motor vehicle definition, or otherwise indicating that these provisions were not already encompassed within Title II authority over ''new motor vehicles'', Congress required EPA to set standards for evaporative emissions from a portion of a motor vehicle. Congress thus indicated in these provisions: (1) That standards should apply to ''vehicles'' whether or not the ''vehicles'' were designed as complete systems; (2) that some standards should explicitly apply only to certain components of a vehicle that are plainly not self-propelled. Congress thus necessarily was of the view that incomplete vehicles can be motor vehicles.

Emission standards EPA sets pursuant to this authority thus can be, and often are focused on emissions from the new motor vehicle, and from portions, systems, parts, or components of the vehicle. Standards thus apply not just to exhaust emissions, but to emissions from non-exhaust portions of a vehicle, or from specific vehicle components or parts. See the various evaporative emission standards for light duty vehicles in 40 CFR part 86, subpart B (*e.g.,* 40 CFR 86.146–96 and 86.150–98 (refueling spitback and refueling test procedures); 40 CFR 1060.101–103 and 73 FR 59114–59115 (various evaporative emission standards for small spark ignition equipment); 40 CFR 86.1813–17(a)(2)(iii) (canister bleed evaporative emission test procedure, where testing is solely of fuel tank and evaporative canister); see also 79 FR 23507 (April 28, 2014) (incomplete heavy duty gasoline vehicles could be subject to, and required to certify compliance with, evaporative emission standards)). These standards are implemented by testing the particular vehicle component, not by whole vehicle testing, notwithstanding that the component may not be self-propelled until it is installed in the vehicle or (in the case of non-road equipment), propelled by an engine.[84]

EPA thus can set standards for all or just a portion of the motor vehicle notwithstanding that an incomplete motor vehicle may not yet be self-propelled. This is not to say that the Act authorizes emission standards for any part of a motor vehicle, however insignificant. Under the Act it is reasonable to consider both the significance of the components in comparison to the entire vehicle and the significance of the components for achieving emissions reductions. A vehicle that is complete except for an ignition switch can be subject to standards even though it is not self-

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[82] Advertisement for Fitzgerald Glider kits in Overdrive magazine (December 2015) (emphasis added).

[83] Fitzgerald states ''All Fitzgerald glider kits will be titled in the state of Tennessee and you will receive a title to transfer to your state.'' *https://www.fitzgeraldgliderkits.com/frequently-asked-questions.* Last accessed July 9, 2016.

[84] ''Non-road vehicles'' are defined differently than ''motor vehicles'' under the Act, but the difference does not appear relevant here. Non-road vehicles, like motor vehicles, must be propelled by an engine. See CAA section 216(11) (''nonroad vehicle' means a vehicle that is powered by a nonroad engine''). Pursuant to this authority, EPA has promulgated many emission standards applicable to components of engineless non-road equipment, for which the equipment manufacturer must certify.

propelled. Likewise, as just noted, vehicle components that are significant for controlling evaporative emissions can be subject to standards even though in isolation the components are not self-propelled. However, not every individual component of a complete vehicle can be subjected to standards as an incomplete vehicle. To reflect these considerations, EPA is adopting provisions stating that a trailer is a vehicle ''when it has a frame with one or more axles attached,'' and a glider kit becomes a vehicle when ''it includes a passenger compartment attached to a frame with one or more axles.'' Section 1037.801 definition of ''vehicle,'' paragraphs (1)(ii) and (iii); see also Section XIII.B below.

TTMA and Daimler each maintained that this claim of authority is open-ended, and can be extended to the least significant vehicle part. As noted above, EPA acknowledges that lines need to be drawn, but whether looking at the relation between the incomplete vehicle and the complete vehicle, or looking at the relation between the incomplete vehicle and the emissions control requirements, it is evident that trailers and glider kits should properly be treated as vehicles, albeit incomplete ones.[85] They properly fall on the vehicle side of the line. When one finishes assembling a whole aggregation of parts to make a finished section of the vehicle (*e.g.* the trailer), that is sufficient. You have an entire, complete section made up of assembled parts. Everything needed to be a trailer is complete. This is not an engine block, a wheel, or a headlight. Similarly, glider kits comprise the largely assembled tractor chassis with front axles, frame, interior and exterior cab, and brakes. This is not a few assembled components; rather, it is an assembled truck with a few components missing. See CAA section 216(9) of the Act, which defines ''motor vehicle or engine part manufacturer'' as ''any person engaged in the manufacturing, assembling or rebuilding of any device, system, part, component or element of design which is installed in or on motor vehicles or motor vehicle engines.'' Trailers and glider kits are not ''installed in or on'' a motor vehicle. A trailer is half of the tractor-trailer, not some component installed on the tractor. And one would more naturally refer to the donor drivetrain being installed on the glider kit than vice versa. See Figure I.1 above. Furthermore, as discussed below, the trailer and the glider kit are significant for purposes of controlling emissions from the completed vehicle.

Incomplete vehicle standards must, of course, be reasonably designed to control emissions caused by that particular vehicle segment. The standards for trailers would do so and account for the tractor-trailer combination by using a reference tractor in the trailer test procedure (and, conversely, by use of a reference trailer in the tractor test procedure). The Phase 2 rule contains no emission standards for glider kits in isolation, but the standards for glider vehicles necessarily reflect the contribution of the glider kit.

(c) Application of Emission Standards to Manufacturers

In some ways, the critical issue is to whom these emission standards apply. As explained in this section, the emission standards apply to manufacturers of motor vehicles, and manufacturers thus are required to test and to certify compliance to those standards. Moreover, the Act contemplates that a motor vehicle can have multiple manufacturers. With respect to the further question of which manufacturer certifies and tests in multiple manufacturer situations, EPA rules have long contained provisions establishing responsibilities where a vehicle has multiple manufacturers. We are applying those principles in the Phase 2 rules. The overarching principle is that the entity with most control over the particular vehicle segment due to producing it is usually the most appropriate entity to test and certify.[86] EPA is implementing the trailer and glider vehicle emission standards in accord with this principle, so that the entities required to test and certify are the trailer manufacturer and, for glider kits and glider vehicles, either the manufacturer of the glider kit or glider vehicle, depending on which is more appropriate in individual circumstances.

(i) Definition of Manufacturer

Emission standards are implemented through regulation of the manufacturer of the new motor vehicle. See, *e.g.* section 206(a)(1) (certification testing of motor vehicle submitted by ''a manufacturer''); 203(a)(1) (manufacturer of new motor vehicle prohibited from introducing uncertified motor vehicles into commerce); 207(a)(1) (manufacturer of motor vehicle to provide warranty to ultimate purchaser of compliance with applicable emission standards); 207(c) (recall authority); 208(a) (recordkeeping and testing can be required of every manufacturer of new motor vehicle).

The Act further distinguishes between manufacturers of motor vehicles and manufacturers of motor vehicle parts. See, *e.g.* section 206(a)(2) (voluntary emission control system verification testing); 203(a)(3)(B) (prohibition on parts manufacturers and other persons relating to defeat devices); 207(a)(2) (parts manufacturer may provide warranty certification regarding use of parts); 208(a) (recordkeeping and testing requirements for manufacturers of vehicle and engine ''parts or components'').

Thus, the question here is whether a trailer manufacturer or glider kit manufacturer can be a manufacturer of a new motor vehicle and thereby become subject to the certification and related requirements for manufacturers, or must necessarily be classified as a manufacturer of a motor vehicle part or component. EPA may reasonably classify trailer manufacturers and glider kit manufacturers as motor vehicle manufacturers.

Section 216(1) defines a ''manufacturer'' as ''any person engaged in the manufacturing or assembling of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, or importing such vehicles or engines for resale, or who acts for and is under the control of any such person in connection with the distribution of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, but shall not include any dealer with respect to new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines received by him in commerce.''

It appears plain that this definition was not intended to restrict the definition of ''manufacturer'' to a single person per vehicle. The use of the conjunctive, specifying that a manufacturer is ''*any* person engaged in the manufacturing or assembling of new motor vehicles . . . *or* who acts for and is under the control of any such person

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[85] Cf. *Marine Shale Processors* v. *EPA,* 81 F. 3d 1371, 1383 (5th Cir. 1996) (''[w]e make no comment on this argument: This is simply not a thimbleful case'').

[86] See discussion of standards applicable to small SI equipment fuel systems, implemented by standards for the manufacturers of that equipment at 73 FR 59115 (''In most cases, nonroad standards apply to the manufacturer of the engine or the manufacturer of the nonroad equipment. Here, the products subject to the standards (fuel lines and fuel tanks) are typically manufactured by a different manufacturer. In most cases the engine manufacturers do not produce complete fuel systems and therefore are not in a position to do all the testing and certification work necessary to cover the whole range of products that will be used. We are therefore providing an arrangement in which manufacturers of fuel-system components are in most cases subject to the standards and are subject to certification and other compliance requirements associated with the applicable standards'').

. . .'' (emphasis added) indicates that Congress anticipated that motor vehicles could have more than one manufacturer, since in at least some cases those will plainly be different people. The capacious reference to ''any person engaged in the manufacturing of motor vehicles'' likewise allows the natural inference that it could apply to multiple entities engaged in manufacturing.[87]

The provision also applies both to entities that manufacture and entities that assemble, and does so in such a way as to encompass multiple parties: Manufacturers ''or'' (rather than 'and') assemblers are included. Nor is there any obvious reason that only one person can be engaged in vehicle manufacture or vehicle assembling.

Reading the Act to provide for multiple motor vehicle manufacturers reasonably reflects industry realities, and achieves important goals of the CAA. Since title II requirements are generally imposed on ''manufacturers'' it is important that the appropriate parties be included within the definition of manufacturer—''any person engaged in the manufacturing or assembling of new motor vehicles.'' Indeed, as set out in Chapter 1 of the RIA, most heavy duty vehicles are manufactured or assembled by multiple entities; see also Comments of Daimler (October 1, 2015) p. 103.[88] One entity produces a chassis; a different entity manufactures the engine; specialized components (*e.g.* garbage compactors, cement mixers) are produced by still different entities. For tractor-trailers, one person manufactures the tractor, another the trailer, a third the engine, and another typically assembles the trailer to the tractor. Installation of various vehicle components occurs at different and varied points and by different entities, depending on ultimate desired configurations. See, *e.g.* Comments of Navistar (October 1, 2015), pp. 12–13. The heavy duty sector thus differs markedly from the light duty sector (and from manufacturing of light duty pickups and vans), where a single company designs the vehicle and engine (and many of the parts), and does all assembling of components into the finished motor vehicle.

(ii) Controls on Manufacturers of Trailers

It is reasonable to view the trailer manufacturer as ''engaged in'' (section 216(1)) the manufacturing or assembling of the tractor-trailer. The trailer manufacturer designs, builds, and assembles a complete and finished portion of the tractor-trailer. All components of the trailer—the tires, axles, flat bed, outsider cover, aerodynamics—are within its control and are part of its assembling process. The trailer manufacturer sets the design specifications that affect the GHG emissions attributable to pulling the trailer. It commences all work on the trailer, and when that work is complete, nothing more is to be done. The trailer is a finished product. With respect to the trailer, the trailer manufacturer is analogous to the manufacturer of the light duty vehicle, specifying, controlling, and assembling all aspects of the product from inception to completion. GHG emissions attributable to the trailer are a substantial portion of the total GHG emissions from the tractor-trailer.[89] Moreover, the trailer manufacturer is not analogous to the manufacturer of a vehicle part or component, like a tire manufacturer, or to the manufacturer of a side skirt. The trailer is a significant, integral part of the finished motor vehicle, and is essential for the tractor-trailer to carry out its commercial purpose. See 80 FR 40170. Although it is true that another person may ultimately hitch the trailer to a tractor (which might be viewed as completing assembly of the tractor-trailer), as noted above, EPA does not believe that the fact that one person might qualify as a manufacturer, due to ''assembling'' the motor vehicle, precludes another person from qualifying as a manufacturer, due to ''manufacturing'' the motor vehicle. Given that section 216(1) does not restrict motor vehicle manufacturers to a single entity, it appears to be consistent with the facts and the Act to consider trailer manufacturers as persons engaged in the manufacture of a motor vehicle.

This interpretation of section 216(1) is also reasonable in light of the various provisions noted above relating to implementation of the emissions standards—certification under section 206, prohibitions on entry into commerce under section 203, warranty and recall under section 207, and recordkeeping/reporting under section 208. All of these provisions are naturally applied to the entity responsible for manufacturing the trailer, which manufacturer is likewise responsible for its GHG emissions.

TTMA maintains that if a tractor-trailer is a motor vehicle, then only the entity connecting the trailer to the tractor could be subject to regulation.[90] This is not a necessary interpretation of section 216(1), as explained above. TTMA does not discuss that provision, but notes that other provisions refer to ''a'' manufacturer (or, in one instance, ''the'' manufacturer), and maintains that this shows that only a single entity can be a manufacturer. See TTMA Comment pp. 4–5, citing to sections 206(a)(1), 206(b), 207, and 203(a). This reading is not compelled by the statutory text. First, the term ''manufacturer'' in all of these provisions necessarily reflects the underlying definition in section 216(1), and therefore is not limited to a single entity, as just discussed. Second, the interpretation makes no practical sense. An end assembler of a tractor-trailer is not in a position to certify and warrant performance of the trailer, given that the end-assembler has no control over how trailers are designed, constructed, or even which trailers are attached to the tractor. It makes little sense for the entity least able to control the outcome to be responsible for that outcome. The EPA doubts that Congress compelled such an ungainly implementation mechanism, especially given that it is well known that vehicle manufacture responsibility in the heavy duty vehicle sector is divided, and given further that title II includes requirements for EPA to promulgate emission standards for portions of vehicles.

(iii) Controls on Manufacturers of Glider Kits

Application of these same principles indicate that a glider kit manufacturer is a manufacturer of a motor vehicle and, as an entity responsible for assuring that glider vehicles meet the Phase 2 vehicle emission standards, can be a party in the certification process as either the certificate holder or the entity which provides essential test information to the glider vehicle manufacturer. As noted above, glider kits include the entire tractor chassis, cab, tires, body, and brakes. Glider kit manufacturers thus control critical elements of the

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[87] See *United States* v. *Gonzales,* 520 U.S. 1, 5, (1997) (''Read naturally the word 'any' has an expansive meaning, that is, 'one or some indiscriminately of whatever kind'); *New York* v. *EPA,* 443 F.3d 880, 884–87 (D.C. Cir. 2006).

[88] ''The EPA should understand that vehicle manufacturing is a multi-stage process (regardless of the technologies on the vehicles) and that each stage of manufacturer has the incentive to properly complete manufacturing . . . [T]he EPA should continue the longstanding industry practice of allowing primary manufacturers to pass incomplete vehicles with incomplete vehicle documents to secondary manufacturers who complete the installation.''

[89] The relative contribution of trailer controls depends on the types of tractors and trailers, as well as the tier of standards applicable; however, it can be approximately one-third of the total reduction achievable for the tractor-trailer.

[90] Consequently, the essential issue here is not whether EPA can issue and implement emission standards for trailers, but at what point in the implementation process those standards apply.

ultimate vehicle's greenhouse gas emissions, in particular, all aerodynamic features and all emissions related to steer tire type. Glider kit manufacturers would therefore be the entity generating critical GEM inputs—at the least, those for aerodynamics and tires. Glider kit manufacturers also often know the final configuration of the glider vehicle, *i.e.* the type of engine and transmission which the final assembler will add to the glider kit.[91] This is because the typical glider kit contains all necessary wiring, and it is necessary, in turn, for the glider kit manufacturer to know the end configuration in order to wire the kit properly. Thus, a manufacturer of a glider kit can reasonably be viewed as a manufacturer of a motor vehicle under the same logic as above: There can be multiple manufacturers of a motor vehicle; the glider kit manufacturer designs, builds, and assembles a substantial, complete and finished portion of the motor vehicle; and that portion contributes substantially to the GHG emissions from the ultimate glider vehicle. A glider kit is not a vehicle part; rather, it is an assembled truck with a few components missing.

EPA rules have long provided provisions establishing responsibilities where there are multiple manufacturers of motor vehicles. See 40 CFR 1037.620 (responsibilities for multiple manufacturers), 40 CFR 1037.621 (delegated assembly), and 40 CFR 1037.622 (shipment of incomplete vehicles to secondary vehicle manufacturers). These provisions, in essence, allow manufacturers to determine among themselves as to which should be the certificate holder, and then assign respective responsibilities depending on that decision. The end result is that incomplete vehicles cannot be introduced into commerce without one of the manufacturers being the certificate holder.

Under the Phase 1 rules, glider kits are considered to be incomplete vehicles which may be introduced into commerce to a secondary manufacturer for final assembly. See 40 CFR 1037.622(b)(1)(i) and 1037.801 (definition of ''vehicle'' and ''incomplete vehicle'') of the Phase 1 regulations (76 FR 57421). Note that 40 CFR 1037.622(b)(1)(i) was originally codified as 40 CFR 1037.620(b)(1)(i). EPA is expanding somewhat on these provisions, but in essence, as under Phase 1, glider kit and glider vehicle manufacturers could operate under delegated assembly provisions whereby the glider kit manufacturer would be the certificate holder. See 40 CFR 1037.621 of the final regulations. Glider kit manufacturers would also continue to be able to ship uncertified kits to secondary manufacturers, and the secondary manufacturer must assemble the vehicle into certifiable condition. 40 CFR 1037.622.[92]

(d) Additional Authorities Supporting EPA's Actions

Even if, against our view, trailers and glider kits are not considered to be ''motor vehicles,'' and the entities engaged in assembling trailers and glider kits are not considered to be manufacturers of motor vehicles, the Clean Air Act still provides authority for the testing requirements adopted here. Section 208 (a) of the Act authorizes EPA to require ''every manufacturer of new motor vehicle or engine parts or components'' to ''perform tests where such testing is not otherwise reasonably available.'' This testing can be required to ''provide information the Administrator may reasonably require to determine whether the manufacturer . . . has acted or is acting in compliance with this part,'' which includes showing whether or not the parts manufacturer is engaged in conduct which can cause a prohibited act. Testing would be required to show that the trailer will conform to the vehicle emission standards. In addition, testing for trailer manufacturers would be necessary here to show that the trailer manufacturer is not causing a violation of the combined tractor-trailer GHG emission standard either by manufacturing a trailer which fails to comply with the trailer emission standards, or by furnishing a trailer to the entity assembling tractor-trailers inconsistent with tractor-trailer certified condition. Testing for glider kit manufacturers is necessary to prevent a glider kit manufacturer furnishing a glider kit inconsistent with the tractor's certified condition. In this regard, we note that section 203 (a)(1) of the Act not only prohibits certain acts, but also prohibits ''the causing'' of those acts. Furnishing a trailer not meeting the trailer standard would cause a violation of that standard, and the trailer manufacturer would be liable under section 203 (a)(1) for causing the prohibited act to occur. Similarly, a glider kit supplied in a condition inconsistent with the tractor standard would cause the manufacturer of the glider vehicle to violate the GHG emission standard, so the glider kit manufacturer would be similarly liable under section 203 (a)(1) for causing that prohibited act to occur.

In addition, section 203 (a)(3)(B) prohibits use of 'defeat devices'—which include ''any part or component intended for use with, or as part of, any motor vehicle . . . where a principal effect of the part or component is to . . . defeat . . . any . . . element of design installed . . . in a motor vehicle'' otherwise in compliance with emission standards. Manufacturing or installing a trailer not meeting the trailer emission standard could thus be a defeat device causing a violation of the emission standard. Similarly, a glider kit manufacturer furnishing a glider kit in a configuration that would not meet the tractor standard when the specified engine, transmission, and axle are installed would likewise cause a violation of the tractor emission standard. For example, providing a tractor with a coefficient of drag or tire rolling resistance level inconsistent with tractor certified condition would be a violation of the Act because it would cause the glider vehicle assembler to introduce into commerce a new tractor that is not covered by a *valid* certificate of conformity. Daimler argued in its comments that a glider kit would not be a defeat device because glider vehicles use older engines which are more fuel efficient since they are not meeting the more rigorous standards for criteria pollutant emissions. (Daimler Truck Comment, April 1, 2016, p. 5). However, the glider kit would be a defeat device with respect to the tractor *vehicle* standard, not the separate engine standard. A non-conforming glider kit would adversely affect compliance with the vehicle standard, as just explained. Furthermore, as explained in RTC Section 14.2, Daimler is incorrect that glider vehicles are more fuel efficient than Phase 1 2017 and later vehicles, much less Phase 2 vehicles.

In the memorandum accompanying the Notice of Data Availability, EPA solicited comment on adopting additional regulations based on these principles. EPA has decided not to adopt those provisions, but again notes

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[91] PACCAR indicated in its comments that manufacturers of glider kits may not know all details of final assembly. Provisions on delegated assembly, shipment of incomplete vehicles to secondary manufacturers, and assembly instructions for secondary vehicle manufacturers allow manufacturers of glider kits and glider vehicles to apportion responsibilities, as appropriate, including responsibility as to which entity shall be the certificate holder. See 40 CFR 1037.130, 1037.621, and 1037.622. Our point here is that both of these entities are manufacturers of the glider motor vehicle and therefore that both are within the Act's requirements for certification and testing.

[92] Under this provision in the Phase 2 regulations, the glider kit manufacturer would still have some responsibility to ensure that products they introduce into U.S. commerce will conform with the regulations when delivered to the ultimate purchasers.

that the authorities in CAA sections 208 and 203 support the actions EPA is taking here with respect to trailer and glider kit testing.

(e) Standards for Glider Vehicles and Lead Time for Those Standards

At proposal, EPA indicated that engines used in glider vehicles are to be certified to standards for the model year in which these vehicles are assembled. 80 FR 40528. This action is well within the agency's legal authority. As noted above, the Act's definition of ''new motor vehicle engine,'' includes any ''engine in a new motor vehicle'' without regard to whether or not the engine was previously used. Given the Act's purpose of controlling emissions of air pollutants from motor vehicle engines, with special concern for pollutant emissions from heavy-duty engines (see, *e.g.,* section 202(a)(3)(A) and (B)), it is reasonable to require engines placed in newly-assembled vehicles to meet the same standards as all other engines in new motor vehicles. Put another way, it is both consistent with the plain language of the Act and reasonable and equitable for the engines in ''new trucks'' (see Section I.E.(1)(a) above) to meet the emission standards for all other engines installed in new trucks.

Daimler challenged this aspect of EPA's proposal, maintaining that it amounted to regulation of vehicle rebuilding, which (according to the commenter) is beyond EPA's authority. Comments of Daimler, p. 123; Comments of Daimler Trucks (April 1, 2016) p. 3. This comment is misplaced. The EPA has authority to regulate emissions of pollutants from engines installed in new motor vehicles. As explained in subsection (a) above, glider vehicles are new motor vehicles. As also explained above, the Act's definition of ''new motor vehicle engine'' includes any ''engine in a new motor vehicle'' without regard to whether or not the engine was previously used. CAA section 216(3). Consequently, a previously used engine installed in a glider vehicle is within EPA's multiple authorities. See CAA sections 202(a)(1) (GHGs), 202(a)(3)(A) and (B)(ii) (hydrocarbon, CO, PM and NO_X from heavy-duty vehicles or engines), and 202(a)(3)(D) (pollutants from rebuilt heavy duty engines).[93]

As explained in more detail in Section XIII.B, the final rule requires that as of January 1, 2017, glider kit and glider vehicle production involving engines not meeting criteria pollutant standards corresponding to the year of glider vehicle assembly be allowed at the highest annual production for any year from 2010 to 2014. See section 1037.150(t)(3). (Certain exceptions to this are explained in Section XIII.B.) The rule further requires that as of January 1, 2018, engines in glider vehicles meet criteria pollutant standards and GHG standards corresponding to the year of the glider vehicle assembly, but allowing certain small businesses to introduce into commerce vehicles with engines meeting criteria pollutant standards corresponding to the year of the engine for up to 300 vehicles per year, or up to the highest annual production volume for calendar years 2010 to 2014, whichever is less. Section 1037.150(t)(1)(ii) (again subject to various exceptions explained in Section XIII.B). Glider vehicles using these exempted engines will not be subject to the Phase 1 GHG *vehicle* standards, but will be subject to the Phase 2 vehicle standards beginning with MY 2021. As explained in Section XIII.B, there are compelling environmental reasons for taking these actions in this time frame.

With regard to the issue of lead time, EPA indicated at proposal that the agency has long since justified the criteria pollutant standards for engines installed in glider kits. 80 FR 40528. EPA further proposed that engines installed in glider vehicles meet the emission standard for the year of glider vehicle assembly, as of January 1, 2018 and solicited comment on an earlier effective date. Id. at 40529. The agency noted that CAA section 202(a)(3)(D)[94] requires that standards for rebuilt heavy-duty engines take effect ''after a period . . . necessary to permit the development and application of the requisite control measures.'' Here, no time is needed to develop and apply requisite control measures for criteria pollutants because compliant engines are immediately available. In fact, manufacturers of compliant engines, and dealers of trucks containing those compliant engines, commented that they are disadvantaged by manufacturing more costly compliant engines while glider vehicles avoid using those engines. Not only are compliant engines immediately available, but (as commenters warned) there can be risk of massive pre-buys. Moreover, EPA does not envision that glider manufacturers will actually modify the older engines to meet the applicable standards. Rather, they will either choose from the many compliant engines available today, or they will seek to qualify under other flexibilities provided in the final rule. See Section XIII.B. Given that compliant engines are immediately available, the flexibilities provided in the final rule for continued use of donor engines for traditional glider vehicle functions and by small businesses, and the need to expeditiously prevent further perpetuation of use of heavily polluting engines, EPA sees a need to begin constraining this practice on January 1, 2017. However, the final rule is merely capping glider production using higher-polluting engines in 2017 at 2010–2014 production levels, which would allow for the production of thousands of glider vehicles using these higher polluting engines, and unlimited production of glider vehicles using less polluting engines.

Various commenters, however, argued that the EPA must provide four years lead-time and three-year stability pursuant to section 202(a)(3)(C) of the Act, which applies to regulations for criteria pollutant emissions from heavy duty vehicles or engines. For criteria pollutant standards, CAA section 202(a)(3)(C) establishes lead time and stability requirements for ''[a]ny standard promulgated or revised under this paragraph and applicable to classes or categories of heavy duty vehicles or engines.'' In this rule, EPA is generally requiring large manufacturers of glider vehicles to use engines that meet the standards for the model year in which a vehicle is manufactured. EPA is not promulgating new criteria pollutant standards. The NO_X and PM standards that apply to heavy duty engines were promulgated in 2001.

We are not amending these provisions or promulgating new criteria pollutant standards for heavy duty engines here. EPA interprets the phrase ''classes or categories of heavy duty vehicles or engines'' in CAA section 202(a)(3)(C) to refer to categories of vehicles established according to features such as their weight, functional type, (*e.g.* tractor, vocational vehicle, or pickup truck) or engine cycle (spark-ignition or compression-ignition), or weight class of the vehicle into which an engine is installed (LHD, MHD, or HHD). EPA has established several different categories

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[93] Comments from, *e.g.* Mondial and MEMA made clear that all of the donor engines installed in glider vehicles are rebuilt. See also *http://www.truckinginfo.com/article/story/2013/04/the-return-of-the-glider.aspx* (''1999 to 2002-model diesels were known for reliability, longevity and good fuel mileage. Fitzgerald favors Detroit's 12.7-liter Series 60 from that era, but also installs pre-EGR 14-liter Cummins and 15-liter Caterpillar diesels. All are rebuilt. . . .'').

[94] The engine rebuilding authority of section 202(a)(3)(D) includes removal of an engine from the donor vehicle. See 40 CFR 86.004–40 and 62 FR 54702 (Oct. 21, 1997). EPA interprets this language as including installation of the removed engine into a glider kit, thereby assembling a glider vehicle.

of heavy duty vehicles (distinguished by gross vehicle weight, engine-cycle, and other criteria related to the vehicles' intended purpose) and is establishing in this rule GHG standards applicable to each category.[95] By contrast, a ''glider vehicle'' is defined not by its weight or function but by its method of manufacture. A Class 8 tractor glider vehicle serves exactly the same function and market as a Class 8 tractor manufactured by another manufacturer. Similarly, rebuilt engines installed in glider vehicles (*i.e.* donor engines) are not distinguished by engine cycle, but rather serve the same function and market as any other HHD or MHD engine. Thus, EPA considers ''glider vehicles'' to be a description of a method of manufacturing new motor vehicles, not a description of a separate ''class or category'' of heavy duty vehicles or engines. Consequently, EPA is not adopting new standards for a class or category of heavy duty engines within the meaning of section 202(a)(3)(C) of the Act.

EPA believes this approach is most consistent with the statutory language and the goals of the Clean Air Act. The date of promulgation of the criteria pollutant standards was 2001. There has been plenty of lead time for the criteria pollutant standards and as a result, manufacturers of glider vehicles have many options for compliant engines that are available on the market today—just as manufacturers of other new heavy-duty vehicles do. We are even providing additional compliance flexibilities to glider manufacturers in recognition of the historic practice of salvaging a small number of engines from vehicles involved in crashes. See Section XIII.B. We do not believe that Congress intended to allow changes in how motor vehicles are manufactured to be a means of avoiding existing, applicable engine standards. Obviously, any industry attempts to avoid or circumvent standards will not become apparent until the standards begin to apply. The commenters' interpretation would effectively preclude EPA from curbing many types of avoidance, however dangerous, until at least four years from detection.

As to Daimler's further argument that the lead time provisions in section 202(3)(C) not only apply but also must trump those specifically applicable to heavy duty engine rebuilding, the usual rule of construction is that the more specific provision controls. See, *e.g. HCSC-Laundry* v. *U.S.,* 450 U.S.1, 6 (1981). Daimler's further argument that section 202(a)(3)(C) lead time provisions also apply to engine rebuilding because those provisions fall within the same paragraph would render the separate lead time provisions for engine rebuilding a virtual nullity. The sense of the provision is that Congress intended there to be independent lead time consideration for the distinct practice of engine rebuilding. In any case, as just explained, it is EPA's view that section 202(a)(3)(C) does not apply here.

(2) NHTSA Authority

The Energy Policy and Conservation Act (EPCA) of 1975 mandates a regulatory program for motor vehicle fuel economy to meet the various facets of the need to conserve energy. In December 2007, Congress enacted the Energy Independence and Security Act (EISA), amending EPCA to require, among other things, the creation of a medium- and heavy-duty fuel efficiency program for the first time.

Statutory authority for the fuel consumption standards in this final rule is found in EISA section 103, 49 U.S.C. 32902(k). This section authorizes a fuel efficiency improvement program, designed to achieve the maximum feasible improvement to be created for commercial medium- and heavy-duty on-highway vehicles and work trucks, to include appropriate test methods, measurement metrics, standards, and compliance and enforcement protocols that are appropriate, cost-effective and technologically feasible.

NHTSA has responsibility for fuel economy and consumption standards, and assures compliance with EISA through rulemaking, including standard-setting; technical reviews, audits and studies; investigations; and enforcement of implementing regulations including penalty actions. This rule continues to fulfill the requirements of section 103 of EISA, which instructs NHTSA to create a fuel efficiency improvement program for ''commercial medium- and heavy-duty on-highway vehicles and work trucks'' by rulemaking, which is to include standards, test methods, measurement metrics, and enforcement protocols. See 49 U.S.C. 32902(k)(2).

Congress directed that the standards, test methods, measurement metrics, and compliance and enforcement protocols be ''appropriate, cost-effective, and technologically feasible'' for the vehicles to be regulated, while achieving the ''maximum feasible improvement'' in fuel efficiency. NHTSA has broad discretion to balance the statutory factors in section 103 in developing fuel consumption standards to achieve the maximum feasible improvement.

As discussed in the Phase 1 final rule, NHTSA has determined that the five year statutory limit on average fuel economy standards that applies to passengers and light trucks is not applicable to the HD vehicle and engine standards. As a result, the Phase 1 HD engine and vehicle standards remain in effect indefinitely at their 2018 or 2019 MY levels until amended by a future rulemaking action. As was contemplated in that rule, NHTSA is finalizing a Phase 2 rulemaking action. Therefore, the Phase 1 standards will not remain in effect at their 2018 or 2019 MY levels indefinitely; they will remain in effect until the MY Phase 2 standards begin. In accordance with section 103 of EISA, NHTSA will ensure that not less than four full MYs of regulatory lead-time and three full MYs of regulatory stability are provided for in the Phase 2 standards.

With respect to the proposal, many stakeholders opined in their comments as to NHTSA's legal authority to issue the Phase 2 medium- and heavy-duty standards (Phase 2 standards), in whole or in part. NHTSA addresses these comments in the following discussion.

Allison Transmission, Inc. (Allison) questioned NHTSA's authority to issue the Phase 2 Standards. Allison stated that the Energy Independence and Security Act of 2007 (EISA)[96] directs NHTSA to undertake ''*a* rulemaking proceeding,'' (emphasis added) predicated on a study by the National Academy of Sciences (NAS). Allison and the Truck Trailer Manufacturers Association (TTMA) asserted that because NAS has published a study on medium- and heavy duty vehicles and NHTSA promulgated the Phase 1 medium- and heavy-duty vehicle standards (Phase 1 standards), NAS and NHTSA have fulfilled their statutory duties under EISA. Thus, Allison stated, NHTSA has no authority to issue standards beyond the Phase 1 standards.

NHTSA maintains that EISA allows the agency to promulgate medium- and heavy duty fuel efficiency standards beyond the Phase 1 standards. EISA states that NHTSA:[97]

> by regulation, shall determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel

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[95] Note, however, the Phase 2 GHG standards for tractors and vocational vehicles do not apply until MY 2021.

[96] Public Law 110–140, 121 Stat. 1492. (December 19, 2007).

[97] By delegation at 49 CFR 1.95(a). For purposes of this NPRM, grants of authority from EISA to the Secretary of Transportation regarding fuel efficiency will be referred to as grants of authority to NHTSA, as NHTSA has been delegated the authority to implement these programs.

> efficiency program designed to achieve the maximum feasible improvement, and shall adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols . . . for commercial medium- and heavy-duty on-highway vehicles and work trucks.[98]

Allison equates the process by which Congress specified NHTSA promulgate standards—a rulemaking proceeding—to mean a limitation or constraint on NHTSA's ability to create, amend, or update the medium- and heavy duty fuel efficiency program. NHTSA believes the charge in 49 U.S.C. 32902(k)(2) discusses ''a rulemaking proceeding'' only insofar as the statute specifies the process by which NHTSA would create a medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program and its associated standards.

Allison and TTMA commented that EISA only refers to an initial NAS study, meaning EISA only specified that NHTSA issue one set of standards based on that study. As NHTSA stated in the NPRM, EISA requires NAS to issue updates to the initial report every five years through 2025.[99] With that in mind, NAS issued an interim version of its first update to inform the Phase 2 NPRM. EISA's requirement that NAS update its initial report, which examines existing and potential fuel efficiency technologies that can practically be integrated into medium- and heavy-duty vehicles, is consistent with the conclusion that EISA intended the medium- and heavy-duty standards to function as part of an ongoing program[100] and not a single rulemaking.

Allison also noted that the language in EISA discussing lead time and stability refers to a single medium- and heavy-duty on-highway vehicle and work truck fuel economy standard.[101] NHTSA believes the language highlighted by Allison serves the purpose of noting that each medium- and heavy-duty segment standard included in its program shall have the requisite amount of lead-time and stability. As discussed in 49 U.S.C. 32902(k)(2), ''[t]he Secretary may prescribe separate standards for different classes of vehicles . . .'' Since NHTSA has elected to set standards for particular classes of vehicles, this language ensures each particular standard shall have the appropriate lead-time and stability required by EISA.

TTMA asserted that NHTSA has no more than 24 months from the completion of the NAS study to issue regulations related to the medium- and heavy-duty program and therefore regulations issued after 2013 ''lack congressional authorization.'' This argument significantly misinterprets the Congressional purpose of this provision. Section 32902(k)(2) requires that, 24 months after the completion of the NAS study, NHTSA begin implementing through a rulemaking proceeding a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement *program.* Congress therefore authorized NHTSA to implement through rulemaking a ''program,'' which the dictionary defines as ''a plan of things that are done in order to achieve a specific result.''[102] Contrary to TTMA's assertion, Congress did not limit NHTSA to the establishment of one set of regulations, nor did it in any way limit NHTSA's ability to update and revise this program. The purpose of the 24 month period was simply to ensure that NHTSA exercised this authority expeditiously after the NAS study, which NHTSA accomplished by implementing the first phase of its fuel efficiency program in 2011.[103] Today's rulemaking merely continues this program and clearly comports with the statutory language in 49 U.S.C. 32902(k). Further, the specific result sought by Congress in establishing the medium- and heavy-duty fuel efficiency program was a program focused on continuing fuel efficiency improvements. Specifically, Congress emphasized that the fuel efficiency program created by NHTSA be ''designed to achieve the maximum feasible improvement,'' allowing NHTSA to ensure the regulations implemented throughout the program encourage regulated entities to achieve the maximum feasible improvements. Congress did not limit, restrict, or otherwise suggest that the phrase ''designed to achieve the maximum feasible improvement'' be confined to the issuance of one set of standards. NHTSA actions are, therefore, clearly consistent with the authority conferred upon it in 49 U.S.C. 32902(k).

POP Diesel stated that the word ''fuel'' has not been defined by Congress, and therefore NHTSA should use its authority to define the term ''fuel'' as ''fossil fuel,'' allowing the agencies to assess fuel efficiency based on the carbon content of the fuels used in an engine or vehicle. Congress has already defined the term ''fuel'' in 49 U.S.C. 32901(a)(10) as gasoline, diesel oil, or other liquid or gaseous fuel that the Secretary decides to include. As Congress has already spoken to the definition of fuel, it would be inappropriate for the agency to redefine ''fuel'' as ''fossil fuel.''

Additionally, POP Diesel asserted that NHTSA's metric for measuring fuel efficiency is contrary to the mandate in EISA. Specifically, POP Diesel stated that many dictionaries define ''efficiency'' as a ratio of work performed to the amount of energy used, and NHTSA's load specific fuel consumption metric runs afoul of the plain meaning of statute the Phase 2 program implements. POP Diesel noted that Congressional debate surrounding what is now codified at 49 U.S.C. 32902(k)(2) included a discussion that envisioned NHTSA and EPA having separate regulations, despite having overlapping jurisdiction.

NHTSA continues to believe its use of load specific fuel consumption is an appropriate metric for assessing fuel efficiency as mandated by Congress. 49 U.S.C. 32902(k)(2) states, as POP Diesel noted, that NHTSA shall develop a medium- and heavy-duty fuel efficiency program. The section further states that NHTSA ''. . . shall adopt and implement appropriate test methods [and] measurement metrics . . . for commercial medium- and heavy-duty on-highway vehicles and work trucks.'' In the Phase 1 rulemaking, NHTSA, aided by the National Academies of Sciences (NAS) report, assessed potential metrics for evaluating fuel efficiency. NHTSA found that fuel economy would not be an appropriate metric for medium- and heavy-duty vehicles. Instead, NHTSA chose a metric that considers the amount of fuel consumed when moving a ton of freight (*i.e.,* performing work).[104] This metric, delegated by Congress to NHTSA to formulate, is not precluded by the text of the statute. It is a reasonable way by which to measure fuel efficiency for a program designed to reduce fuel consumption.

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[98] Public Law 110–140, 121 Stat. 1492, Section 108. Codified at 49 U.S.C. 32902(k)(2).

[99] 80 FR 40512 (July 13, 2015).

[100] ''. . . the Secretary . . . shall determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency program designed to achieve the maximum feasible improvement . . .'' 49 U.S.C. 42902(k)(2).

[101] 49 U.S.C. 32902(k)(3) states that, ''The commercial medium- and heavy-duty on-highway vehicle and work truck fuel economy standard adopted pursuant to this subsection shall provide not less than—(A) 4 full model years of regulatory lead-time; and (B) 3 full model years of regulatory stability.''

[102] ''Program.'' Merriam-Webster (2016 *http://www.merriam-webster.com/dictionary/program* (last accessed July 19, 2016).

[103] 76 FR 57016 (September 15, 2011).

[104] See: 75 FR 74180 (November 30, 2010).

(a) NHTSA's Authority To Regulate Trailers

As contemplated in the Phase 1 proposed and final rules, the agencies proposed standards for trailers in the Phase 2 rulemaking. Because Phase 1 did not include standards for trailers, NHTSA did not discuss its authority for regulating them in the proposed or final rules; that authority is described here.

NHTSA is finalizing fuel efficiency standards applicable to heavy-duty trailers as part of the Phase 2 program. NHTSA received several comments on the proposal relating to the agency's statutory authority to issue standards for trailers as part of the Phase 2 program. In particular, TTMA commented that NHTSA does not have the authority to regulate trailers as part of the medium- and heavy-duty standards. TTMA took issue with NHTSA's use of the National Traffic and Motor Vehicle Safety Act as an aid in defining an undefined term in EISA. Additionally, TTMA stated that EISA's use of GVWR instead of gross combination weight rating (GCWR) to define the vehicles subject to these regulations was intended to exclude trailers from the regulation.

As stated in the proposal, EISA directs NHTSA to ''determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement . . . .''[105] EISA defines a commercial medium- and heavy-duty on-highway vehicle to mean ''an on-highway vehicle with a GVWR of 10,000 lbs or more.'' A ''work truck'' is defined as a vehicle between 8,500 and 10,000 lbs GVWR that is not an MDPV. These definitions do not explicitly exclude trailers, in contrast to MDPVs. Because Congress did not act to exclude trailers when defining these terms by GVWRs, despite demonstrating the ability to exclude MDPVs, it is reasonable to interpret the provision to include them.

Both the tractor and the trailer are vehicles subject to regulation by NHTSA in the Phase 2 program. Although EISA does not define the term ''vehicle,'' NHTSA's authority to regulate motor vehicles under its organic statute, the Motor Vehicle Safety Act (''Safety Act''), does. The Safety Act defines a motor vehicle as ''a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways. . . .''[106] NHTSA clearly has authority to regulate trailers under this Act as they are vehicles that are drawn by mechanical power—in this instance, a tractor engine—and NHTSA has exercised that authority numerous times.[107] Given the absence of any apparent contrary intent on the part of Congress in EISA, NHTSA believes it is reasonable to interpret the term ''vehicle'' as used in the EISA definitions to have a similar meaning that includes trailers.

Additionally, it is worth noting that the dictionary definition of ''vehicle'' is ''a machine used to transport goods or persons from one location to another.''[108] A trailer is a machine designed for the purpose of transporting goods. With these foregoing considerations in mind, NHTSA interprets its authority to regulate commercial medium- and heavy-duty on-highway vehicles, including trailers.

TTMA pointed to language in the Phase 1 NPRM where the agencies stated that GCWR included the weight of a loaded trailer and the vehicle itself. TTMA interprets this language to mean that standards applicable to vehicles defined by GVWR must inherently exclude trailers. The language TTMA cited is a clarification from a footnote in an introductory section describing the heavy-duty trucking industry. This statement was not a statement of NHTSA's legal authority over medium- and heavy-duty vehicles. NHTSA continues to believe a trailer is a vehicle under EISA if its GVWR fits within the definitions in 49 U.S.C. 32901(a), and is therefore subject to NHTSA's applicable fuel efficiency regulations.

Finally, in a comment on the Notice of Data Availability, TTMA stated that because NHTSA's statutory authority instructs the agency to develop a fuel efficiency program for medium- and heavy-duty on-highway vehicles, and trailers themselves do not consume fuel, trailers cannot be regulated for fuel efficiency. The agency disagrees with this assertion. A tractor-trailer is designed for the purpose of holding and transporting goods. While heavy-duty trailers themselves do not consume fuel, they are immobile and inoperative without a tractor providing motive power. Inherently, trailers are designed to be pulled by a tractor, which in turn affects the fuel efficiency of the tractor-trailer as a whole. As previously discussed, both a tractor and trailer are motor vehicles under NHTSA's authority. Therefore it is reasonable to consider all of a tractor-trailer's parts—the engine, the cab-chassis, and the trailer—as parts of a whole. As such they are all parts of a vehicle, and are captured within the scope of NHTSA's statutory authority. As EPA describes above, the tractor and trailer are both incomplete without the other. Neither can fulfill the function of the vehicle without the other. For this reason, and the other reasons stated above, NHTSA interprets its authority to regulate commercial medium- and heavy-duty on-highway vehicles, including tractor-trailers, as encompassing both tractors and trailers.

(b) NHTSA's Authority To Regulate Recreational Vehicles

NHTSA did not regulate recreational vehicles as part of the Phase 1 medium- and heavy-duty fuel efficiency standards, although EPA did regulate them as vocational vehicles for GHG emissions. In the Phase 1 NPRM, NHTSA interpreted ''commercial medium- and heavy duty on-road vehicle'' to mean that recreational vehicles, such as motor homes, were not to be included within the program because recreational vehicles are not commercial. Following comments to the Phase 1 proposal, NHTSA reevaluated its statutory authority and proposed that recreational vehicles be included in the Phase 2 standards, and that early compliance be allowed for manufacturers who want to certify during the Phase 1 period.

The Recreational Vehicle Industry Association (RVIA) and Newell Coach Corporation (Newell) asserted that NHTSA does not have the authority to regulate recreational vehicles (RVs). RVIA and Newell stated that NHTSA's authority under EISA is limited to commercial medium- and heavy-duty vehicles and that RVs are not commercial. RVIA pointed to the fact that EISA gives NHTSA fuel efficiency authority over ''commercial medium- and heavy-duty vehicles'' and ''work trucks,'' the latter of which is not prefaced with the word ''commercial.'' Because of this difference, RVIA argued that NHTSA is ignoring a limitation on its authority—that is, that NHTSA only has authority over medium- and heavy-duty vehicles that are commercial in nature. RVIA stated that RVs are not used for commercial purposes, and are therefore not subject to Phase 2.

NHTSA's authority to regulate medium- and heavy-duty vehicles under EISA extends to ''commercial medium- and heavy-duty on-highway vehicles''

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[105] 49 U.S.C. 42902(k)(2).

[106] 49 U.S.C. 30102(a)(6).

[107] See, *e.g.,* 49 CFR 571.106 (Standard No. 106; Brake hoses); 49 CFR 571.108 (Standard No. 108; Lamps, reflective devices, and associated equipment); 49 CFR 571.121 (Standard No. 121; Air brake systems); 49 CFR 571.223 (Standard No. 223; Rear impact guards).

[108] ''Vehicle.'' Merriam-Webster (2016). *http://www.merriam-webster.com/dictionary/vehicle* (last accessed May 20, 2016).

and ''work truck[s].'' [109] If terms in the statute are defined, NHTSA must apply those definitions. Both terms highlighted by RVIA have been defined in EISA, therefore, NHTSA will use their defined meanings. ''Work truck'' means a vehicle that is rated between 8,500 and 10,000 pounds GVWR and is not an MDPV.[110] ''Commercial medium- and heavy-duty on-road highway vehicle'' means an on-highway vehicle with a gross vehicle weight rating (GVWR) of 10,000 pounds or more.[111] Based on the definitions in EISA, recreational vehicles would be regulated as class 2b–8 vocational vehicles. Neither statutory definition requires that those vehicles encompassed be commercial in nature, instead dividing the medium- and heavy-duty segments based on weight. The definitions of ''work truck'' and ''commercial medium- and heavy-duty on-highway vehicles'' collectively encompass the on-highway motor vehicles not covered in the light duty CAFE standards.

RVIA further stated that NHTSA's current fuel efficiency regulations are not consistent with EISA and do not purport to grant NHTSA authority to regulate vehicles simply based on weight. NHTSA's regulations at 49 CFR 523.6 define, by cross-reference the language in 49 U.S.C. 32901(a)(7) and (19), and consistent with the discussion above, include recreational vehicles.

Finally, NHTSA notes that excluding recreational vehicles in Phase 2 could create illogical results, including treating similar vehicles differently, as determinations over whether a given vehicle would be covered by the program would be based upon either its intended or actual use, rather than the actual characteristics of the vehicle. Moreover, including recreational vehicles under NHTSA regulations furthers the agencies' goal of one national program, as EPA regulations will continue to regulate recreational vehicles. NHTSA will allow early compliance for manufacturers that want to certify during the Phase 1 period.

F. Other Issues

In addition to establishing new Phase 2 standards, this document addresses several other issues related to those standards. The agencies are adopting some regulatory provisions related to the Phase 1 program, as well as amendments related to other EPA and NHTSA regulations. These other issues are summarized briefly here and discussed in greater detail in later sections.

(1) Opportunities for Further Oxides of Nitrogen (NO_X) Reductions From Heavy-Duty On-Highway Engines and Vehicles

The EPA has the authority under section 202 of the Clean Air Act to establish, and from time to time revise, emission standards for certain air pollutants emitted from heavy-duty on-highway engines and vehicles. The emission standards that EPA has developed for heavy-duty on-highway engines have become progressively more stringent over the past 40 years, with the most recent NO_X standards for new heavy-duty on-highway engines fully phased in with the 2010 model year. NO_X emissions standards for heavy-duty on-highway engines have contributed significantly to the overall reduction in the national NO_X emissions inventory. Nevertheless, a need for additional NO_X reductions remains, particularly in areas of the country with elevated levels of air pollution. As discussed further below, in response to EPA's responsibilities under the Clean Air Act, the significant comments we received on this topic during the public comment period, the recent publication by the California Air Resources Board (CARB) of its May 2016 Mobile Source Strategy report and Proposed 2016 Strategy for the State implementation Plan [112] and a recent Petition for Rulemaking,[113] EPA plans to further engage with stakeholders after the publication of this Final Rule to discuss the opportunities for developing more stringent federal standards to further reduce the level of NO_X emissions from heavy-duty on-highway engines through a coordinated effort with CARB.

NO_X is one of the major precursors of tropospheric ozone (ozone), exposure to which is associated with a number of adverse respiratory and cardiovascular effects, as described in Section VIII.A.2 below. These effects are particularly pronounced among children, the elderly, and among people with lung disease such as asthma. NO_X is also a major contributor to secondary $PM_{2.5}$ formation, and exposure to $PM_{2.5}$ itself has been linked to a number of adverse health effects (see Section VIII.A.1), such as heart attacks and premature mortality. In addition, NO_2 exposure is linked to asthma exacerbation and possibly to asthma development in children (see Section VIII.A.3). EPA has already adopted many emission control programs that are expected to reduce ambient ozone levels. However, the U.S. Energy Information Administration's AEO 2015 predicts that vehicles miles travelled (VMT) for heavy-duty trucks will increase in the coming years,[114] and even with the implementation of all current state and federal regulations, some of the most populous counties in the United States are expected to have ozone air quality that exceeds the National Ambient Air Quality Standards (NAAQS) into the future. As of April 22, 2016, there were 44 ozone nonattainment areas for the 2008 ozone NAAQS composed of 216 full or partial counties, with a population of more than 120 million. These nonattainment areas are dispersed across the country, with counties in the west, northeastern United States, Texas, and several Great Lakes states. The geographic diversity of this problem necessitates action at the national level. In California, the San Joaquin Valley and the South Coast Air Basin are highly-populated areas classified as ''extreme nonattainment'' for the 2008 8-hour ozone standard, with an attainment demonstration deadline of 2031 (one year in advance of the actual 2032 attainment date). In addition, EPA lowered the level of the primary and secondary NAAQS for the 8-hour standards from 75 ppb to 70 ppb in 2015 (2015 ozone NAAQS),[115] with plans to finalize nonattainment designations for the 2015 ozone NAAQS in October 2017. Further NO_X reductions would provide reductions in ambient ozone levels, helping to prevent adverse health impacts associated with ozone exposure and assisting states and local areas in attaining and maintaining the applicable ozone NAAQS. Reductions in NO_X emissions would also improve air quality and provide

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[109] 49 U.S.C. 42902(k)(2).

[110] 49 U.S.C. 42901(a)(19).

[111] 49 U.S.C. 42901(a)(7).

[112] See ''Mobile Source Strategy,'' May 16, 2016 from CARB. Available at: *http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.htm* and ''Proposed 2016 State Strategy for the State Implementation Plan,'' May 17, 2016 from CARB. Available at *http://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm.*

[113] EPA received a Petition for Rulemaking to adopt new NO_X emission standards for on-road heavy-duty trucks and engines on June 3, 2016 from the South Coast Air Quality Management District, the Arizona Pima County Department of Environmental Quality, the Bay Area Air Quality Management District, the Connecticut Department of Energy and Environmental Protection Agency, the Delaware Department of Energy and Environmental Protection, the Nevada Washoe County Health District, the New Hampshire Department of Environmental Services, the New York City Department of Environmental Protection, the Akron Regional Air Quality Management District of Akron, Ohio, the Washington State Department of Ecology, and the Puget Sound Clean Air Agency.

[114] US Energy Information Administration. Annual Energy Outlook 2015. April 2015. Page E–8. *http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.*

[115] 80 FR 65292 (Oct. 26, 2015).

public health and welfare benefits throughout the country by (1) reducing PM formed by reactions of NO_X in the atmosphere; (2) reducing concentrations of the criteria pollutant NO_2; (3) reducing nitrogen deposition to sensitive environments; and (4) improving visibility.

In the past year, EPA has received requests from several state and local air quality districts and other organizations asking that EPA establish more stringent NO_X standards for heavy-duty on-highway engines to help reduce the public's exposure to air pollution. In its comments, CARB estimated that heavy-duty on-highway vehicles currently contribute about one-third of all NO_X emissions in California. In order to achieve the 2008 ozone NAAQS, California has estimated that the state's South Coast Air Basin will need an 80 percent reduction in NO_X emissions by 2031. California has the unique ability among states to adopt its own separate new motor engine and vehicle emission standards under section 209 of the CAA; however, CARB commented that EPA action to establish a new federal low-NO_X standard for heavy-duty trucks is critical, since California standards alone are not sufficient to demonstrate compliance with either the 2008 ozone NAAQS or the 2015, even more stringent ozone NAAQS. CARB has developed a comprehensive mobile source strategy which for heavy-duty on-highway vehicles includes: Lowering the emissions from the in-use fleet; establishing more stringent NO_X standards for new engines; and accelerating the deployment of zero and near-zero emissions technology.[116] In September of 2015, CARB published a draft of this strategy, *Mobile Source Strategy Discussion Draft,* after which CARB held a public workshop and provided opportunity for public comment. On May 16, 2016, CARB issued a final *Mobile Source Strategy* report.[117] In this report, CARB provides a comprehensive strategy plan for the future of mobile sources and goods movement in the State of California for how mobile sources in California can meet air quality and climate goals over the next fifteen years. Among the many programs discussed are plans for a future on-highway heavy-duty engine and vehicle NO_X control regulatory program for new products with implementation beginning in 2024. CARB states ''*The need for timely action by U.S. EPA to establish more stringent engine performance standards in collaboration with California efforts is essential. About 60 percent of total heavy-duty truck VMT in the South Coast on any given day is accrued by trucks purchased outside of California, and are exempt from California standards. U.S. EPA action to establish a federal low-*NO_X *standard for trucks is critical.*'' CARB lays out a time line for a California specific action for new highway heavy-duty NO_X standards with CARB action in 2017–2019 that would lead to new standards that could begin with the model year 2023. CARB also requests that the U.S. EPA work on a Federal rulemaking action in the 2017–2019 time frame which could result in standards that could begin with the model year 2024. The CARB Mobile Source Strategy document also states ''Due to the preponderance of interstate trucking's contribution to in-state VMT, federal action would be far more effective at reducing in-state emissions than a California-only standard. However, California is prepared to develop a California-only standard, if needed, to meet federal attainment targets.'' CARB goes on to state ''[C]ARB will begin development of new heavy-duty low NO_X emission standard in 2017 with Board action expected in 2019. ARB may also petition U.S. EPA in 2016 to establish new federal heavy-duty engine emission standards . . . . If U.S. EPA begins the regulatory development process for a new federal heavy-duty emission standard by 2017, ARB will coordinate its regulatory development efforts with the federal regulation.'' On May 17, 2016, CARB published its ''Proposed 2016 State Strategy for the State Implementation Plan.''[118] This document contains CARB staff's proposed strategy to attain the health-based federal air quality standards over the next fifteen years. With respect to future on-highway heavy-duty NO_X standards, the proposed State Implementation Plan is fully consistent with the information published by CARB in the Mobile Source Strategy report. EPA intends to work with CARB to consider the development of a new harmonized Federal and California program that would apply lower NO_X emissions standards at the national level to heavy-duty on-highway engines and vehicles.

In addition to CARB, EPA received compelling letters and comments from the National Association of Clean Air Agencies, the Northeast States for Coordinated Air Use Management, the Ozone Transport Commission, and the South Coast Air Quality Management District explaining the critical and urgent need to reduce NO_X emissions that significantly contribute to ozone and fine particulate air quality problems in their represented areas. The comments describe the challenges many areas face in meeting both the 2008 and recently strengthened 2015 ozone NAAQS. These organizations point to the significant contribution of heavy-duty vehicles to NO_X emissions in their areas, and call upon EPA to begin a rulemaking to require further NO_X controls for the heavy-duty sector as soon as possible. Commenters such as the American Lung Association, Environmental Defense Fund, Union of Concerned Scientists, the California Interfaith Power and Light, Coalition for Clean Air/California Cleaner Freight Coalition, and the Moving Forward Network similarly describe the air quality and public health need for NO_X reductions and request EPA to lower NO_X emissions standards for heavy-duty vehicles. Taken as a whole, the numerous comments, the expected increase in heavy-duty truck VMT, and the fact that ozone challenges will remain across the country demonstrate the critical need for more stringent nationwide NO_X emissions standards. Such standards are vital to improving air quality nationwide and reducing public health effects associated with exposure to ozone and secondary $PM_{2.5}$, especially for vulnerable populations and in highly impacted regions.

On June 3, 2016, the EPA received a Petition for Rulemaking from the South Coast Air Quality Management District (California), the Pima County Department of Environmental Quality (Arizona), the Bay Area Air Quality Management District (California), the Connecticut Department of Energy and Environmental Protection Agency, the Delaware Department of Energy and Environmental Protection, the Washoe County Health District (Nevada), the New Hampshire Department of Environmental Services, the New York City Department of Environmental Protection, the Akron Regional Air Quality Management District (Ohio), the Washington State Department of Ecology, and the Puget Sound Clean Air

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[116] To foster the development of the next generation of lower NO_X engines, in 2013, CARB adopted optional low-NO_X heavy-duty engine standards ranging from 0.10 down to 0.02 grams per brake horsepower-hour (g/bhp-hr). CARB also funded over $1 million to a low-$NO_X$ engine research and demonstration project at Southwest Research Institute (SwRI).

[117] See ''Mobile Source Strategy,'' May 16, 2016 from CARB. Available at: *http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.htm.*

[118] See ''Proposed 2016 State Strategy for the State Implementation Plan,'' May 17, 2016 from CARB. Available at *http://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm.*

Agency (Washington).[119] [120] In a June 15, 2016 letter to EPA, the Commonwealth of Massachusetts also joined this petition. On June 22, 2016, the San Joaquin Valley Air Pollution Control District (California) also submitted a petition for rulemaking to EPA.[121] In these Petitions, the Petitioners request that EPA establish a new, lower NO_X emission standard for on-road heavy-duty engines. The Petitioners request that EPA implement a new standard by January 1, 2022, and that EPA establish this new standard through a Final Rulemaking issued by December 31, 2017. EPA is not formally responding to this Petition in this Final Rule, but we will do so in a future action. In the petitions, the Petitioners include a detailed discussion of their views and underlying data regarding the need for large scale reduction in NO_X emissions from heavy-duty engines, why they believe new standards can be achieved, and their legal views on EPA's responsibilities under the Clean Air Act.

Since the establishment of the current heavy-duty on-highway standards in January of 2001,[122] there has been continued progress in emissions control technology. EPA and CARB are currently investing in research to evaluate opportunities for further NO_X reductions from heavy-duty on-highway vehicles and engines. Programs and research underway at CARB, as well as a significant body of work in the technical literature, indicate that reducing NO_X emissions significantly below the current on-highway standard of 0.20 grams per brake horsepower-hour (g/bhp-hr) is potentially feasible.[123] [124] Opportunities for additional NO_X reductions include reducing emissions over cold start operation as well as low-speed, low-load off-cycle operation. Reductions are being accomplished through the use of improved engine management, advanced aftertreatment technologies (improvements in SCR catalyst design/formulation), catalyst positioning, aftertreatment thermal management, and heated diesel exhaust fluid dosing. At the same time, the effect of these new technologies on cost and GHG emissions is being carefully evaluated,[124] since it is important that any future NO_X control technologies be considered in the context of the final Phase 2 GHG standards. During the Phase 2 program public comment period, EPA received some comments stressing the need for careful evaluation of emerging NO_X control technologies and urging EPA to consider the relationship between CO_2 and NO_X before setting lower NO_X standards (commenters include American Trucking Association, Caterpillar, Daimler Trucks North America, Navistar Inc., PACCAR Inc., Volvo Group, Truck and Engine Manufacturers Association, Diesel Technology Forum, National Association of Manufacturers, and National Automobile Dealers Association). EPA also received comments pointing to advances in NO_X emission control technologies that would lower NO_X without reducing engine efficiency (commenters include Advanced Engine Systems Institute, Clean Energy, Manufacturers of Emission Controls Association, and Union of Concerned Scientists). EPA will continue to evaluate both opportunities and challenges associated with lowering NO_X emissions from the current standards, and over the coming months we intend to engage with many stakeholders as we develop our response to the June 2016 Petitions for Rulemaking discussed above.

EPA believes the opportunity exists to develop, in close coordination with CARB and other stakeholders, a new, harmonized national NO_X reduction strategy for heavy-duty on-highway engines which could include the following:

- Substantially lower NO_X emission standards;
- Improvements to emissions warranties;
- Consideration of longer useful life, reflecting actual in-use activity;
- Consideration of rebuilding/remanufacturing practices;
- Updated certification and in-use testing protocols;
- Incentives to encourage the transition to next-generation cleaner technologies as soon as possible;
- Improvements to test procedures and test cycles to ensure emission reductions occur in the real-world, not only over the applicable certification test cycles.

Based on the air quality need, the requests described above, the continued progress in emissions control technology, and the June 2016 petitions for rulemaking, EPA plans to engage with a range of stakeholders to discuss the opportunities for developing more stringent federal standards to further reduce the level of NO_X emissions from heavy-duty on-highway engines, after the publication of this Final Rule. Recognizing the benefits of a nationally harmonized program and given California's unique ability under CAA section 209 to be allowed to regulate new motor vehicle and engine emission standards if certain criteria are met, EPA intends to work closely with CARB on this effort. EPA also intends to engage with truck and engine manufacturers, suppliers, state air quality agencies, NGOs, labor, the trucking industry, and the Petitioners over the next several months as we develop our formal response to the June 2016 Petitions for Rulemaking.

(2) Issues Related to Phase 2

(a) Natural Gas Engines and Vehicles

This combined rulemaking by EPA and NHTSA is designed to regulate two separate characteristics of heavy duty vehicles and engines: GHGs and fuel consumption. In the case of diesel or gasoline powered vehicles, there is a one-to-one relationship between these two characteristics. For alternatively fueled vehicles, which use no petroleum, the situation is different. For example, a natural gas vehicle that achieves approximately the same fuel efficiency as a diesel powered vehicle will emit 20 percent less CO_2; and a natural gas vehicle with the same fuel efficiency as a gasoline vehicle will emit 30 percent less CO_2. Yet natural gas vehicles consume no petroleum. The agencies are continuing Phase 1 approach, which the agencies have previously concluded balances these facts by applying the gasoline and diesel CO_2 standards to natural gas engines based on the engine type of the natural gas engine. Fuel consumption for these vehicles is then calculated according to their tailpipe CO_2 emissions. In essence, this applies a one-to-one relationship between fuel efficiency and tailpipe CO_2 emissions for all vehicles, including natural gas vehicles. The agencies determined that this approach will likely create a small balanced incentive for natural gas use. In other words, it created a small incentive for the use of natural gas engines that appropriately balanced concerns about the climate impact methane emissions against other factors such as the energy security

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[119] *http://4cleanair.org/sites/default/files/resources/HD_Ultra-Low-NO$_X$_Petition_to_EPA-060316.pdf.*

[120] *http://4cleanair.org/sites/default/files/resources/Petition_Attachments-Ultra-Low-NO$_X$_Petition_to_EPA-060316_0.pdf.*

[121] *http://www.valleyair.org/recent_news/Media_releases/2016/PR-District-Petitions-Federal-Government-06-22-16.pdf.*

[122] 66 FR 5002 (January 18, 2001).

[123] See CARB's September 2015 *Draft Technology Assessment: Lower NO_X Heavy-Duty Diesel Engines,* and *Draft Technology Assessment: Low Emission Natural Gas and Other Alternative Fuel Heavy-Duty Engines.*

[124] *http://www.arb.ca.gov/research/veh-emissions/low-nox/low-nox.htm*, 4/26/16. This low NO_X study is in the process of selecting the emission reduction systems for final testing and it is expected that this demonstration program will be complete by the end of 2016.

benefits of using domestic natural gas. See 76 FR 57123.

(b) Alternative Refrigerants

In addition to use of low-leak components in air conditioning system design, manufacturers can also decrease the global warming impact of any refrigerant leakage emissions by adopting systems that use alternative, lower global warming potential (GWP) refrigerants, to replace the refrigerant most commonly used today, HFC–134a (R–134a). HFC–134a is a potent greenhouse gas with a GWP 1,430 times greater than that of CO_2.

Under EPA's Significant New Alternatives Policy (SNAP) Program,[125] EPA has found acceptable, subject to use conditions, three alternative refrigerants that have significantly lower GWPs than HFC–134a for use in A/C systems in newly manufactured *light-duty vehicles:* HFC–152a, CO_2 (R–744), and HFO–1234yf.[126] HFC–152a has a GWP of 124, HFO–1234yf has a GWP of 4, and CO_2 (by definition) has a GWP of 1, as compared to HFC–134a which has a GWP of 1,430.[127] CO_2 is nonflammable, while HFO–1234yf and HFC–152a are flammable. All three are subject to use conditions requiring labeling and the use of unique fittings, and where appropriate, mitigating flammability and toxicity. Currently, the SNAP listing for HFO–1234yf is limited to newly manufactured A/C systems in light-duty vehicles, whereas HFC–152a and CO_2 have been found acceptable for all motor vehicle air conditioning applications, including heavy-duty vehicles.

None of these alternative refrigerants can simply be ''dropped'' into existing HFC–134a air conditioning systems. In order to account for the unique properties of each refrigerant and address use conditions required under SNAP, changes to the systems will be necessary. Typically these changes will need to occur during a vehicle redesign cycle but can also occur during a refresh. For example, because CO_2, when used as a refrigerant, is physically and thermodynamically very different from HFC–134a and operates at much higher pressures, a transition to this refrigerant would require significant hardware changes. A transition to A/C systems designed for HFO–1234yf, which is more thermodynamically similar to HFC–134a than is CO_2, requires less significant hardware changes that typically include installation of a thermal expansion valve and can potentially require resized condensers and evaporators, as well as changes in other components. In addition, vehicle assembly plants require re-tooling in order to handle new refrigerants safely. Thus a change in A/C refrigerants requires significant engineering, planning, and manufacturing investments.

EPA is not aware of any significant development of A/C systems designed to use alternative refrigerants in heavy-duty vehicles.[128] However, all three lower GWP alternatives are in use or under various stages of development for use in LD vehicles. Of these three refrigerants, most manufacturers of LD vehicles have identified HFO–1234yf as the most likely refrigerant to be used in that application. For that reason, EPA anticipates that HFO–1234yf will be a primary candidate for refrigerant substitution in the HD market in the future if it is listed as an acceptable substitute under SNAP for HD A/C applications.

As mentioned above, EPA has listed as acceptable, subject to use conditions, two lower-GWP refrigerants, R–744 (CO_2) and HFC–152a, for use in HD vehicles. On April 18, 2016, EPA also proposed to list HFO–1234yf as acceptable, subject to use conditions, in A/C systems for newly manufactured MDPVs, HD pickup trucks, and complete HD vans (81 FR 22810). In that action, EPA proposed to list HFO–1234yf as acceptable, subject to use conditions, for those vehicle types for which human health and environmental risk could be assessed using the currently available risk assessments and analysis on LD vehicles. Also in that action, EPA requested ''information on development of HFO–1234yf MVAC systems for other HD vehicle types or off-road vehicles, or plans to develop these systems in the future.'' EPA also stated ''This information may be used to inform a future listing'' (81 FR 22868).

In another rulemaking action under the SNAP program, on July 20, 2015, EPA published a final rule (80 FR 42870) that will change the listing status of HFC–134a to unacceptable for use in newly manufactured LD motor vehicles beginning in MY 2021 (except as allowed under a narrowed use limit for use in newly manufactured LD vehicles destined for use in countries that do not have infrastructure in place for servicing with other acceptable refrigerants through MY 2025). In that same rule, EPA listed the refrigerant blends SP34E, R–426A, R–416A, R–406A, R–414A, R–414B, HCFC Blend Delta, Freeze 12, GHG–X5, and HCFC Blend Lambda as unacceptable for use in newly manufactured light-duty vehicles beginning in MY 2017. EPA's decisions were based on the availability of other substitutes that pose less overall risk to human health and the environment, when used in accordance with required use conditions. Neither the April 2016 proposed rule nor the July 2015 final rule consider a change of listing status for HFC–134a in HD vehicles.

LD vehicle manufacturers are currently making investments in systems designed for lower-GWP refrigerants, both domestically and on a global basis. In support of the LD GHG rule, EPA projected a full transition of LD vehicles to lower-GWP alternatives in the United States by MY 2021. We expect the costs of transitioning to decrease over time as alternative refrigerants are adopted across all LD vehicles and trucks, in part due to increased availability of components and the continuing increases in refrigerant production capacity, as well as knowledge gained through experience. As lower-GWP alternatives become widely used in LD vehicles, some HD vehicle manufacturers may wish to also transition their vehicles. Transitioning could be advantageous for a variety of reasons, including platform standardization and company environmental stewardship policies.

In the proposal for this Phase 2 HD rule, EPA proposed another action related to alternative refrigerants. EPA proposed to allow a manufacturer to be ''deemed to comply'' with the leakage standard if its A/C system used a refrigerant other than HFC–134a that was both listed as an acceptable substitute refrigerant for heavy-duty A/C systems under SNAP, and was identified in the LD GHG regulations at 40 CFR 86.1867–12(e). 80 FR 40172. By slightly reducing the regulatory burden of compliance with the leakage standard for a manufacturer that used an alternative refrigerant, the ''deemed to comply'' provision was intended to provide a modest incentive for the use of such refrigerants. There were comments in support of this approach,

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[125] Section 612(c) of the Clean Air Act requires EPA to review substitutes for class I and class II ozone-depleting substances and to determine whether such substitutes pose lower risk than other available alternatives. EPA is also required to publish lists of substitutes that it determines are acceptable and those it determines are unacceptable. See *http://www3.epa.gov/ozone/snap/refrigerants/lists/index.html*, last accessed on March 5, 2015.

[126] Listed at 40 CFR part 82, subpart G.

[127] GWP values cited in this final action are from the IPCC Fourth Assessment Report (AR4) unless stated otherwise. Where no GWP is listed in AR4, GWP values are determined consistent with the calculations and analysis presented in AR4 and referenced materials.

[128] To the extent that some manufacturers produce HD pickups and vans on the same production lines or in the same facilities as LD vehicles, some A/C system technology commonality between the two vehicle classes may be developing.

including from Honeywell and Chemours, both of which manufacture HFO–1234yf.

For several reasons, EPA has reconsidered the proposed ''deemed to comply'' provision for this rule, and instead, the Phase 2 program retains the Phase 1 requirement that manufacturers attest that they are using low-leak components, regardless of the refrigerant they use. CARB and several NGO commenters expressed concerns about the proposed ''deemed to comply'' provision, primarily citing the potential for manufacturers to revert to less leak-tight components if they were no longer required to attest to the use of low-leak A/C system components because they used a lower-GWP refrigerant. In general, we expect that the progress LD vehicle manufacturers are making toward more leak-tight A/C systems will continue and that this progress will transfer to HD A/C systems. Still, we agree that continued improvements in low-leak performance HD vehicles is an important goal, and that continuing the Phase 1 leakage requirements in the Phase 2 program should discourage manufacturers from reverting to higher-leak and potentially less expensive components. It is also important to note that there is no ''deemed to comply'' option in the parallel LD–GHG program—manufacturers must attest to meeting the leakage standard. There is no compelling reason to have a different regime for heavy duty applications.

Although leakage of lower-GWP refrigerants is of less concern from a climate perspective than leakage of higher GWP refrigerants, we also agree with several commenters that expressed a concern related to the servicing of lower-GWP systems with higher-GWP refrigerants in the aftermarket. We agree that this could result due to factors such as price differentials between aftermarket refrigerants. However, as is the case for Phase 1, as a part of certification, HD manufacturers will attest both to the use of low-leak components as well as to the specific refrigerant used. Thus, in the future, a manufacturer wishing to certify a vehicle with an A/C system designed for an alternative refrigerant will attest to the use of that specific refrigerant. In that situation, any end-user servicing and recharging that A/C system with any other refrigerant would be considered tampering with an emission-related component under Title II of the CAA. For example, recharging an A/C system certified to use a lower-GWP refrigerant, such as HFO–1234yf, with any other refrigerant, including but not limited to HFC–134a, would be considered a violation of Title II tampering provisions.

At the same time, EPA does not believe that finalizing the ''deemed to comply'' provision would have had an impact on any future transition of the HD industry to alternative refrigerants. As discussed above, two lower-GWP refrigerants are already acceptable for use in HD vehicles, and EPA has proposed to list HFO–1234yf as acceptable, subject to use conditions, for limited HD vehicle types. As also discussed above, and especially in light of the rapid expansion of alternative refrigerants that has been occurring in the LD vehicle market, similar trends may develop in the HD vehicle market, regardless of EPA's action regarding leakage of alternative refrigerants in this final rule.

(c) Small Business Issues

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. See generally 5 U.S.C. 601–612. The RFA analysis is discussed in Section XIV.

Pursuant to section 609(b) of the RFA, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), EPA also conducted outreach to small entities and convened a Small Business Advocacy Review Panel to obtain advice and recommendations of representatives of the small entities that potentially will be subject to the rule's requirements. Consistent with the RFA/SBREFA requirements, the Panel evaluated the assembled materials and small-entity comments on issues related to elements of the Initial Regulatory Flexibility Analysis (IRFA). A copy of the Panel Report was included in the docket for this rule.

The agencies previously determined that the Phase 2 regulations could potentially have a significant economic impact on small entities. Specifically, the agencies identified four categories of directly regulated small businesses that could be impacted:

- Trailer Manufacturers
- Alternative Fuel Converters
- Vocational Chassis Manufacturers
- Glider Vehicle[129] Assemblers

To minimize these impacts the agencies are adopting certain regulatory flexibilities—both general and category-specific. In general, we are delaying new requirements for EPA GHG emission standards by one initial year and simplifying certification requirements for small businesses. Even with this one year delay, small businesses will be required to comply with EPA's standards before NHTSA's fuel efficiency standards are mandatory. Because of this timing, compliance with NHTSA's regulations will not be delayed, as small business manufacturers will be accommodated through EPA's initial one year delay. The agencies are also providing the following specific relief:

- *Trailers:* Adopting simpler requirements for non-box trailers, which are more likely to be manufactured by small businesses; reduced reliance on emission averaging; and making third-party testing easier for certification.
- *Alternative Fuel Converters:* Omitting recertification of a converted vehicle when the engine is converted and certified; reduced N_2O testing; and simplified onboard diagnostics and delaying required compliance with each new standard by one model year.
- *Vocational Chassis:* Less stringent standards for certain vehicle categories; opportunity to generate credits under the Phase 1 program.
- *Glider Vehicle Assemblers:*[130] Exempting existing small businesses, but limiting the small business exemption to a capped level of annual production (production in excess of the capped amount will be allowed, but subject to all otherwise applicable requirements including the Phase 2 standards). Providing additional flexibility for newer engines.

These flexibilities are described in more detail in Section XIV, in RIA Section 12 and in the Panel Report. Flexibilities specific to glider vehicle assemblers are described in Section XIII.

(d) Confidentiality of Test Results and GEM Inputs

The agencies received mixed comments regarding the question of whether GEM inputs should be made available to public. Some commenters supported making this information available, while others thought it should

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[129] Vehicles produced by installing a used engine into a new chassis are commonly referred to as ''gliders,'' ''glider kits,'' or ''glider vehicles.'' See Section I.E.i and XIII.B.

[130] EPA is amending its rules applicable to engines installed in glider kits, which will affect emission standards not only for GHGs but for criteria pollutants as well. EPA is also clarifying its requirements for certification and revising its definitions for glider kit and glider vehicle manufacturers. NHTSA is not including glider vehicles under its Phase 2 fuel consumption standards. See Section XIII.B.

be protected as confidential business information (CBI). In accordance with Federal statutes, EPA does not release information from certification applications (or other compliance reports) that we determine to be CBI under 40 CFR part 2. Consistent with section 114(c) of the CAA, EPA does not consider emission test results to be CBI after introduction into commerce of the certified engine or vehicle. (However, we have generally treated test results as protected before the introduction into commerce date). EPA has not yet made a final determination for Phase 1 or Phase 2 certification test results. Nevertheless, at this time we expect to continue this policy and consider it likely that we would not treat any test results or other GEM inputs as CBI after the introduction into commerce date as identified by the manufacturer.

With regard to NHTSA's treatment of confidential business information, manufacturers must submit a request for confidentiality with each electronic submission specifying any part of the information or data in a report that it believes should be withheld from public disclosure as trade secret or other confidential business information. A form is available through the NHTSA Web site to request confidentiality. NHTSA does not consider manufacturers to continue to have a business case for protecting pre-model report data after the vehicles contained within that report have been introduced into commerce.

(e) Delegated Assembly and Secondary Manufacturers

In EPA's existing regulations (40 CFR 1068.261), we allow engine manufacturers to sell or ship engines that are missing certain emission-related components if those components will be installed by the vehicle manufacturer. These provisions already apply to Phase 1 vehicles as well, providing a similar allowance for *vehicle* manufacturers to sell or ship *vehicles* that are missing certain emission-related components if those components will be installed by a *secondary* vehicle manufacturer. See section 1037.620. EPA has found this provision to work well and is finalizing certain amendments in this rule. See 40 CFR 1037.621. Under the amended rule, as conditions of this allowance, manufacturers will be required to:

- Have a contractual obligation with the secondary manufacturer to complete the assembly properly and provide instructions about how to do so
- Keep records to demonstrate compliance
- Apply a temporary label to the incomplete vehicles
- Take other reasonable steps to ensure the assembly is completed properly
- Describe in its application for certification how it will use this allowance

Under delegated assembly, it is the upstream manufacturer that holds the certificate and assumes primary responsibility for all compliance requirements. Our experience applying this approach has shown that holding the upstream manufacturer responsible ensures that they will exercise due diligence throughout the process.

EPA proposed to apply this new section broadly. However, commenters raised valid questions about whether it is necessary to apply this formal process as broadly as proposed. In response, we have reconsidered the proposed approach and have determined that it would be appropriate to allow a less formal process with components for which market forces will make it unlikely that a secondary manufacturer would not complete assembly properly. In those cases, the certifying manufacturers will be required to provide sufficiently detailed installation instructions to the secondary manufacturers, who would then be obligated to complete assembly properly before the vehicles are delivered to the ultimate purchasers.

One example of a case for which market forces could ensure that assembly is completed properly would be air conditioning leakage requirements. Purchasers will have the expectation that the systems will not leak, and a secondary manufacturer should have no incentive to not follow the certifying manufacturer's instructions.

As revised, § 1037.621 will require the formal delegated assembly process for the following technologies if they are part of the OEM's certified configuration but not shipped with the vehicle:

- Auxiliary power units
- Aerodynamic devices
- Hybrid components
- Natural gas fuel tanks

Certificate holders will remain responsible for other certified components, but will not automatically be required to comply with the formal delegated assembly requirements. That determination will be made case-by-case as part of the certification process. We are also explicitly making the flexibility in 40 CFR 1037.621 available for HD pickups and vans certified to the standards in 40 CFR part 86. As is currently specified in 40 CFR 1068.261, EPA will retain the authority to apply additional necessary conditions (at the time of certification) to the allowance to delegate assembly of emission to secondary manufacturers (when emission control equipment is not shipped with the vehicle to the secondary manufacturer, as just noted). In particular, we would likely apply such additional conditions for manufacturers that we determine to have previously not completed assembly properly. Issues of delegated assembly are addressed in more detail in Section 1.4.4 of the RTC.

(f) Engine/Vehicle Useful Life

We received comment on what policies we should adopt to address the situation where the engine and the vehicle are subject to emission standards over different useful-life periods. For example, a medium heavy-duty engine may power vehicles in weight classes ranging from 2b to 8, with correspondingly different regulatory useful lives for those vehicles. As provided in 40 CFR 1037.140 of the final regulations, we have structured the vehicle regulations to generally apply the same useful life for the vehicle that applies for the engines. However, these regulations also allow vehicle manufacturers to certify their vehicles to longer useful lives. The agencies see no problem with allowing vehicles to have longer useful lives than the engines.

(g) Compliance Reports

The agencies received comment on the NPRM from two environmental organizations requesting that the agencies make available to the public data and information that would enable the public to track trends in technology sales over time, as well as track company-specific compliance data. The commenters suggested that this should include an agency publication of an annual compliance report for the Heavy-duty Phase 2 program. The commenters requested this information to allow all stakeholders to see how individual companies, as well as the industry overall, were performing relative to their compliance obligations (see comments from ACEEE and NRDC).

The agencies agree with this comment. In the context of the light-duty vehicle GHG standards, EPA has already published four annual compliance reports which has made available to the public detailed information regarding both how individual light-duty vehicle companies have been meeting their compliance obligations, as well as summary information at the light-duty fleet level. NHTSA makes the up-to-date information on the light-duty fuel economy program available through its

CAFE Public Information Center (*http://www.nhtsa.gov/CAFE_PIC/CAFE_PIC_Home.htm*). Information includes manufacturer and overall fleet standards and CAFE performance, credit status, and civil penalty status. This information has been helpful to increase transparency to all stakeholders and to allow the public to see how companies are progressing from one year to the next with respect to their compliance requirements. It is EPA's intention to publish a similar annual compliance report for the heavy duty GHG program, covering both the existing Phase 1 program, as well as the Phase 2 standards contained in this final rule. It is NHTSA's intention to expand the Public Information Center to include the medium- and heavy-duty fuel efficiency program and to make up-to-date information collected in the heavy-duty fuel efficiency compliance process available publicly. Both the EPA and NHTSA compliance reports will provide available information at the vehicle subclass level for each of the four vehicle categories (*i.e.* Tractors, Trailers, Vocational, and Heavy-Duty Pickups and Vans), and EPA will provide available information for the other GHG standards, such as N_2O and refrigerant leak detection standards. Prior to issuing the compliance reports, EPA and NHTSA will work with regulated manufacturers to reconcile concerns over the release of claimed confidential business information, consistent with 40 CFR part 2 and 49 CFR 512.

(3) Life Cycle Emissions

The agencies received many comments expressing concerns about establishing the GHG and fuel consumption standards as tailpipe standards that do not account for upstream emissions or other life cycle impacts. However, many other commenters supported this approach. Comments specifically related to alternative fuels or electric vehicles are addressed in Section I.C.(1)(d) and in Section XI.B. This section addresses the issue more broadly.

As discussed below, the agencies do not see how we could accurately account for life cycle emissions in our vehicle standards, nor have commenters shown that such an accounting is needed. In addition, NHTSA has already noted that the fuel efficiency standards are necessarily tailpipe-based, and that a lifecycle approach would likely render it impossible to harmonize the fuel efficiency and GHG emission standards, to the great detriment of our goal of achieving a national, harmonized program. See 76 FR 57125.

It is also worth noting that EPA's engine and vehicle emission standards and NHTSA's vehicle fuel consumption standards (including those for light-duty vehicles) have been in place for decades as tailpipe standards. The agencies find no reasonable basis in the comments or elsewhere to change fundamentally from this longstanding approach.

Although the final standards do not account for life cycle emissions, the agencies have estimated the upstream emission impact of reducing fuel consumption for heavy-duty vehicles. As shown in Section VII and VIII, these upstream emission reductions are significant and worth estimating, even with some uncertainty. However, this analysis would not be a sufficient basis for inclusion in the standards themselves.

(a) Challenges for Addressing Life Cycle Emissions With Vehicle Standards

Commenters supporting accounting for life cycle emissions generally did so in the context of one or more specific technologies. However, the agencies cannot accurately address life-cycle emissions on a technology specific basis at this time for two reasons:

- We lack data to address each technology, and see no path to selectively apply a life cycle analysis to some technologies, but not to others.
- Actual life cycle emissions are dependent on factors outside the scope of the rulemaking that may change in the future.

With respect to the first reason, even if we were able to accurately and fully account for life cycle impacts of one technology (such as weight reduction), this would not allow us to address life cycle emissions for other technologies. For example, how would the agencies address potential differences in life cycle emissions for shifting from a manual transmission to and AMT, or the life cycle emissions of aerodynamic fairings? If we cannot factor in life cycle impacts for all technologies, how would we do it for weight reductions? Given the complexity of these rules and the number of different technologies involved, we see no way to treat the technologies equitably. Commenters do not provide the information necessary to address this challenge, nor are the agencies aware of such information.

The second reason is just as problematic. This rulemaking is setting standards for vehicles under specific statutory provisions. It is not regulating manufacturing processes, distribution practices, or the locations of manufacturing facilities. And yet each of these factors could impact life cycle emissions. So while we could take a snapshot of life cycle emissions at this point in time for specific manufacturers, it may or may not have any relation to life cycle emissions in 2027, or for other manufacturers. Consider, for example, two component manufacturers: One that produces its components near the vehicle assembly plant, and relies on natural gas to power its factory; and a second that is located overseas and relies on coal-fired power. How would the agencies equitably (or even non-arbitrarily) factor in these differences without regulating these processes? To the extent commenters provided any information on life cycle impacts, they did not address this challenge.

(b) Need for Life Cycle Consideration in the Standards

The agencies acknowledge that a full and accurate accounting of life cycle emissions (if it were possible) could potentially make the Phase 2 program marginally better. However, we do not agree that this is an issue of fundamental importance. While some commenters submitted estimates of the importance of life cycle emissions for light-duty vehicles, life cycle emissions are less important for heavy-duty vehicles. Consider, for example, the difference between a passenger car and a heavy-duty tractor. If the passenger car achieves 40 mile per gallon and travels 150,000 miles in its life, it would consume less than 4,000 gallons of fuel in its life. On the other hand, a tractor that achieves 8 miles per gallon and travels 1,000,000 miles would consume 125,000 gallons of fuel in its life, or more than 30 times the fuel of the passenger car. Commenters provide no basis to assume the energy consumption associated with tractor production would be 30 times that of the production of a passenger car.

(4) Amendments to the Phase 1 Program

The agencies are revising some test procedures and compliance provisions used for Phase 1. These changes are described in Section XII. This includes both amendments specific to Phase 1, as well as amendments that apply more broadly than Phase 1, such as the revisions to the delegated assembly provisions. As a drafting matter, EPA notes that we are moving the GHG standards for Class 2b and 3 pickups and vans from 40 CFR 1037.104 to 40 CFR 86.1819–14.

NHTSA is also amending 49 CFR part 535 to make technical corrections to its Phase 1 program to better align with EPA's compliance approach, standards and CO_2 performance results. In general, these changes are intended to improve the regulatory experience for regulated parties and also reduce agency administrative burden. More specifically, NHTSA is changing the rounding of its standards and performance values to have more significant digits. Increasing the number of significant digits for values used for compliance with NHTSA standards reduces differences in credits generated and overall credit balances for the EPA and NHTSA programs. NHTSA is also removing the petitioning process for off-road vehicles, clarifying requirements for the documentation needed for submitting innovative technology requests in accordance with 40 CFR 1037.610 and 49 CFR 535.7, and adding further detail to requirements for submitting credit allocation plans as specified in 49 CFR 535.9. Finally, NHTSA is adding the same recordkeeping requirements that EPA currently requires to facilitate in-use compliance inspections. These changes are intended to improve the regulatory experience for regulated parties and also reduce agency administrative burden.

The agencies received few comments on these changes, with most supporting the proposed changes or suggesting improvements. These comments as well as the few comments opposing any of these changes are discussed in Section XII and in the RTC.

(5) Other Amendments to EPA Regulations

EPA is finalizing certain other changes to regulations that we proposed, which are not directly related to the HD Phase 1 or Phase 2 programs, as detailed in Section XIII. For these amendments, there are no corresponding changes in NHTSA regulations. Some of these amendments relate directly to heavy-duty highway engines, but not to the GHG programs. Others relate to nonroad engines. This latter category reflects the regulatory structure EPA uses for its mobile source regulations, in which regulatory provisions applying broadly to different types of mobile sources are codified in common regulatory parts such as 40 CFR part 1068. This approach creates a broad regulatory structure that regulates highway and nonroad engines, vehicles, and equipment collectively in a common program. Thus, it is appropriate to include some amendments to nonroad regulations in addition to the changes applicable only for highway engines and vehicles.

Except as noted below, the agencies received relatively few significant comments on these issues. All comments are discussed in more detail in Section XIII and in the RTC. One area, for which we did receive significant comment was the issue of competition vehicles. As described in Section XIII, EPA is not finalizing the proposed clarification related to highway vehicles used for competition.

(a) Standards for Engines Installed In Glider Kits

EPA regulations currently allow used pre-2013 engines to be installed into new glider kits without meeting currently applicable standards. As described in Section XIII.B, EPA is amending its regulations to allow only engines that have been certified to meet standards for the model year in which the glider vehicle is assembled (*i.e.* current model year engine standards) to be installed in new glider kits, with certain exceptions. First, engines certified to earlier MY standards that are identical to the current model year standards may be used. Second, engines still within their useful life (and certain similar engines) may be used. Note that this would not allow use of the pre-2002 engines that are currently being used in most glider vehicles because they all would be outside of the 10-year useful life period. Finally, the interim small manufacturer allowance for glider vehicles will also apply for the engines used in the exempted glider kits. Comments on this issue are summarized and addressed in Section XIII.B and in RTC Section 14.2.

(b) Nonconformance Penalty Process Changes

Nonconformance penalties (NCPs) are monetary penalties established by regulation that allow a vehicle or engine manufacturer to sell engines that do not meet the emission standards. Manufacturers unable to comply with the applicable standard pay penalties, which are assessed on a per-engine basis.

On September 5, 2012, EPA adopted final NCPs for heavy heavy-duty diesel engines that could be used by manufacturers of heavy-duty diesel engines unable to meet the current oxides of nitrogen (NO_X) emission standard. On December 11, 2013 the U.S. Court of Appeals for the District of Columbia Circuit issued an opinion vacating that Final Rule. It issued its mandate for this decision on April 16, 2014, ending the availability of the NCPs for the current NO_X standard, as well as vacating certain amendments to the NCP regulations due to concerns about inadequate notice. In particular, the amendments revise the text explaining how EPA determines when NCP should be made available. In the Phase 2 NPRM, EPA re-proposed most of these amendments to provide fuller notice and additional opportunity for public comment. As discussed in Section XIII, although EPA received one comment opposing these amendments, they are being finalized as proposed.

(c) Updates to Heavy-Duty Engine Manufacturer In-Use Testing Requirements

EPA and manufacturers have gained substantial experience with in-use testing over the last four or five years. This has led to important insights in ways that the test protocol can be adjusted to be more effective. We are accordingly making changes to the regulations in 40 CFR part 86, subparts N and T.

(d) Extension of Certain 40 CFR Part 1068 Provisions to Highway Vehicles and Engines

As part of the Phase 1 GHG standards, we applied the exemption and importation provisions from 40 CFR part 1068, subparts C and D, to heavy-duty highway engines and vehicles. We also specified that the defect reporting provisions of 40 CFR 1068.501 were optional. In an earlier rulemaking, we applied the selective enforcement auditing under 40 CFR part 1068, subpart E (75 FR 22896, April 30, 2010). We are adopting the rest of 40 CFR part 1068 for heavy-duty highway engines and vehicles, with certain exceptions and special provisions.

As described above, we are applying all the general compliance provisions of 40 CFR part 1068 to heavy-duty engines and vehicles subject to 40 CFR parts 1036 and 1037. We are also applying the recall provisions and the hearing procedures from 40 CFR part 1068 for highway motorcycles and for all vehicles subject to standards under 40 CFR part 86, subpart S.

EPA is updating and consolidating the regulations related to formal and informal hearings in 40 CFR part 1068, subpart G. This will allow us to rely on a single set of regulations for all the different categories of vehicles, engines, and equipment that are subject to emission standards. We also made an effort to write these regulations for improved readability.

We are also making a number of changes to part 1068 to correct errors, to add clarification, and to make adjustments based on lessons learned from implementing these regulatory provisions.

(e) Amendments to Engine and Vehicle Test Procedures in 40 CFR Parts 1065 and 1066

EPA is making several changes to our engine testing procedures specified in

40 CFR part 1065. None of these changes will significantly impact the stringency of any standards.

(f) Amendments Related to Marine Diesel Engines in 40 CFR Parts 1042 and 1043

EPA's emission standards and certification requirements for marine diesel engines under the Clean Air Act and the act to Prevent Pollution from Ships are identified in 40 CFR parts 1042 and 1043, respectively. EPA is amending these regulations with respect to continuous NO_X monitoring and auxiliary engines, as well as making several other minor revisions.

(g) Amendments Related to Locomotives in 40 CFR Part 1033

EPA's emission standards and certification requirements for locomotives under the Clean Air Act are identified in 40 CFR part 1033. EPA is making several minor revisions to these regulations.

(6) Other Amendments to NHTSA Regulations

NHTSA proposed to amend 49 CFR parts 512 and 537 to allow manufacturers to submit required compliance data for the Corporate Average Fuel Economy (CAFE) program electronically, rather than submitting some reports to NHTSA via paper and CDs and some reports to EPA through its VERIFY database system. NHTSA is not finalizing this proposal in this rulemaking and will consider electronic submission for CAFE reports in a future action.

II. Vehicle Simulation and Separate Engine Standards for Tractors and Vocational Chassis

A. Introduction

This Section II. describes two regulatory program elements that are *common* among tractors and vocational chassis. In contrast, Sections III and V respectively describe the regulatory program elements that are *unique* to tractors and to vocational chassis. The common elements described here are the vehicle simulation approach to vehicle certification and the separate standards for engines. Section II.B discusses the reasons for this Phase 2 regulatory approach; namely, requiring vehicle simulation for tractor and vocational chassis certification, maintaining separate engine standards, and expanding and updating their related mandatory and optional test procedures. Section II.C discusses in detail the evolution and final version of the vehicle simulation computer program, which is called the Greenhouse gas Emissions Model or ''GEM.'' Section II.C also discusses the evolution and final versions of the test procedures for determining the GEM inputs that are common for tractors and vocational chassis. Section II.D discusses in detail the separate engine standards for GHGs and fuel efficiency and their requisite test procedures.

In this final action, the agencies have built on the success of the Phase 1 GEM-based approach for the certification of tractors and vocational chassis. To better recognize the real-world impact of vehicle technologies, we have expanded the number of required and optional vehicle inputs into GEM. Inputting these additional details into GEM results in more accurate representations of vehicle performance and greater opportunities to demonstrate reductions in CO_2 emissions and fuel consumption. We are also finalizing revisions to the vehicle driving patterns that are programmed into GEM to better reflect real-world vehicle operation and the emissions reductions that result from applying GHG and fuel efficiency technologies to vehicles. As a result of these revisions, the final GEM-based vehicle certification approach necessitates new testing of engines and testing of some other vehicle components to generate the additional GEM inputs for Phase 2. More detail is provided in Section II.C.

Based on our assessments of the technological feasibility; cost effectiveness; requisite lead times for implementing new and additional tractor and vocational vehicle technologies; and based on comments we received in response to our notice of proposed rulemaking and in response to our more recent notice of additional data availability, the agencies are finalizing steadily increasing stringencies of the CO_2 and fuel consumption standards for tractors and vocational chassis for vehicle model years 2021, 2024 and 2027. See Section I or Sections III and V respectively for these numerical standards for tractors and vocational chassis. As part of our analytical process for determining the numerical values of these standards, the agencies utilized GEM. Using GEM as an integral part of our own standard-setting process helps ensure consistency between our technology assessments and the GEM-based certification process that we require for compliance with the Phase 2 standards. Our utilization of GEM in our standard-setting process is described further in Section II.C.

For Phase 2 we are finalizing, as proposed, the same Phase 1 certification approach for all of the GHG and fuel efficiency separate engine standards for those engines installed in tractors and vocational chassis. For the separate engine standards, we will continue to require the Phase 1 engine dynamometer certification test procedures, which were adopted substantially from EPA's existing heavy-duty engine emissions test procedures. In this action we are finalizing, as proposed, revisions to the weighting factors of the tractor engine 13-mode steady-state test cycle (*i.e.,* the Supplemental Engine Test cycle or ''SET''). The SET is required for determining tractor engine CO_2 emissions and fuel consumption. Consistent with the rationale we presented in our proposal and consistent with comments we received, these revised SET weighting factors better reflect the lower engine speed operation of modern engines, which frequently occurs at tractor cruise speeds. We used these revised weighting factors as part of our engine technology assessments of both current engine technology (*i.e.,* our ''baseline engine'' technology) and future engine technology.

Based on our assessments of the technological feasibility; cost effectiveness; requisite lead times for implementing new and additional engine technologies; and based on comments we received in response to our notice of proposed rulemaking and in response to our more recent notice of additional data availability, the agencies are finalizing steadily increasing stringencies of the CO_2 and fuel consumption separate engine standards for engine model years 2021, 2024 and 2027. In addition, for each of these model years, EPA is maintaining the Phase 1 separate engine standards for CH_4 and N_2O emissions—both at their Phase 1 numeric values. While EPA is not finalizing at this time more stringent N_2O emissions standards, as originally proposed, EPA may soon revisit these separate engine N_2O standards in a future rulemaking. All of the final Phase 2 separate engine standards are presented in Section II.D, along with our related assessments.

B. Phase 2 Regulatory Structure

As proposed, in this final action the agencies have built on the success of the Phase 1 GEM-based approach for the certification of tractors and vocational chassis, while also maintaining the Phase 1 separate engine standards approach to engine certification. While the regulatory structures of both Phase 1 and Phase 2 are quite similar, there are a number of new elements for Phase 2. Note that we are not applying these new

Phase 2 elements for compliance with the Phase 1 standards.

These modifications for Phase 2 are consistent with the agencies' Phase 1 commitments to consider a range of regulatory approaches during the development of future regulatory efforts (76 FR 57133), especially for vehicles not already subject to full vehicle chassis dynamometer testing. For example, we committed to consider a more sophisticated approach to vehicle testing to more completely capture the complex interactions within the total vehicle, including the engine and powertrain performance. We also committed to consider the potential for full vehicle certification of complete tractors and vocational chassis using a chassis dynamometer test procedure. We also considered chassis dynamometer testing of complete tractors and vocational chassis as a complementary approach for validating a more complex vehicle simulation approach. We committed to consider the potential for a regulatory program for some of the trailers hauled by tractors. After considering these various approaches, the agencies proposed a structure in which regulated tractor and vocational chassis manufacturers would additionally enter engine and powertrain-related inputs into GEM, which was not part of in Phase 1.

The basic structure in the proposal was widely supported by commenters, although some commenters supported changing certain aspects. Some commenters suggested revising GEM to recognize additional technologies, such as tire pressure monitoring systems and electronic controls that decrease fuel consumption while a vehicle is coasting. To the extent that the agencies were able to collect and receive sufficient data to support such revisions in GEM, these changes were made. See Section II.C. for details. For determining certain GEM inputs, some commenters suggested more cost-effective test procedures for separate engine and transmission testing, compared to the engine-plus-transmission powertrain test procedure that the agencies proposed. In collaboration with researchers at engine manufacturer test laboratories, at Oak Ridge National Laboratory and at Southwest Research Institute, the agencies completed a number of laboratory evaluations of these suggested test procedures.[131] Based on these results, which were made available to the public for a 30-day comment period in the NODA, the agencies are finalizing these more cost-effective test procedures as options, in addition to the powertrain test procedure we proposed. We note that we are also finalizing some of these more cost-effective test procedures, the cycle average approach for all vehicle cycles, as optional for the testing of ''pre-transmission'' hybrids. In response to our request for comment, some commenters expressed support for a so-called, ''cycle-average'' approach for generating engine map data for input into GEM. This approach facilitates an accurate recognition of an engine's transient performance. The agencies further refined this approach, and we made detailed information on this approach available in the NODA.[132] Based on comments, we are finalizing this approach as mandatory for mapping engines over GEM's transient cycle, and we are allowing this approach as optional for GEM's 55 mph and 65 mph cycles.

Some commenters expressed concern about GEM and our proposed tractor standards appropriately accounting for the performance of powertrain technologies installed in some of the largest specialty tractors. We have addressed this concern by finalizing a new ''heavy-haul'' tractor sub-category, with a unique payload and vehicle masses in GEM, which result in a unique set of numeric standards for these vehicles. This is explained in detail in Section III.D. Other commenters expressed concern about the greater complexity of GEM's additional inputs and the appropriateness of our proposed vocational chassis standards, as applied to certain custom-built vocational chassis. We have addressed these concerns by finalizing a limited number of optional custom chassis standards, tailored according to a vocational chassis' final application (*e.g.,* school bus, refuse truck, cement mixer, etc.). To address the concerns about GEM's complexity for these specialty vehicles, these optional custom chassis standards require a smaller number of GEM inputs. This is explained in detail in Section V.D.

Some vehicle manufacturers did not support the agencies finalizing separate engine standards. However, as described below, the agencies continue to believe that separate engine standards are necessary and appropriate. Thus, the agencies are finalizing the basic rule structure that was proposed, but with a number of refinements.

For trailer manufacturers, which will be subject to first-time standards under Phase 2, we will apply the standards using a GEM-based certification, but to do so without actually running GEM. More specifically, based on the agencies' analysis of the results of running GEM many times and varying GEM's trailer configurations, the agencies have developed a simple equation that replicates GEM results, based on inputting certain trailer values into the equation. Use of the equation, rather than full GEM, should significantly facilitate trailer certification. As described in Chapter 2.10.5 of the RIA, the equation has a nearly perfect correlation with GEM, so that they can be used instead of GEM, without impacting stringency. This is a result of the relative simplicity of the trailer inputs as compared to the tractor and vocational vehicle inputs.

(1) Other Structures Considered

To follow-up on the commitment to consider other approaches, the agencies spent significant time and resources before the proposal in evaluating six different options for demonstrating compliance with the proposed Phase 2 standards as shown in Figure II.1

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[131] Oak Ridge National Laboratory results docketed for the NODA: EPA–HQ–OAR–2014–0827–1622 and NHTSA–2014–0132–0183. Southwest Research Institute results docketed for the NODA: EPA–HQ–OAR–2014–0827–1619 and NHTSA–2014–0132–0184.

[132] Ibid.

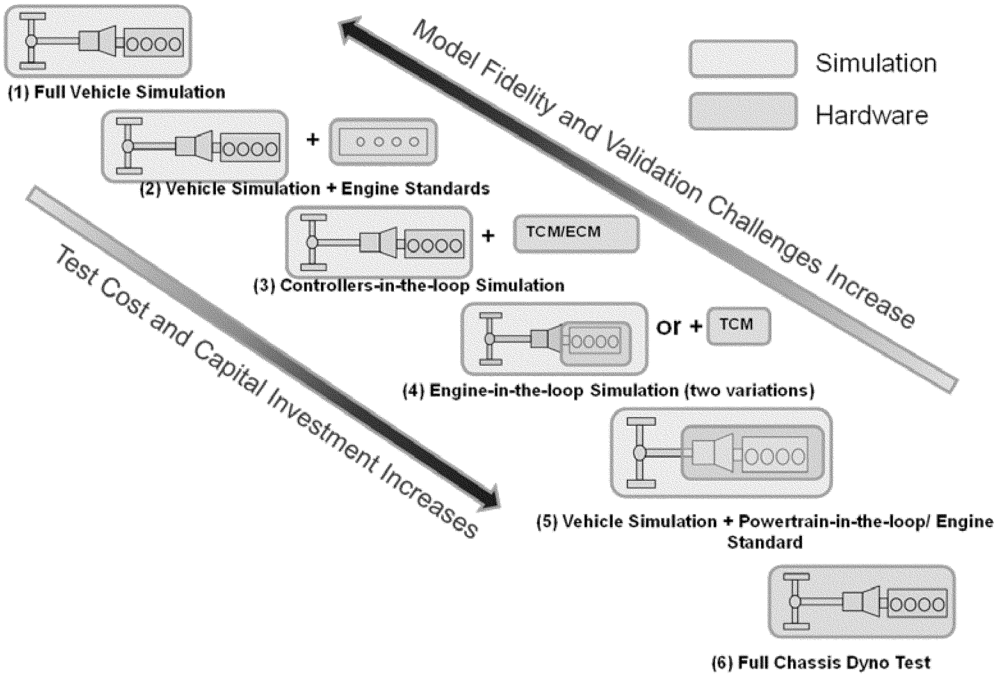

Figure II.1 Six Certification Options

As shown in Figure II.1 these six options include:

1. Full vehicle simulation, where vehicle inputs are entered into simulation software.
2. Vehicle simulation, supplemented with separate engine standards.
3. Controllers-in-the-loop simulation, where an actual electronic transmission controller module (TCM) and an actual engine controller module (ECM) are tested in hardware.
4. Engine-in-the-loop simulation, with or without a TCM, where at least the engine is tested in hardware.
5. Vehicle simulation with powertrain-in-the-loop, where the engine and transmission are tested in hardware. One variation involves an engine standard.
6. Full vehicle chassis dynamometer testing.

The agencies evaluated these options in terms of the capital investment required of regulated manufacturers to conduct the testing and/or simulation, the cost per test, the accuracy of the simulation, and the challenges of validating the results. Other considerations included the representativeness compared to the real world behavior, maintaining existing Phase 1 certification approaches that are known to work well, enhancing the Phase 1 approaches that could use improvements, the alignment of test procedures for determining GHG and non-GHG emissions compliance, and the potential to circumvent the intent of the test procedures. The agencies presented our evaluations in the proposal, and we received comments on some of these approaches, and these comments were considered carefully in our evaluations for this final action. Notably, in this final action we are adopting a combination of these options, where some are mandatory and others are optional for certification via GEM. We have concluded that this combination of these options strikes an optimal balance between their costs, accuracy with respect to real-world performance, and robustness for ensuring compliance. In this section we present our evaluation and rationale for finalizing these Phase 2 certification approaches.

Chassis dynamometer testing (Option 6) is used extensively in the development and certification of light-duty vehicles. It also is used in Phase 1 to certify complete Class 2b/3 pickups and vans, as well as to certify certain incomplete vehicles (at the manufacturer's option). The agencies considered chassis dynamometer testing more broadly as a heavy-duty fuel efficiency and GHG certification option because chassis dynamometer testing has the ability to evaluate a vehicle's performance in a manner that most closely resembles the vehicle's in-use performance. Nearly all of the fuel efficiency technologies can be evaluated simultaneously on a chassis dynamometer, including the vehicle systems' interactions that depend on the behavior of the engine, transmission, and other vehicle electronic controllers. One challenge associated with the application of wide-spread heavy-duty chassis testing is the small number of heavy-duty chassis test sites that are available in North America. As discussed in RIA Chapter 3, the agencies were only able to locate 11 heavy-duty chassis test sites. However, more recently we have seen an increased interest in building new sites since issuing the Phase 1 Final Rule. For example, EPA is currently building a heavy-duty chassis dynamometer with the ability to test up to 80,000 pound vehicles at the National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Michigan.

Nevertheless, the agencies continue to be concerned about requiring a chassis test procedure for certifying tractors or vocational chassis due to the initial cost of a new test facility and the large number of heavy duty tractor and vocational chassis variants that could require testing. We have also concluded that for heavy-duty tractors and vocational chassis, there can be increased test-to-test variability under chassis dynamometer test conditions, versus other approaches. First, the agencies recognize that such testing requires expensive, specialized equipment that is not widely available. The agencies estimate that it would vary from about $1.3 to $4.0 million per new test site depending on existing facilities.[133] In addition, the large number of heavy-duty vehicle configurations would require significant amounts of testing to cover the sector. For example, for Phase 1 tractor manufacturers typically certified several thousand variants of one single tractor model. Finally, EPA's evaluation of heavy-duty chassis dynamometer testing has shown that the variation of chassis test results is greater than light-duty testing, up to 3 percent worse, based on our sponsored testing at Southwest Research Institute.[134] The agencies' research identified a number of unique sources of test-to-test variability in HD chassis dynamometer testing versus other types of testing (described next). These unique sources include variations in HD tire performance and tire temperature and pressure stability; variations in human driver performance; and variations in the test facilities' heating, ventilation and air conditioning system affecting emissions after-treatment performance (*e.g.,* increased fuel consumption to maintain after-treatment temperature) and engine accessory power (*e.g.,* engine fan clutching). Although the agencies are not requiring chassis dynamometer certification of tractors and vocational chassis, we believe such an approach could potentially be appropriate in the future for some heavy duty vehicles if more test facilities become available and if the agencies are able to address the large number of vehicle variants that might require testing and the unique sources of test-to-test variability. Note, as discussed in Section II.C.(4) we are finalizing a manufacturer-run complete tractor heavy-duty chassis dynamometer test program for monitoring relative trends fuel efficiency and for comparing those trends to the trends indicated via GEM simulation. While the agencies did not receive significant comment on the appropriateness of full vehicle heavy-duty chassis dynamometer testing for certification, the agencies did receive significant, mostly negative, comment on the costs versus benefits of a manufacturer-run complete tractor heavy-duty chassis dynamometer test program for data collection. These comments and our responses are detailed in Section II.C.(4).

Another option considered for certification involves testing a vehicle's powertrain in a modified engine dynamometer test facility, which is part of option 5 shown in Figure II.1. In this case the engine and transmission are installed together in a laboratory test facility, and a dynamometer is connected to the output shaft of the transmission. GEM or an equivalent vehicle simulation computer program is then used to control the dynamometer to simulate vehicle speeds and loads. The step-by-step test procedure considered for this option was initially developed as an option for hybrid powertrain testing for Phase 1. We are not finalizing this approach as mandatory, but we are allowing this as an option for manufacturers to generate powertrain inputs for use in GEM. For Phase 2 we generally require this test procedure for evaluating hybrid powertrains for inputs into GEM, but there are certain exceptions where engine-only test procedures may be used to certify hybrids via GEM (*e.g.,* pre-transmission hybrids).

A key advantage of the powertrain test approach is that it directly measures the effectiveness of the engine, the transmission, and the integration of these two components. Engines and transmissions are particularly challenging to simulate within a computer program like GEM because the engines and transmissions installed in vehicles today are actively and interactively controlled by their own sophisticated electronic controls; namely the ECM and TCM.

We believe that the capital investment impact on manufacturers for powertrain testing is reasonable; especially for those who already have heavy-duty engine dynamometer test facilities. We have found that, in general, medium-duty powertrains can be tested in heavy-duty engine test cells. EPA has successfully completed such a test facility conversion at the National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Michigan. Southwest Research Institute (SwRI) in San Antonio, Texas has completed a similar test cell conversion. Oak Ridge National Laboratory in Oak Ridge, Tennessee has been operating a recently constructed heavy heavy-duty powertrain dynamometer facility, and EPA currently has an interagency agreement with DOE to fund EPA powertrain testing at ORNL. The results from this testing were published for a 30-day comment period, as part of the NODA.[135] Eaton Corporation has been operating a heavy-duty powertrain test cell and has provided the agencies with valuable test results and other comments.[136] PACCAR recently constructed and began operation of a powertrain test cell that includes engine, transmission and axle test capabilities.[137] EPA also contracted SwRI to evaluate North America's capabilities (as of 2014) for powertrain testing in the heavy-duty sector and the cost of installing a new powertrain cell that meets agency requirements.[138] Results from this 2014 survey indicated that one supplier (Eaton) already had this capability. We estimate that the upgrade costs to an existing engine test facility are on the order of $1.2 million, and a new test facility in an existing building are on the order of $1.9 million. We also estimate that current powertrain test cells that could be upgraded to measure CO_2 emissions would cost approximately $600,000. For manufacturers or suppliers wishing to contract out such testing, SwRI estimated that a cost of $150,000 would provide about one month of powertrain testing services. Once a powertrain test cell is fully operational, we estimate that for a nominal powertrain family (*i.e.* one engine family tested with one transmission family), the cost for powertrain installation, testing, and data analysis would be about $70,000 in calendar year 2016, in 2016 dollars. Since the NPRM in July 2015, the agencies and other stakeholders have completed significant new work toward refining the powertrain test procedure itself, and these results confirm the robustness of this approach. The agencies regulations provide details of the final powertrain test procedure. See 40 CFR 1037.550.

Furthermore, the agencies have worked with key transmission suppliers to develop an approach to define transmission families. Coupled with the agencies' existing definitions of engine families (40 CFR 1036.230 and 1037.230), we are finalizing powertrain family definitions in 40 CFR 1037.231 and axle and transmission families in 40 CFR 1037.232.

Even though there is conclusive evidence that powertrain testing is a

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[133] 03–19034 TASK 2 Report-Paper 03-Class8_hil_DRAFT, September 30, 2013.

[134] GEM Validation, Technical Research Workshop, San Antonio, December 10–11, 2014.

[135] Oak Ridge National Laboratory results docketed for the NODA: EPA–HQ–OAR–2014–0827–1622 and NHTSA–2014–0132–0183. Southwest Research Institute results docketed for the NODA: EPA–HQ–OAR–2014–0827–1619 and NHTSA–2014–0132–0184.

[136] Eaton, Greenhouse gas emissions and fuel efficiency standards for medium- and heavy-duty engines and vehicles—Phase 2, 80 FED. REG. 40,137—Docket ID NOS. EPA–HQ–OAR–2014–0827, October 1, 2015.

[137] *https://engines.paccar.com/technology/research-development/.*

[138] 03–19034 TASK 2 Report-Paper 03-Class8_hil_DRAFT, September 30, 2013.

technically robust and cost-effective approach to evaluating the CO_2 and fuel consumption performance of powertrains, and even though there has been a clear trend toward manufacturers and other test laboratories recognizing the benefits and investing in new powertrain testing facilities, the agencies also received significant negative comment regarding the sheer amount of powertrain testing that could be required to certify the large number of unique configurations (*i.e.,* unique *combinations* of engines and transmissions). While the agencies proposed to allow manufacturers to group powertrains in powertrain families, as defined by the EPA in 40 CFR 1037.231, requiring powertrain testing broadly would still likely require a large number of tests. To address these concerns, while at the same time achieving most of the advantages of powertrain testing, the agencies are also finalizing some mandatory and optional test procedures to separately evaluate engine transient performance (via the mandatory ''cycle-average'' approach for the transient cycle) and transmission efficiency performance. While neither of these test procedures capture the optimized shift logic and other benefits of deep integration of the engine and transmission controllers, which only powertrain testing can capture, these separate test procedures do capture the remaining benefits of powertrain testing. The advantage of these separate tests is that their results can be mixed and matched within GEM to represent many more combinations of engines and transmissions than a comparable number of powertrain tests. For example, separately testing three parent engines that each have two child ratings and separately efficiency testing three transmissions that each have three major calibrations requires the equivalent test time of testing 6 powertrains, but without requiring the use of a powertrain test facility. More importantly, the results of these 6 tests can be combined within GEM to certify at least 27 different powertrain families, which would otherwise have required 27 powertrain tests—more than a four-fold increase in costs. This example clearly shows how cost-effective a vehicle simulation approach to vehicle certification can be.

Another regulatory structure option considered by the agencies was engine-only testing over the GEM duty cycles over a range of simulated vehicle configurations, which is part of Option 4 in Figure II.1. This is essentially a ''cycle-average approach,'' which would use GEM to generate engine duty cycles by simulating a range of transmissions and other vehicle variations. These engine-level duty cycles would then be programmed into a separate controller of a dynamometer connected to an engine's output shaft. The agencies requested comment on this approach, and based on continued research that has been conducted since the proposal, and based on comments we received in response to the NODA, we are finalizing this approach as mandatory for determining the GEM inputs that characterize an engine's transient engine performance within GEM over the ARB Transient duty cycle. We are also finalizing this approach as optional for characterizing the more steady-state engine operation in GEM over the 55 mph and 65 mph duty cycles with road grade, in lieu of steady-state engine mapping for these two cycles. We are also finalizing this approach as an option for certifying pre-transmission hybrids, in lieu of powertrain testing. We are calling this approach the ''cycle-average'' approach, which generates a cycle-average engine fuel map that is input into GEM. This map simulates an engine family's performance over a given vehicle drive cycle, for the full range of vehicles into which that engine could be installed. Unlike the chassis dynamometer or powertrain dynamometer approaches, which could have significant test facility construction or modification costs, this engine-only approach necessitates little capital investment because engine manufacturers already have engine test facilities to both develop engines and to certify engines to meet both EPA's non-GHG standards and the agencies' Phase 1 fuel efficiency and GHG separate engine standards. This option has received significant attention since our notice of proposed rulemaking. EPA and others have published peer reviewed journal articles demonstrating the efficacy of this approach,[139] [140] and the agencies have received significant comments on both the information we presented in the proposal and in the NODA. Comments have been predominantly supportive, and the comments we received tended to focus on ideas for further minor refinements of this test procedure.[136] [141] [142] [143] [144] [145] At this time the agencies believe that the wealth of experimental data supporting the robustness and cost-effectiveness of the cycle-average approach, supports the agencies' decision to finalize this test procedure as mandatory for the determination of the transient performance of engines for use in GEM (*i.e.,* over the ARB Transient Cycle).

The agencies also considered simulating the engine, transmission, and vehicle using a computer program; while having the actual transmission electronic controller connected to the computer running the vehicle simulation program, which is part of Option 3 in Figure II.1. The output of the simulation would be an engine cycle that would be used to test the engine in an engine test facility. Just as in the cycle-average approach, this procedure would not require significant capital investment in new test facilities. An additional benefit of this approach would be that the actual transmission controller would be determining the transmission gear shift points during the test, without a transmission manufacturer having to reveal their proprietary transmission control logic. This approach comes with some significant technical challenges, however. The computer model would have to become more complex and tailored to each new transmission and controller to make sure that the controller would operate properly when it is connected to a computer instead of an actual transmission. Some examples of the transmission specific requirements would be simulating all the Controller Area Network (CAN) communication to and from the transmission controller and the specific sensor responses both through simulation and hardware. Each vehicle manufacturer would have to be

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[139] H. Zhang, J, Sanchez, M, Spears, ''Alternative Heavy-duty Engine Test Procedure for Full Vehicle Certification,'' *SAE Int. J. Commer. Veh. 8(2): 2015, doi:10.4271/2015–01–2768.*

[140] G. Salemme, E.D., D. Kieffer, M. Howenstein, M. Hunkler, and M. Narula, *An Engine and Powertrain Mapping Approach for Simulation of Vehicle CO_2 Emissions.* SAE Int. J. Commer. Veh, October 2015. 8: p. 440–450.

[141] Cummins, Inc., Comments in Response to Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2 (Docket ID No. EPA–HQ–OAR–2014–0827 and Docket ID No. NHTSA–2014–0132).

[142] Paccar, Inc., Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Phase 2; Proposed Rule, 80 FR 40138 (July 13, 2015); Docket I.D. No.: EPA–HQ–OAR–2014–0827 and NHTSA–2014–0132.

[143] Daimler Trucks North America LLC, Detroit Diesel Corporation, And Mercedes-Benz USA, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, Phase 2, Proposed Rule, Docket ID No: EPA–HQ–OAR–2014–0827 and NHTSA–2014–0132; 80 FR 40137 (July 13, 2015).

[144] Volvo Group, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, Phase 2, Proposed Rule, Dockets ID No: EPA–HQ–OAR–2014–0827 and NHTSA–2014–0132;80 FR 40137 (July 13, 2015).

[145] Navistar, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, Phase 2, Proposed Rule, Dockets ID No: EPA–HQ–OAR–2014–0827 and NHTSA–2014–0132;80 FR 40137 (July 13, 2015).

responsible for connecting the transmission controller to the computer, which would require a detailed verification process to ensure it is operating properly while it is in fact disconnected from a real transmission. Determining full compliance with this test procedure would be a significant challenge for the regulatory agencies because the agencies would have to be able to replicate each of the manufacturer's unique interfaces between the transmission controller and computer running GEM. The agencies did not receive any significant comments on this approach, presumably because commenters focused on the more viable options of powertrain testing and the cycle-average engine mapping approach. And because of the significant challenges noted above, the agencies did not pursue this option further between the time of proposal and this final action. However, should this approach receive more research attention in the future, such that the concerns noted above are sufficiently addressed, the agencies could consider allowing this certification approach as an option, within the context of a separate future rulemaking.

Finally, the agencies considered full vehicle simulation plus separate engine standards (Option 2 in Figure II.1), which is the required approach being finalized for Phase 2. This approach is discussed in more detail in the following sections. It should be noted before concluding this subsection that the agencies do provide a regulatory path for manufacturers to apply for approval of alternative test methods that are different than those the agencies specify. See 40 CFR part 1065, subpart A. Therefore, even though we have not finalized some of the certification approaches and test procedures that we investigated, our conclusions about these procedures do not prevent a manufacturer from seeking agency approval of any of these procedures or any other alternative procedures.

(2) Final Phase 2 Regulatory Structure

Under the final Phase 2 structure, tractor and vocational chassis manufacturers will be required to provide engine, transmission, drive axle(s) and tire inputs into GEM (as well as the inputs already required under Phase 1). For Phase 1, GEM used fixed default values for all of these, which limited the types of technologies that could be recognized by GEM to show compliance with the standards. We are expanding GEM to account for a wider range of technological improvements that would otherwise need to be recognized through the more cumbersome off-cycle crediting approach in Phase 1. Additional technologies that will now be recognized in GEM also include lightweight thermoplastic materials, automatic tire inflation systems, tire pressure monitoring systems, advanced cruise control systems, electronic vehicle coasting controls, engine stop-start idle reduction systems, automatic engine shutdown systems, hybrids, and axle configurations that decrease the number of drive axles. The agencies are also continuing separate engine standards. As described below, we see advantages to having both engine-based and vehicle-based standards. Moreover, the advantages described here for full vehicle simulation do not necessarily correspond to disadvantages for engine testing or vice versa.

(a) Advantages of Vehicle Simulation

The agencies' primary purpose in developing fuel efficiency and GHG emissions standards is to increase the use of vehicle technologies that improve fuel efficiency and decrease GHG emissions. Under the Phase 1 tractor and vocational chassis standards, there is no *regulatory* incentive for vehicle manufacturers to consider adopting new engine, transmission or axle technologies because GEM was not configured to recognize these technologies uniquely, leaving off-cycle credits as the only regulatory mechanism to recognize these technologies' benefits. By recognizing such technologies in GEM under Phase 2, the agencies will be creating a direct regulatory incentive to improve engine, transmission, and axle technologies to improve fuel efficiency and decrease GHG emissions. In its 2014 report, NAS also recognized the benefits of full vehicle simulation and recommended that the Phase 2 rules incorporate such an approach.[160]

The new Phase 2 approach will create three new specific regulatory incentives. First, vehicle manufacturers will have an incentive to use the most efficient engines. Since GEM will no longer use the agency default engine in simulation, manufacturers will have their own engines recognized in GEM. Under Phase 1, engine manufacturers have a regulatory incentive to design efficient engines, but vehicle manufacturers do not have a similar regulatory incentive to use the most efficient engines in their vehicles. Second, the new Phase 2 approach will create incentives for both engine and vehicle manufacturers to design engines and vehicles to work together to ensure that engines actually operate as much as possible near their most efficient points. This is because Phase 2 GEM will require the vehicle manufacturers to input specific transmission, axle, and tire characteristics, thus recognizing powertrain optimization, such as engine down-speeding, and different transmission architectures and technologies, such as automated manual transmissions, automatic transmissions, and different numbers of transmission gears, transmission gear ratios, axle ratios and tire revolutions per mile. No matter how well designed, all engines have speed and load operation points with differing fuel efficiency and GHG emissions. The speed and load point with the best fuel efficiency (*i.e.,* peak thermal efficiency) is commonly known as the engine's ''sweet spot.'' The more frequently an engine operates near its sweet spot, the better the vehicle's fuel efficiency will be. In Phase 1, a vehicle manufacturer receives no regulatory credit under GEM for designing its vehicle to operate closer to its engine's sweet spot because Phase 1 GEM does not model the specific engine, transmission, axle, or tire revolutions per mile of the vehicle. Third, this approach will recognize improvements to the overall efficiency of the drivetrain, including the axle. The new version of GEM will recognize the benefits of different integrated axle technologies including axle lubricants (via an optional axle efficiency test), and technologies that reduce axle losses such as by enabling three-axle vehicles to deliver power to only one rear axle. This is accomplished through the simulation of axle disconnect technology (see Chapter 4.5 of the RIA). The new version of GEM also will be able to recognize the benefits of reducing energy losses within a transmission, via an optional transmission efficiency test.

In addition to providing regulatory incentives to use more fuel efficient technologies, expanding GEM to recognize engine and other powertrain component improvements will provide important flexibility to vehicle manufacturers. Providing flexibility to effectively trade engine and other powertrain component improvements against the other vehicle improvements that are recognized in GEM will allow vehicle manufacturers to better optimize their vehicles to achieve the lowest cost for specific customers. Because of the improvements in GEM, GEM will recognize this deeper level of vehicle optimization. Vehicle manufacturers could use this flexibility to reduce overall compliance costs and/or address special applications where certain vehicle technologies are not preferred or practical. The agencies considered in Phase 1 allowing the exchange of emission certification credits generated relative to the separate brake-specific engine standards and credits generated relative to the vehicle standards. However, we did not allow this in Phase 1 due in part to concerns about the equivalency of credits generated relative to different standards, with different units of measure and different test procedures. The Phase 2 approach eliminates these concerns because engine and other vehicle component improvements will be evaluated relative to the same vehicle standard in GEM. This also means that under the Phase 2 approach there is no need to consider allowing emissions credit trading between engine-generated and vehicle-generated credits because vehicle manufacturers are directly credited by the combination of engine and vehicle technologies they choose to install in each vehicle. Therefore, this approach eliminates one of the concerns about continuing separate engine standards, which was that a separate engine standard and a full vehicle standard were somehow mutually exclusive. That is not the case. In fact, in the next section we describe how we are continuing the separate engine standard along with recognizing engine performance at the vehicle level. The agencies acknowledge that maintaining a separate engine standard will limit flexibility in cases where a vehicle manufacturer wanted to use less efficient engines and make up for them using more efficient vehicle technologies. However, as described below, we see important advantages to maintaining a separate engine standard, and we believe they more than justify the reduced flexibility. Furthermore, in response to comments about some specialized vocational custom chassis, the agencies are finalizing a limited number of optional standards that would be met using a somewhat simplified version of GEM. Specifically, in this simplified version of GEM, which is only applicable as an option for certain custom chassis applications, the GEM inputs for the engine, transmission gears, gear ratios, gear efficiency; axle ratio, axle efficiency; and tire revolutions per mile are all fixed to default values. This simplification allows the option of certifying these custom chassis without penalty for utilizing less efficient engines, transmissions, or axles. This flexibility also addresses a comment the agencies received from Cummins that the inclusion of the specific engine in GEM limits the flexibility provided by the separate engine standards' emissions averaging, banking and trading program. Cummins explained that certain applications like emergency vehicles, cement mixers and recreational vehicles oftentimes require higher-performance, less-efficient, engines, which are credit using engines under the ABT program of the separate engine standards. Because these particular vehicle applications have few other cost-effective and practical vehicle-level technologies with which to offset their use of less efficient engines, the main Phase 2 vocational chassis standards that require engine and other powertrain inputs into GEM (*i.e.,* the standards for other than custom chassis vocational vehicles) could be particularly challenging for these applications. However, the optional custom chassis standards solves this issue for custom chassis applications. This approach solves two issues. First, it provides a means toward certification for these custom chassis applications, without penalty for using the engines they need. Second, this approach maintains the flexibility intended by the separate engine standards' averaging, banking and trading program since these custom chassis applications would still be using certified engines.

One disadvantage of recognizing engines and transmission in GEM is that it will increase complexity for the vehicle standards. For example, vehicle manufacturers will be required to conduct additional engine tests and to generate additional GEM inputs for compliance purposes. However, we believe that most of the burden associated with this increased complexity will be an infrequent burden of engine testing and updating information systems to track these inputs. Furthermore, the agencies are requiring that engine manufacturers certify their respective GEM inputs; namely, their own engine maps. Because there are a relatively small number of heavy-duty engine manufacturers who will be responsible for generating and complying with their declared engine maps for GEM, the overall engine testing burden to the heavy-duty vehicle industry is small. With this approach, the large number of vocational chassis manufacturers will not have to conduct any engine testing.

Another potential disadvantage to GEM-based vehicle certification is that because GEM measures performance over specific duty cycles intended to represent average operation of vehicles in-use, this approach might also create an incentive to optimize powertrains and drivetrains for the best GEM performance rather than the best in-use performance for a particular application. This is always a concern when selecting duty cycles for certification, and so is not an issue unique to GEM. There will always be instances, however infrequent, where specific vehicle applications will operate differently than the duty cycles used for certification. The question is would these differences force manufacturers to optimize vehicles to the certification duty cycles in a way that decreases fuel efficiency and increases GHG emissions in-use? We believe that the certification duty cycles will not create a disincentive for manufacturers to properly optimize vehicles for customer fuel efficiency. First, the impact of the certification duty cycles versus any other real-world cycle will be relatively small because they affect only a small fraction of all vehicle technologies. Second, the emission averaging and fleet average provisions mean that the regulations will not require all vehicles to meet the standards. Vehicles exceeding a standard over the duty cycles because they are optimized for different in-use operation can be offset by other vehicles that perform better over the certification duty cycles. Third, vehicle manufacturers also have the ability to lower such a vehicle's measured GHG emissions by adding technology that would improve fuel efficiency both over the certification duty cycles and in-use (and to be potentially eligible to generate off-cycle credits in doing so). These standards are not intended to be at a stringency where manufacturers will be expected to apply all technologies to all vehicles. Thus, there should be technologies available to add to vehicle configurations that initially fail to meet the Phase 2 standards. Fourth, we are further sub-categorizing the vocational vehicle segment compared to Phase 1, tripling the number of subcategories within this segment from three to nine. These nine subcategories will divide each of the three Phase 1 weight categories into three additional vehicle speed categories. Each of the three speed categories will have unique duty cycle weighting factors to recognize that different vocational chassis are configured for different vehicle speed applications. This further subdivision better recognizes technologies' performance under the conditions for which the vocational chassis was configured to operate. This also decreases the potential of the certification duty cycles to encourage manufacturers to configure vocational chassis differently than the optimum configuration for specific customers' applications. Similarly, for the tractor category we are finalizing a new ''heavy-haul'' category to recognize the greater payload and vehicle mass of these tractors, as well as their limitations to effectively utilize some technologies like aerodynamic technologies. These new categories help minimize differences between GEM simulation and real-world operation. Finally, we are also recognizing seven specific vocational vehicle applications under the optional custom chassis vocational vehicle standards.

Another disadvantage of our full vehicle simulation approach is the potential requirement for engine manufacturers to disclose information to vehicle manufacturers who install their engines that engine manufacturers might consider to be proprietary. Under this approach, vehicle manufacturers may need to know some additional details about engine performance long before production, both for compliance planning purposes, as well as for the actual submission of applications for certification. Moreover, vehicle manufacturers will need to know details about the engine's performance that are generally not publicly available—specifically the detailed steady-state fuel consumption map of an engine. Some commenters expressed significant concern about the Phase 2 program forcing the disclosure of proprietary steady-state engine performance information to business competitors; especially prior to an engine being introduced into commerce. It can be argued that a sufficiently detailed steady-state engine map, such as the one required for input into GEM, can reveal proprietary engine design elements such as intake air, turbo-charger, and exhaust system design; exhaust gas recirculation strategies; fuel injection strategies; and exhaust after-treatment thermal management strategies. Conversely, the agencies also received comments requesting that all GEM inputs be made public, as a matter of transparency and public interest.

It is unclear at this point whether such information is truly proprietary. In accordance with Federal statutes, EPA does not release information from certification applications (or other compliance reports) that we determine to be Confidential Business Information (CBI) under 40 CFR part 2. Consistent with section 114(c) of the CAA, EPA does not consider emission test results to be CBI *after* introduction into commerce of the certified engine or vehicle. However, we have generally treated test results as protected *before* a product's introduction into commerce date. EPA has not yet made a final CBI determination for Phase 1 or Phase 2 GEM inputs. Nevertheless, at this time we expect to continue our current policy of non-disclosure prior to introduction into commerce, but we consider it likely that we would ultimately not treat any test results or other GEM inputs as CBI *after* the introduction into commerce date, as identified by the manufacturer.

To further address the specific concern about the Phase 2 program forcing the disclosure of proprietary steady-state engine maps to business competitors, especially prior to an engine being introduced into commerce, the agencies are finalizing an option for engine manufacturers to certify only ''cycle average'' engine maps over the 55-mph and 65-mph GEM cycles and separately mandating the cycle average approach for use over the ARB Transient cycle. See Section II.B. above. The advantage to this approach is that each data point of a cycle average map represents the average emissions over an entire cycle. Therefore, the cycle average engine map approach does not reveal any potentially proprietary information about an engine's performance at a particular steady-state point of operation.

(b) Advantages of Separate Engine Standards

For engines installed in tractors and vocational vehicle chassis, we are maintaining separate engine standards for fuel consumption and GHG emissions in Phase 2 for both spark-ignition (SI, generally but not exclusively gasoline-fueled) and compression-ignition (CI, generally but not exclusively diesel-fueled) engines. Moreover, we are adopting a sequence of new more stringent engine standards for CI engines for engine model years 2021, 2024 and 2027. While the vehicle standards alone are intended to provide sufficient incentive for improvements in engine efficiency, we continue to see important advantages to maintaining separate engine standards for both SI and CI engines. The agencies believe the advantages described below are critical to fully achieve the goals of the EPA and NHTSA standards.

First, EPA has a robust compliance program based on separate engine testing. For the Phase 1 standards, we applied the existing criteria pollutant compliance program to ensure that engine efficiency in actual use reflected the improvements manufacturers claimed during certification. With engine-based standards, it is straightforward to hold engine manufacturers accountable by testing in-use engines in an engine dynamometer laboratory. If the engines exceed the standards, manufacturers can be required to correct the problem or perform other remedial actions. Without separate engine standards in Phase 2, addressing in-use compliance would be more subjective. Having clearly defined compliance responsibilities is important to both the agencies and to the manufacturers.

Second, engine standards for CO_2 and fuel efficiency force engine manufacturers to optimize engines for both fuel efficiency and control of non-CO_2 emissions at the same engine operating points. This is of special concern for NO_X emissions, given the strong counter-dependency between engine-out NO_X emissions and fuel consumption. By requiring engine manufacturers to comply with both NO_X and CO_2 standards using the same test procedures, the agencies ensure that manufacturers include technologies that can be optimized for both, rather than alternate, calibrations that would trade NO_X emissions against fuel consumption, depending how the engine or vehicle is tested. In the past, when there was no CO_2 engine standard and no steady-state NO_X standard, some manufacturers chose this dual calibration approach instead of investing in technology that would allow them to simultaneously reduce both CO_2 and NO_X.

It is worth noting that these first two advantages foster fair competition within the marketplace. In this respect, the separate engine standards help assure manufacturers that their competitors are not taking advantage of regulatory ambiguity. The agencies believe that the absence of separate engine standards would leave open the opportunity for a manufacturer to choose a high-risk compliance strategy by gaming the NO_X-CO_2 tradeoff. Manufacturer concerns that competitors might take advantage of this can create a dilemma for those who wish to fully comply, but also perceive shareholder pressure to choose a high-risk compliance strategy to maintain market share.

Finally, the existence of meaningful separate engine standards allows the agencies to exempt certain vehicles from some or all of the vehicle standards and requirements without forgoing the engine improvements. A good example of this is the off-road vehicle exemption in 40 CFR 1037.631 and 49 CFR 535.3, which exempts vehicles ''intended to be used extensively in off-road environments'' from the vehicle requirements. The engines used in such vehicles must still meet the engine standards of 40 CFR 1036.108 and 49 CFR 535.5(d). The agencies see no reason why efficient engines cannot be used in such vehicles. However, without separate engine standards, there would be no way to require the engines to be efficient. The engine standards provide a similar benefit with respect to the custom chassis program discussed in Section V.

In the past there has been some confusion about the Phase 1 separate engine standards somehow preventing the recognition of engine-vehicle optimization that vehicle manufacturers perform to minimize a vehicle's overall fuel consumption. It was not the existence of separate engine standards that prevented recognition of this optimization. Rather it was that the agencies did not allow manufacturers to enter inputs into GEM that characterized unique engine performance. For Phase 2 we are requiring that manufacturers input such data because we intend for GEM to recognize this engine-vehicle optimization. The continuation of separate engine standards in Phase 2 does not undermine in any way the recognition of this optimization in GEM.

C. Phase 2 GEM and Vehicle Component Test Procedures [146]

GEM was originally created for the certification of tractors and vocational vehicle chassis to the agencies' Phase 1 CO_2 and fuel efficiency standards. See 76 FR 57116, 57146, and 57156–57157. For Phase 2 the agencies proposed a number of modifications to GEM, and based on public comments in response to the agencies' proposed modifications, the agencies have further refined these modifications for this final action.

In Phase 1 the agencies adopted a regulatory structure where regulated entities are required to use GEM to simulate and certify tractors and vocational vehicle chassis. This computer program is provided free of charge for unlimited use, and the program may be downloaded by anyone from EPA's Web site: *http://www3.epa.gov/otaq/climate/gem.htm.* GEM mathematically combines the results of a number of performance tests of certain vehicle components, along with other pre-determined vehicle attributes and driving patterns to determine a vehicle's characteristic levels of fuel consumption and CO_2 emissions, for certification purposes. For Phase 1, the required inputs to GEM for tractors include vehicle aerodynamics information, tire rolling resistance, and whether or not a vehicle is equipped with certain lightweight high-strength steel or aluminum components, a tamper-proof speed limiter, or tamper-proof idle reduction technologies. For Phase 1, the sole input for vocational vehicles is tire rolling resistance. For Phase 1, the computer program's inputs did not include engine test results or attributes related to a vehicle's powertrain; namely, its transmission, drive axle(s), or tire revolutions per mile. Instead, for Phase 1 the agencies specified generic engine and powertrain attributes within GEM. For Phase 1 these are fixed and cannot be changed in GEM.[147]

Similar to other vehicle simulation computer programs, GEM combines various vehicle inputs with known physical laws and justified assumptions to predict vehicle performance for a given period of vehicle operation. GEM represents this information numerically, and this information is integrated as a function of time to calculate CO_2 emissions and fuel consumption. Some of the justified assumptions in GEM include average energy losses due to friction between moving parts of a vehicle's powertrain; the logical behavior of an average driver shifting from one transmission gear to the next; and speed limit assumptions such as 55 miles per hour for urban highway driving and 65 miles per hour for rural interstate highway driving. The sequence of the GEM vehicle simulation can be visualized by imagining a human driver initially sitting in a parked running tractor or vocational vehicle. The driver then proceeds to drive the vehicle over a prescribed route that includes three distinct patterns of driving: Stop-and-go city driving, urban highway driving, and rural interstate highway driving. The driver then exits the highway and brings the vehicle to a stop, with the engine still running at idle. This concludes the vehicle simulation sequence.

Over each of the three driving patterns or ''duty cycles,'' GEM simulates the driver's behavior of pressing the accelerator, coasting, or applying the brakes. GEM also simulates how the engine operates as the gears in the vehicle's transmission are shifted and how the vehicle's weight, aerodynamics, and tires resist the forward motion of the vehicle. GEM combines the driver behavior over the duty cycles with the various vehicle inputs and other assumptions to determine how much fuel must be consumed to move the vehicle forward at each point during the simulation. For Phase 2 the agencies added the effect of road grade. In GEM the effect of road grade on fuel consumption is simulated by increasing fuel consumption uphill, by the amount of fuel consumed by the engine to provide the power needed to raise the mass of the vehicle and its payload against the force of Earth's gravity—while at the same time maintaining the duty cycle's vehicle speed. Downhill road grades are simulated by decreasing the engine's fuel consumption, by the amount of power returned to the vehicle by it moving in the same direction as Earth's gravity. To maintain vehicle speed downhill, simulated brakes are sometimes applied, and the energy lost due to braking results in a certain amount of fuel consumption as well. For each of the three duty cycles, GEM totals the amount of fuel consumed and then divides that amount by the product of the miles travelled and tons of payload carried. The tons of payload carried are specified by the agencies for each vehicle type and weight class, and these cannot be changed in GEM.

In addition to determining fuel consumption over these duty cycles, for Phase 2, GEM calculates a vehicle's fuel consumption rate when it is stopped in traffic with the driver still operating the vehicle (*i.e.,* ''drive idle'') and when the vehicle is stopped and parked with the engine still running (*i.e.,* ''parked idle''). For each regulatory subcategory of tractor and vocational vehicle (*e.g.,* sleeper cab tractor, day cab tractor, light heavy-duty urban vocational vehicle, heavy heavy-duty regional vocational vehicle, etc.), GEM applies the agencies' prescribed weighting factors to each of the three duty cycles and to each of the two idle fuel consumption rates to represent the fraction of city driving, urban highway driving, rural highway driving, drive idle, and parked idle that is typical of each subcategory. After combining the weighted results of all the cycles and idle fuel rates, GEM then outputs a single composite result for the vehicle, expressed as both fuel consumed in gallon per 1,000 ton-miles (for NHTSA standards) and an equivalent amount of CO_2 emitted in grams per ton-mile (for EPA standards). These are the vehicle's GEM results that are used along with other information to demonstrate that a vehicle certificate holder (*e.g.,* a vehicle manufacturer) complies with the applicable standards. This other information includes the annual sales volume of the vehicle family, plus information on emissions credits that may be generated or used as

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[146] The specific version of GEM used to develop these standards, and which we propose to use for compliance purposes is also known as GEM 3.0.

[147] These attributes are recognized in Phase 1 innovative technology provisions at 40 CFR 1037.610.

part of that vehicle family's certification.

For Phase 1 GEM's tractor inputs include vehicle aerodynamics information, tire rolling resistance, and whether or not a vehicle is equipped with lightweight materials, a tamper-proof speed limiter, or tamper-proof idle reduction technologies. Other vehicle and engine characteristics in GEM were fixed as defaults that cannot be altered by the user. These defaults included tabulated data of engine fuel rate as a function of engine speed and torque (*i.e.,* ''engine fuel maps''), transmissions, axle ratios, and vehicle payloads. For tractors, Phase 1 GEM simulates a tractor pulling a standard trailer. For vocational vehicles, Phase 1 GEM includes a fixed aerodynamic drag coefficient and vehicle frontal area.

For Phase 2 new inputs are required and other new inputs are allowed as options. These include the outputs of new test procedures to ''map'' an engine to generate steady-state and transient, cycle-average, engine fuel rate inputs to represent the actual engine in a vehicle. As described in detail in RIA Chapter 4, certification to the Phase 2 standards will require entering new inputs into GEM to describe the vehicle's transmission type and its number of gears and gear ratios. Manufacturers must also enter attributes that describe the vehicle's drive axle(s) type, axle ratio and tire revolutions per mile. We are also finalizing a number of options to conduct additional component testing for the purpose of replacing some of the agencies' ''default values'' in GEM with inputs that are based on component testing. These include optional axle and transmission power loss test procedures. We are also finalizing an optional powertrain test procedure that would replace both the required engine mapping and the agencies' default values for a transmission and its automated shift strategy. We are also finalizing an option to generate cycle-average maps for the 55 mph and 65 mph cycles in GEM. In addition, we have made a number of improvements to the aerodynamic coast-down test procedures and associated aerodynamic data analysis techniques. While these aerodynamic test and data analysis improvements are primarily intended for tractors, for Phase 2 we are providing a streamlined off-cycle credit pathway for vocational vehicle aerodynamic performance to be recognized in GEM.

As proposed, we are finalizing a significantly expanded number of technologies that are recognized in GEM. These include recognizing lightweight thermoplastic materials, automatic tire inflation systems, advanced cruise control systems, workday idle reduction systems, and axle configurations that decrease the number of drive axles. In response to comments and data submitted to the agencies on the Phase 2 proposal we are also finalizing inputs related to tire pressure monitoring systems and advanced electronically controlled vehicle coast systems.

Although GEM is similar in concept to a number of other commercially available vehicle simulation computer programs, the applicability of GEM is unique. First, GEM was designed exclusively for manufacturers and regulated entities to certify tractor and vocational vehicle chassis to the agencies' fuel consumption and CO_2 emissions standards. For GEM to be effective for this purpose, the inputs to GEM include only information related to certain vehicle components and attributes that significantly impact vehicle fuel efficiency and CO_2 emissions. For example, these include vehicle aerodynamics, tire rolling resistance, and powertrain component information. On the other hand, other attributes such as those related to a vehicle's suspension, frame strength, or interior features are not included, where these otherwise might be included in other commercially available vehicle simulation programs that are used for other purposes. Furthermore, the simulated payload, driver behavior and duty cycles in GEM cannot be changed. Keeping these values constant helps to ensure that all vehicles are simulated and certified in the same way. However, these fixed attributes in GEM largely preclude GEM from being of much use as a research tool for exploring the effects of payload, driver behavior and different duty cycles.

Similar to Phase 1, GEM for Phase 2 is available free of charge for unlimited use, and the GEM source code is open source. That is, the programming source code of GEM is freely available upon request for anyone to examine, manipulate, and generally use without restriction. In contrast, commercially available vehicle simulation programs are generally not free and open source. Additional details of GEM are included in Chapter 4 of the RIA.

GEM is a computer software program, and like all other software development processes the agencies periodically released a number of developmental versions of the GEM software for others to review and test during the Phase 2 rulemaking process. This type of user testing significantly helps the agencies detect and fix any problems or ''bugs'' in the GEM software.

As part of Phase 1, the agencies conducted a peer review of GEM version 1.0, which was the version released for the Phase 1 proposal.[148] [149] In response to this peer review and to comments from stakeholders, EPA made changes to the version of GEM released with the Phase 1 final rule. Updates to the Phase 1 GEM were also made via Technical Amendments.[150] The current version of Phase 1 GEM is v2.0.1, which is the version applicable for the Phase 1 standards.[150] As part of the development of GEM for Phase 2, both a formal peer review [149] and a series of expert reviews were conducted.[151] [152] [153] [154]

The agencies have provided numerous opportunities for comment on GEM, and its iterative development. Shortly after the Phase 2 proposal's publication in July 2015 (and before the end of the public comment period), the agencies received comments on GEM. Based on these early comments, the agencies made minor revisions to fix a few bugs in GEM and in August 2015 released an updated version of GEM to the public for additional comment, which also included new information on GEM road grade profiles. The agencies also extended the public comment period on the proposal, which provided at least 30 days for public comment on this slightly updated version of GEM.[153] Then, in response to comments submitted at the close of the comment period, in early January 2016

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[148] See 76 FR 57146–57147.

[149] U.S. Environmental Protection Agency. ''Peer Review of the Greenhouse Gas Emissions Model (GEM) and EPA's Response to Comments.'' EPA–420–R–11–007. Last access on November 24, 2014 at *http://www3.epa.gov/otaq/climate/documents/420r11007.pdf.*

[150] See EPA's Web site at *http://www3.epa.gov/otaq/climate/gem.htm* for the Phase 1 GEM revision dated May 2013, made to accommodate a revision to 49 CFR 535.6(b)(3).

[151] U.S. Environmental Protection Agency, GEM new release (GEM P2v1.1) and known issues and workarounds for GEM P2v1.0), Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2—EPA–HQ–OAR–2014–0827, August 19, 2015.

[152] U.S. Environmental Protection Agency, GEM Power User Release for Debugging, Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2—EPA–HQ–OAR–2014–0827, January 27, 2016.

[153] U.S. Environmental Protection Agency, GEM NODA Release, Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2—EPA–HQ–OAR–2014–0827, February 16, 2016.

[154] U.S. Environmental Protection Agency, GEM Power User Release for Debugging, Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2—EPA–HQ–OAR–2014–0827, May 19, 2016.

the agencies released a ''debugging'' version of GEM to a wide range of expert reviewers.[152] The agencies provided one month for expert reviewers to provide informal feedback for debugging purposes.[152] Because the changes for this debugging version mostly added new features to make GEM easier to use for certifying via optional test procedures, like the powertrain test, there were only minor changes to the way that GEM performed. In the March 2016 NODA, the agencies included another developmental version of GEM[153] for public comment and provided 30 days for public comment. Based on the NREL report, which was also released as part of the NODA for public comment, the NODA version of GEM contained updated weighting factors of the duty cycles and idle cycles.[155] Therefore, the outputs of GEM for a given vehicle configuration changed because these duty cycle weighting factors changed, but there were only minor updates to how the individual technologies were simulated in GEM. Based on comments received on the NODA, the agencies made minor changes to GEM and released another debugging version in May 2016 to manufacturers, NGOs, suppliers, and CARB staff.[154] The most significant change to GEM for the May 2016 version was that 0.5 miles of flat road was added to the beginning and end of the 55 mph and 65 mph drive cycles in response to concerns raised by manufacturers.[156] This change did not change the way that GEM worked, but it did change GEM results because of the change in the duty cycles. This change was made to better align GEM simulation with real-world engine operation. The agencies provided the expert reviewers with at least a 3-week period in which to review GEM and provide feedback. Details on the history of the comments the agencies received and the history of the agencies responses leading to these multiple releases of GEM can be found in Section II.C.(1). The following list summarizes the changes in GEM in response to those comments and data submitted to the agencies in response to the Phase 2 proposal, NODA and other GEM releases:

- Revised road grade profiles for 55- and 65-mph cruise cycles, only minor changes since August 2015.
- Revised idle cycles for vocational vehicles with new vocational cycle weightings, weightings released for public comment in NODA.
- Made changes to the input file structures. Examples includes additions of columns for axle configuration (''6×2,'' ''6×4,'' ''6×4D,'' ''4×2''), and additions of a few more technology improvement inputs, such as ''Neutral Idle,'' ''Start/Stop,'' and ''Automatic Engine Shutdown.'' These were minor changes, all were in NODA version of GEM.
- Made changes to the output file structures. Examples include an option to allow the user to select an output of detailed results on average speed, average work at the input and output of the transmission, and the numbers of shifts for each cycle (*e.g.,* 55 mph cycle, 65 mph cycle and the ARB Transient cycle). These were minor changes, all were in NODA version of GEM.
- Added an input file for optional axle power losses (function of axle output speed and torque) and replaced a single axle efficiency value with lookup table of power loss. These were minor changes to streamline the use of GEM, all were in NODA version of GEM.
- Modified engine torque response to be more realistic, with a fast response region scaled by engine displacement, and a slower torque response in the turbo-charger's highly boosted region. These were minor changes, all were in NODA version of GEM.
- Added least-squares regression models to interpret cycle-average fuel maps for all cycles. These were minor changes to streamline the use of GEM, all were in NODA version of GEM.
- Added different fuel properties according to 40 CFR 1036.530. This was a fix to align GEM with regulations.
- Improved shift strategy based on testing data and comments received. These were minor changes, all were in NODA version of GEM.
- Added scaling factors for transmission loss and inertia, per regulatory subcategory. These were minor changes, all were in NODA version of GEM.
- Added optional input table for transmission power loss data. These were minor changes to streamline the use of GEM, all were in NODA version of GEM.
- Added minimum torque converter lock-up gear user input for automatic transmissions. This was a minor change to streamline the use of GEM, this change was in the NODA version of GEM.
- Revised the default transmission power loss tables, based on test data. This was a minor change to streamline the use of GEM, this change was in the NODA version of GEM.
- Added neutral idle and start/stop effects idle portions of the ARB Transient cycle. These were minor changes, all were in NODA version of GEM
- Adjusted shift and torque converter lockup strategy. This was a minor change to streamline the use of GEM, this change was in the NODA version of GEM.

Notwithstanding these numerous opportunities for public comment (as well as many informal opportunities via individual meetings), some commenters maintained that they still had not received sufficient notice to provide informed comment because each proposal represented too much of a ''moving target.''[157] [158] [159] The agencies disagree. Even at proposal, Phase 2 GEM provided nearly all of the essential features of the version we are promulgating in final form. These include: (1) The reconfiguration of the engine, transmission, and axle sub-models to reflect additional designs and to receive manufacturer inputs; and (2) the addition of road grade and idle cycles for vocational vehicles, along with revised weighting factors. Moreover, the changes the agencies have made to GEM in response to public comment indicates that those comments were highly informed by the proposal. The agencies thus do not accept the contention that commenters were not afforded sufficient information to provide meaningful comment on GEM.

(1) Description of Modifications to GEM From Phase 1 to Phase 2

As explained above, GEM is a computer program that was originally developed by EPA specifically for manufacturers to use to certify to the Phase 1 tractor and vocational chassis standards. GEM mathematically combines the results of vehicle component test procedures with other vehicle attributes to determine a vehicle's certified levels of fuel consumption and CO_2 emissions. Again as explained above, for Phase 1 the required inputs to GEM include vehicle aerodynamics information, tire rolling resistance, and whether or not a vehicle is equipped with certain lightweight

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[155] EPA–HQ–OAR–2014–0827–1621 and NHTSA–2014–0132–0187.

[156] Memo to Docket, ''Summary of Meetings and Conference Calls with the Truck and Engine Manufacturers Association to Discuss the Phase 2 Heavy-Duty GHG Rulemaking'', August 2016.

[157] Memo to Docket, ''Summary of Meetings and Conference Calls with the Truck and Engine Manufacturers Association to Discuss the Phase 2 Heavy-Duty GHG Rulemaking'', August 2016.

[158] Memo to Docket, ''Summary of Meetings and Conference Calls with Allison Transmission to Discuss the Phase 2 Heavy-Duty GHG Rulemaking'', August 2016.

[159] ''Heavy-Duty Phase 2 Stakeholder Meeting Log'', August 2016.

high-strength steel or aluminum components, a tamper-proof speed limiter, or tamper-proof idle reduction technologies for tractors. The vocational vehicle inputs to GEM for Phase 1 only included tire rolling resistance. For Phase 1 GEM's inputs did not include engine test results or attributes related to a vehicle's powertrain; namely, its transmission, drive axle(s), or loaded tire radius. Instead, for Phase 1 the agencies specified a generic engine and powertrain within GEM, and for Phase 1 these cannot be changed in GEM.

For this rulemaking, GEM has been modified as proposed and validated against a set of experimental data that represent over 130 unique vehicle variants conducted at powertrain and chassis dynamometers with the manufacturers' provided transmission shifting tables. In addition, GEM has been validated against different types of tests when the EPA transmission default auto-shift strategy is used, which includes powertrain dynamometer tests and two truck tests running in a real-world driving route. Detailed comparisons can be seen in Chapter 4 of the RIA. As noted above, the agencies believe that this new version of GEM is an accurate and cost-effective alternative to measuring fuel consumption and CO_2 over a chassis dynamometer test procedure. Again as noted earlier, some of the key modifications will require additional vehicle component test procedures (both mandatory and optional) to generate additional GEM inputs. The results of which will provide additional inputs into GEM. These include a new required engine test procedure to provide engine fuel consumption inputs into GEM. We proposed to measure fuel consumption as a matrix of steady-state points, but also sought comment on a newly developed engine test procedure that captures transient engine performance for use in GEM. We are specifying a combination of these procedures for the final rule—steady-state fuel maps for the highway cruise simulations, and cycle-average maps for transient simulations. As an option, cycle average maps could be also used for the highway cruise simulation as well. See Chapter 3 of the RIA for additional discussion of the fuel mapping procedures. We are also requiring inputs that describe the vehicle's transmission type, and its number of gears and gear ratios. We are allowing an optional powertrain test procedure that would provide inputs to override the agencies' simulated engine and transmission in GEM. In addition, in response to comments, we will also allow manufacturers to measure transmission efficiency in the form of the power loss tables to replace the default values in GEM. We are finalizing the proposed requirement to input a description of the vehicle's drive axle(s), including its type (*e.g.,* 6×4 or 6×2) and axle ratio. We are also finalizing the optional axle efficiency test procedure for which we sought comment. This would allow manufacturers to override the agencies' simulated axle in GEM. Chapter 4 of the RIA details all of these GEM related input changes.

As noted above, we are significantly expanding the number of technologies that are recognized in GEM. These include recognizing lightweight thermoplastic materials, automatic tire inflation systems, advanced cruise control systems, engine stop-start idle reduction systems, and axle configurations that decrease the number of drive axles. To better reflect real-world operation, we are also revising the vehicle simulation computer program's urban and rural highway duty cycles to include changes in road grade, and including a new duty cycle to capture the performance of technologies that reduce the amount of time a vehicle's engine is at idle during a workday. Finally, to better recognize that vocational vehicle powertrains are configured for particular applications, we are further subdividing the vocational chassis category into three different vehicle speed categories, where GEM weights the individual duty cycles' results of each of the speed categories differently. Section 4.2 of the RIA details all these modifications. The following sub-sections provide further details on some of these key modifications to GEM.

(a) Simulating Engines for Vehicle Certification

Before describing the Phase 2 approach, this section first reviews how engines are simulated for vehicle certification in Phase 1. As noted earlier, GEM for Phase 1 simulates the same generic engine for any vehicle in a given regulatory subcategory with a data table of steady-state engine fuel consumption mass rates (g/s) versus a series of steady-state engine output shaft speeds (revolutions per minute, rpm) and loads (torque, N·m). This data table is also sometimes called a ''fuel map'' or an ''engine map,'' although the term ''engine map'' can mean other kinds of data in different contexts. The engine speeds in this map range from idle to maximum governed speed and the loads range from engine motoring (negative load) to the maximum load of an engine. When GEM executes a simulation over a vehicle duty cycle, this data table is linearly interpolated to find a corresponding fuel consumption mass rate at each engine speed and load that is demanded by the simulated vehicle operating over the duty cycle. The fuel consumption mass rate of the engine is then integrated over each duty cycle in GEM to arrive at the total mass of fuel consumed for the specific vehicle and duty cycle. Under Phase 1, manufacturers were not allowed to input their own engine fuel maps to represent their specific engines in the vehicle being simulated in GEM. Because GEM was programmed with fixed engine fuel maps for Phase 1 that all manufacturers had to use, the tables themselves did not have to exactly represent how an actual engine might operate over these three different duty cycles.

In contrast, for Phase 2 we are requiring manufacturers to generate their own engine fuel maps to represent each of their engine families in GEM. This Phase 2 approach is consistent with the 2014 NAS Phase 2 First Report recommendation.[160] To investigate this approach, before proposal we examined the results from 28 individual engine dynamometer tests. Three different engines were used to generate this data, and these engines were produced by two different engine manufacturers. One engine was tested at three different power ratings (13 liters at 410, 450 & 475 bhp) and one engine was tested at two ratings (6.7 liters at 240 and 300 bhp), and other engine with one rating (15 liters 455 bhp) service classes. For each engine and rating the steady-state engine dynamometer test procedure was conducted to generate an engine fuel map to represent that particular engine in GEM. Next, with GEM, we simulated various vehicles in which the engine could be installed. For each of the GEM duty cycles we are using, namely the urban local (ARB Transient), urban highway with road grade (55 mph), and rural highway with road grade (65 mph) duty cycles, we determined the GEM result for each vehicle configuration, and we saved the engine output shaft speed and torque information that GEM created to interpolate the steady-state engine map for each vehicle configuration We then had this same engine output shaft speed and torque information programmed into an engine dynamometer controller, and we had each engine perform the same duty cycles that GEM demanded of the

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[160] National Academy of Science. ''Reducing the Fuel Consumption and GHG Emissions of Medium- and Heavy-Duty Vehicles, Phase Two, First Report.'' 2014. Recommendation 3.8.

simulated version of the engine. We then compared the GEM results based on GEM's linear interpolation of the engine maps to the measured engine dynamometer results. We concluded that for the 55 mph and 65 mph duty cycles, GEM's interpolation of the steady-state data tables was sufficiently accurate versus the measured results. This is an outcome one would reasonably expect because even with changes in road grade, the 55 mph and 65 mph duty cycles do not demand rapid changes in engine speed or load. The 55 mph and 65 mph duty cycles are nearly steady-state, as far as engine operation is concerned, just like the engine maps themselves. However, for the ARB Transient cycle, we observed a consistent bias when using the steady-state maps, where GEM consistently under-predicted fuel consumption and CO_2 emissions. This low bias over the 28 engine tests ranged from 4.2 percent low to 7.8 percent low. The mean was 5.9 percent low and the 90th percentile value was 7.1 percent low. These observations are consistent with the fact that engines generally operate less efficiently under transient conditions than under steady-state conditions.

A number of reasons explain this consistent trend. For example, under rapidly changing (*i.e.* transient) engine conditions, it is generally more challenging to program an engine electronic controller to respond with optimum fuel injection rate and timing, exhaust gas recirculation valve position, variable nozzle turbocharger vane position and other set points than under steady-state conditions. Transient heat and mass transfer within the intake, exhaust, and combustion chambers also tend to increase turbulence and enhance energy loss to engine coolant during transient operation. In many cases during cold transient operation, the thermal management is triggered in order to maintain optimal performance of selective catalytic reduction devices for a diesel engine. Furthermore, because exhaust emissions control is more challenging under transient engine operation, engineering tradeoffs sometimes need to be made between fuel efficiency and transient criteria pollutant emissions control. Special calibrations are typically also required to control smoke and manage exhaust temperatures during transient operation for a transient cycle.

To account for these effects in GEM, the agencies have developed and are finalizing a test procedure called ''cycle average'' mapping to account for this transient behavior (40 CFR 1036.540). Detailed analyses and presentation of the test procedure was published in two peer-reviewed journal articles.[139,140] A number of commenters likewise suggested this approach. Additionally, progress has been made on further improving this test procedure since publication, based on a large number of engine dynamometer tests conducted by a variety of laboratory test facilities.[161] Since the proposal, further refinement of the numerical schemes used for interpreting cycle average engine fuel map was also completed. The engine dynamometer tests include a Cummins medium duty ISB engine, a Navistar heavy duty N13 engine, a Volvo heavy duty D13 engine, and a Cummins heavy duty ISX engine. All testing results indicated that the new test procedure works well for the transient ARB cycle.[162] In addition, Cummins in their NODA comments (see the following paragraph) provided additional data supporting this approach with their ISL 450 bhp rating engine. This data corroborated earlier data showing good agreement between engine dynamometer tests and the cycle average engine mapping approach.[163]

EPA solicited comment on the cycle average approach at proposal. 80 FR 40193. EPA also specifically provided notice and a 30-day opportunity for public comment on the possibility of requiring use of the cycle average mapping approach for the ARB Transient cycle. This was included in the version of GEM that was made available for public comment as part of the NODA [153]. In response, many comments were received on the cycle average approach. These include comments from Cummins [163] and Volvo.[164] Cummins was very supportive of the cycle average approach and also supported applying this approach to the 55 mph and 65 mph cruise cycles in GEM. Volvo expressed some concern over having enough time to fully evaluate this approach. The agencies believe that one of the reasons that Volvo expressed concern over having enough time to evaluate this approach is because Volvo initially declined working with the agencies to collaboratively refine this approach. At the same time, a number of Volvo's competitors chose to actively coordinate laboratory testing and technical analysis to contribute to the development of this approach. We believe these other manufacturers gained a deeper understanding of the approach earlier than Volvo because they invested time and resources to make technical contributions at earlier point in time. Nevertheless, the agencies fully welcome and appreciate Volvo's more recent active involvement in reviewing the cycle average approach and for making a number of productive suggestions for further refinement.

While the agencies are finalizing the cycle average engine mapping test procedure as mandatory for the ARB Transient cycle, for the 55 mph and 65 mph GEM drive cycles, the agencies are finalizing the same steady-state mapping procedure that the agencies originally proposed. The only difference is that we are finalizing about 85 unique steady-state map points, versus the about 143 points that were proposed. See 40 CFR 1036.535 for details. We are adopting a lower number of points because many of the originally proposed points were specified for use with the ARB Transient cycle.[139] Again, as an option, the cycle average mapping test procedure also may be used for these two cruise speed cycles, in lieu of the steady-state mapping procedure.

(b) Simulating Human Driver Behavior and Transmissions for Vehicle Certification

GEM for Phase 1 simulates the same generic human driver behavior and manual transmission shifting patterns for all vehicles. The simulated driver responds to changes in the target vehicle speed of the duty cycles by changing the simulated positions of the vehicle's accelerator pedal, brake pedal, clutch pedal, and gear shift lever. For simplicity, in Phase 1 the GEM driver shifted at pre-specified vehicle speeds and the manual transmission was simulated as an ideal transmission that did not have any delay time (*i.e.,* torque interruption) between gear shifts and did not have any energy losses associated with clutch slip during gear shifts.

In GEM for Phase 2 we are allowing manufacturers to select one of four types of transmissions to represent the transmission in the vehicle they are certifying: Manual transmission (MT), automated manual transmission (AMT), automatic transmission (AT) and dual clutch transmission (DCT). For Phase 2 the agencies proposed unique transmission shifting patters to

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[161] Memos to Docket, ''Test Procedure Review with Cummins, Volvo, Navistar, Paccar, Daimler Eaton and Allison.''

[162] Michael Ross, *Validation Testing for Phase 2 Greenhouse Gas Test Procedures and the Greenhouse Gas Emission Model (GEM) for Medium and Heavy-Duty Engines and Powertrains,* Final Report to EPA, Southwest Research Institute, June 2016, found in docket of this rulemaking, EPA–HQ–QAR–2014–0827.

[163] Cummins NODA Comments, found in Phase 2 Docket: ID No. EPA–HQ–OAR–2014–0817, April 1, 2016.

[164] Volvo Group NODA Comments, found in Phase 2 Docket: ID No. EPA–HQ–OAR–2014–0817, April 1, 2016.

represent the different types of automated transmissions. These shifting patterns over the steady state cruise cycles has been further modified from the proposed version to be more realistic with respect to slight variations in vehicle speed due to road grade. In particular, when going downhill, the simulated vehicle is now allowed to exceed the speed target by 3 mph before the brakes are applied. In the proposed version, the driver model applied the brakes much sooner to prevent the vehicle from exceeding the speed target. This change allows the vehicle to carry additional momentum into the next hill, much the same as real drivers would.

In the final version of GEM, the driver behavior and the different transmission types are simulated in the same basic manner as in Phase 1, but each transmission type features unique transmission responses that match the transmission responses we measured during vehicle testing of these three transmission types. In general the transmission gear shifting strategy for all of the transmissions is designed to shift the transmission so that it is in the most efficient gear for the current vehicle demand, while staying within certain limits to prevent unrealistically high frequency shifting (*i.e.,* to prevent ''short-shifting''). Some examples of these limits are torque reserve limits (which vary as function of engine speed), minimum time-in-gear and minimum fuel efficiency benefit to shift to the next gear. Some of the differences between the transmission types include a driver ''double-clutching'' during gear shifts of the manual transmission only, and ''power shifts'' and torque converter torque multiplication, slip, and lock-up in automatic transmissions only. Refer to Chapter 4 of the RIA for a more detailed description of these different simulated driver behaviors and transmission types.

Prior to the proposal, we considered an alternative approach where transmission manufacturers would provide vehicle manufacturers with detailed information about their automated transmissions' proprietary shift strategies for representation in GEM. NAS also recommended this approach.[165] The advantages of this approach would include a more realistic representation of a transmission in GEM and potentially the recognition of additional fuel efficiency improving strategies to achieve additional fuel consumption and CO_2 emissions reductions. However, there are a number of technical and compliance disadvantages of this approach. One disadvantage is that it would require the disclosure of proprietary information because some vehicle manufacturers produce their own transmissions and also use other suppliers' transmissions. There are technical challenges too. For example, some transmission manufacturers have upwards of 40 different shift strategies programmed into their transmission controllers. Depending on in-use driving conditions, some of which are not simulated in GEM (*e.g.,* changing payloads, changing tire traction) a transmission controller can change its shift strategy. Representing dynamic switching between multiple proprietary shift strategies would be extremely complex to simulate in GEM. Furthermore, if the agencies were to require transmission manufacturers to provide shift strategy inputs for use in GEM, then the agencies would have to devise a compliance strategy to monitor in-use shift strategies, including a driver behavior model that could be implemented as part of an in-use shift strategy confirmatory test. This too would be very complex. If manufacturers were subject to in-use compliance requirements of their transmission shift strategies, this could lead to restricting the use of certain shift strategies in the heavy-duty sector, which would in turn potentially lead to sub-optimal vehicle configurations that do not improve fuel efficiency or adequately serve the wide range of customer needs; especially in the vocational vehicle segment. For example, if the agencies were to restrict the use of more aggressive and less fuel efficient in-use shift strategies that are used only under heavy loads and steep grades, then certain vehicle applications would need to compensate for this loss of capability through the installation of over-sized and over-powered engines that are subsequently poorly matched and less efficient under lighter load conditions. Therefore, as a policy consideration to preserve vehicle configuration choice and to preserve the full capability of heavy-duty vehicles today, the agencies are intentionally not allowing transmission manufacturers to submit detailed proprietary shift strategy information to vehicle manufacturers to input into GEM. The agencies are finalizing as proposed that vehicle manufacturers can choose from among several transmission types that the agencies have already developed, validated, and programmed into GEM. The vehicle manufacturers will then enter into GEM their particular transmission's number of gears and gear ratios, optionally together with power loss tables representing their transmission's gear friction, pumping and spin losses. If a manufacturer chooses to use the optional powertrain test procedure, however, then the agencies' transmission types in GEM would be overridden by the actual data collected during the powertrain test, which would recognize the transmission's unique shift strategy. (Presumably, vehicle manufacturers will choose to use the optional powertrain test procedure only if their actual transmission shift strategy is more efficient compared to its respective default shift strategy simulated by GEM.)

(c) Simulating Axles for Vehicle Certification

In GEM for Phase 1 the axle ratio of the primary drive axle and the energy losses assumed in the simulated axle itself were the same for all vehicles. For Phase 2 the vehicle manufacturer will be required to input into GEM the axle ratio of the primary drive axle. This input will recognize the design to operate the engine at a particular engine speed when the transmission is operating in its highest transmission gear; especially for the 55 mph and 65 mph duty cycles in GEM. This input facilitates GEM's recognition of vehicle designs that take advantage of operating the engine at the lowest possible engine speeds. This is commonly known as ''engine down-speeding,'' and the general rule-of-thumb for heavy-duty engines is that for every 100 rpm decrease in engine speed, there can be about a 1 percent decrease in fuel consumption and CO_2 emissions. Therefore, it is important that GEM allow this value to be input by the vehicle manufacturer. Axle ratio is also straightforward to verify during any in-use compliance audit. UCS and ACEEE commented that engine down-speeding should be recognized in the agencies' separate engine standards, rather than in the vehicle standard. The agencies disagree with this because recognizing down-speeding at the vehicle level ensures that the powertrain configuration in-use, in the real world, will lead to the engine operating at lower speeds. In contrast, the engine speeds specified in the separate engine standards' test procedures are based on the engine's maximum torque versus speed curve (*i.e.,* lug curve) and not on the configuration of the powertrain to

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[165] Transportation Research Board 2014. ''Reducing the Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two.'' (''Phase 2 First Report'') Washington, DC, The National Academies Press. Cooperative Agreement DTNH22–12–00389. Available electronically from the National Academy Press Web site at *http://www.nap.edu/catalog.php?record_id=12845* (last accessed December 2, 2014). Recommendation 3.7.

which the engine is attached in a vehicle. This means that even if a manufacturer manipulated the engine's lug curve such that the separate engine standards' test procedure led to the engine operating at lower speeds during certification, that same engine could be installed in a vehicle with a powertrain configured for the engine to operate at higher engine speeds. Therefore, recognizing down-speeding within GEM, at the vehicle level, best ensures that the agencies' test procedures and standards lead to real-world engine down-speeding in-use.

We proposed to use a fixed axle ratio energy efficiency of 95.5 percent at all speeds and loads, but requested comment on whether this pre-specified efficiency is reasonable. 80 FR 40185. In general, commenters stated that the efficiency of the axle actually varies as a function of axle ratio, axle speed, and axle input torque. Therefore, we have modified GEM to accept an input data table of power loss as a function of axle speed and axle torque. The modified version of GEM subsequently interpolates this table over each of the duty cycles to represent a more realistic axle efficiency at each point of each duty cycle. The agencies specify a default axle efficiency table in GEM for any manufacturer to use. We are also finalizing an optional axle power loss test procedure that requires the use of a dynamometer test facility (40 CFR 1037.560). With this optional test procedure, a manufacturer can create an axle efficiency table for use in lieu of the EPA default table. We requested comment on this test procedure in the proposal, and we received supportive comments. Refer to 40 CFR 1037.560 of the Phase 2 regulations, which contain this test procedure.

Moreover, the final regulations allow the manufacturers to develop analytical methods to derive axle efficiency tables for untested axle configurations, based on testing of similar axles. This would be similar to the analytically derived CO_2 emission calculations allowed for pickups and vans. However, manufacturers would be required to obtain prior approval from the agencies before using analytically derived values. In addition, the agencies could conduct confirmatory testing or require a selective enforcement audit for any axle configuration. See 40 CFR 1037.235.

In addition to requiring the primary drive axle ratio input into GEM (and an option to input an actual axle power loss data table), we are requiring that the vehicle manufacturer input into GEM whether one or two drive axles are driven by the engine. When a heavy-duty vehicle is equipped with two rear axles where both are driven by the engine, this is called a ''6×4'' configuration. ''6'' refers to the total number of wheel hubs on the vehicle. In the 6×4 configuration there are two front wheel hubs for the two steer wheels and tires plus four rear wheel hubs for the four rear wheels and tires (or more commonly four *sets* of rear dual wheels and tires). ''4'' refers to the number of wheel hubs driven by the engine. These are the two rear axles that have two wheel hubs each. Compared to a 6×4 configuration, a 6×2 configuration decreases axle energy loss due to friction and oil churning in two driven axles, by driving only one axle. The decrease in fuel consumption and CO_2 emissions associated with a 6×2 versus 6×4 axle configuration can be in the range of 2.5 percent depending on specific axles, which is modeled by the power loss table.[166] Therefore, in the Phase 2 version of GEM, if a manufacturer simulates a 6×2 axle configuration using the default axle efficiencies, GEM decreases the overall GEM result roughly by 2.5 percent on average through the power loss table. Note that GEM will similarly decrease the overall GEM result by 2.5 percent for a 4×2 tractor or Class 8 vocational chassis configuration if it has only two wheel hubs driven. If a manufacturer does not use the default efficiencies, the benefit of 6×2 and 4×2 configurations will be reflected directly in its input tables. Note that the Phase 2 version of GEM does not have an option to simulate more than two drive axles or configurations where the front axle(s) are driven or where there are more than two rear axles. The regulations specify that such vehicles are to be simulated as 6×4 vehicles in GEM. This is consistent with how the standards were developed and the agencies believe this approach will provide the appropriate incentive for manufacturers to apply the same fuel saving technologies to these vehicles, as they would to their conventional 6×4 vehicles. Moreover, because these configurations are manufactured for specialized vehicles that require extra traction for off-road applications, they have very low sales volume and any increased fuel consumption and CO_2 emissions from them are not significant in comparison to the overall reductions of the Phase 2 program. Note that 40 CFR 1037.631 (for off-road vocational vehicles), which is being continued from the Phase 1 program, exempts many of these vehicles from the vehicle standards because they are limited mechanically to low-speed operation.

(d) Simulating Accessories for Vehicle Certification

The agencies proposed to continue the approach from Phase 1 whereby GEM uses a fixed power consumption value to simulate the fuel consumed for powering accessories such as steering pumps and alternators. 80 FR 40186. The final rule continues the Phase 1 approach, as proposed. However, Phase 2 GEM provides an option to provide a GEM input reflecting technology improvement inputs for the accessory loads. This allows the manufacturers to receive credit for those technologies that are not modeled in GEM. Manufacturers seeking credit for those technologies that are not modeled in GEM would generally follow the off-cycle credit program procedures in 40 CFR 1037.610.

(e) Aerodynamics in GEM for Tractor, Vocational Vehicle, and Trailer Certification

Phase 2 GEM simulates aerodynamic drag in using C_dA (the product of the drag coefficient and frontal area of the vehicle) rather than a drag coefficient (C_d). For tractors and trailers we will continue to use an aerodynamic bin approach similar to the one that exists in Phase 1 today, although the actual Phase 2 bins are being revised to reflect new test procedures and our projections for more aerodynamic tractors and trailers in the future. This approach allows manufacturers to determine C_dA (or delta-C_dA in the case of trailers) from coastdown testing, scale wind tunnel testing and/or computational fluid dynamics modeling. It requires tractor manufacturers (but not trailer manufacturers) to conduct a certain minimum amount of coast-down vehicle testing to validate their methods. The regulations also provide an alternate path for trailer manufacturers to rely on testing performed by component suppliers. See 40 CFR 1037.

The results of these tests determine into which bin a tractor or trailer is assigned. GEM uses the aerodynamic drag coefficient applicable to the bin, which is the same for all tractors (or trailers) within a given bin. This approach helps to account for limits in the repeatability of aerodynamic testing and it creates a compliance margin since any test result which keeps the vehicle in the same aerodynamic bin is considered compliant. For Phase 2 we are establishing new boundary values for the bins themselves and we are adding two additional tractor bins in order to recognize further advances in

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[166] NACFE. Executive Report—6×2 (Dead Axle) Tractors. November 2010. See Docket EPA–HQ–OAR–2014–0827.

aerodynamic drag reduction beyond what was recognized in Phase 1. Furthermore, while Phase 1 GEM used predefined frontal areas for tractors where the manufacturers input only a C_d value, manufacturers will use a measured drag area (C_dA) value for each tractor configuration for Phase 2. See 40 CFR 1037.525. The agencies do not project that vocational vehicles will need to improve their aerodynamic performance to comply with the Phase 2 vocational chassis standards. However, the agencies are providing features in GEM for vocational vehicles to receive credit for improving the aerodynamics of vocational vehicles (see 40 CFR 1037.520(m)).

In addition to these changes, we are making a number of aerodynamic drag test procedure improvements. One improvement is to update the ''standard trailer'' that is prescribed for use during aerodynamic drag testing of a tractor. Using the C_dA from such testing means the standard trailer would also be the hypothetical trailer modeled in GEM to represent a trailer paired with the tractor in actual use.[167] In Phase 1, a non-aerodynamic 53-foot long box-shaped dry van trailer was specified as the standard trailer for tractor aerodynamic testing (see 40 CFR 1037.501(g)). For Phase 2 we are modifying this standard trailer for tractor testing to make it more similar to the trailers we expect to be produced during the Phase 2 timeframe. More specifically, we are prescribing the installation of aerodynamic trailer skirts (and low rolling resistance tires as applied in Phase 1) on the standard trailer, as discussed in further in Section III.E.2. As explained more fully in Sections III and IV, the agencies believe that tractor-trailer pairings will be optimized aerodynamically to a significant extent in-use (such as using high-roof cabs when pulling box trailers), and that this real-world optimization should be reflected in the certification testing. We are also revising the test procedures to better account for average wind yaw angle to reflect the true impact of aerodynamic features on the in-use fuel consumption and CO_2 emissions of tractors, again as discussed in more detail in Section III below. Refer to the test procedures in 40 CFR 1037.525 through 1037.527 for further details of these aerodynamic test procedures.

For trailer certification, the agencies use GEM in a different way than it is used for tractor certification. As described in Section IV, the agencies developed a simple equation to replicate GEM performance. The trailer standards are based on this equation, and trailer manufacturers use this GEM-based equation for certification. The only technologies recognized by this GEM-based equation for trailer certification are aerodynamic technologies, tire technologies (including tire rolling resistance and tire pressure systems), and weight reduction. Note that since the purpose of this equation is to replicate GEM performance, it can be considered as simply another form of the model using a different input interface. Thus, for simplicity, the remainder of this Section II.C. sometimes discusses GEM as being used for trailers, without regard to how manufacturers will actually input GEM variables. As with all of the standards in Phase 2, compliance is measured consistent with the same test methods used by the agencies to establish the standard.

Similar to tractor certification, trailer manufacturers will use data from aerodynamic testing (*e.g.,* coastdown testing, scale wind tunnel testing, computational fluid dynamics modeling, or possibly aerodynamic component testing) with the equation.[168] As part of the protocol for generating these inputs, the agencies are specifying the configuration of a reference tractor for conducting trailer testing. Refer to Section IV of this Preamble and to 40 CFR 1037.501 of the regulations for details on the reference tractor configuration for trailer test procedures.

Finally, GEM has been modified to accept an optional delta C_dA value for vocational chassis, to simulate aerodynamic improvements relative to pre-specified baseline defined in Chapter 4 of RIA. For example, a manufacturer that demonstrates that adding side skirts to a box truck reduces its C_dA by 0.2 m^2 could input that value into GEM for box trucks that include those skirts. See 40 CFR 1037.520(m).

(f) Tires and Tire Inflation Systems for Truck and Trailer Certification

For GEM in Phase 1 tractor and vocational chassis manufacturers input the tire rolling resistance of steer and drive tires directly into GEM. The agencies prescribed an internationally recognized tire rolling resistance test procedure, ISO 28580, for determining the tire rolling resistance value that is input into GEM, as described in 40 CFR 1037.520(c). For Phase 2 we will continue this same approach and the use of ISO 28580, and we are expanding these requirements to trailer tires as well.

In addition to tire rolling resistance, Phase 2 vehicle manufacturers will enter into GEM the tire manufacturer's specified revolutions per distance directly (revs/mile) for the vehicle's drive tires. This value is commonly reported by tire manufacturers already so that vehicle speedometers can be adjusted appropriately. This input value is needed so that GEM can accurately convert simulated vehicle speed into axle speed, transmission speed, and ultimately engine speed.

For tractors and trailers, we proposed to allow manufacturers to specify whether or not an automatic tire inflation system (ATIS) is installed. 80 FR 40187. Based on comments and as discussed further in Sections III, IV, and V, in the Phase 2 final rule we are adopting provisions that allow manufacturers of tractors, trailers, and vocational vehicle chassis to input a percent decrease in overall fuel consumption and CO_2 emissions into GEM if the vehicle includes either an ATIS or a tire pressure monitoring system (TPMS). The value that can be input depends on whether a TPMS or ATIS is deployed. See 40 CFR 1037.520.

(g) Weight Reduction for Tractor, Vocational Chassis and Trailer Certification

Phase 2 GEM continues the weight reduction recognition approach in Phase 1, where the agencies prescribe fixed weight reductions, or ''deltas,'' for using certain lightweight materials for certain vehicle components. In Phase 1 the agencies published a list of weight reductions for using high-strength steel and aluminum materials on a part by part basis. For Phase 2 we use updated values for high-strength steel and aluminum parts for tractors and for trailers and we have scaled these values for use in certifying the different weight classes of vocational chassis. In addition we use a similar part by part weight reduction list for tractor parts made from thermoplastic material. We proposed to assign a fixed weight increase to natural gas fueled vehicles to reflect the weight increase of natural gas fuel tanks versus gasoline or diesel tanks, but we are not finalizing that provision based on comments. 80 FR 40187. Commenters opposing this provision generally noted that the proposed provision was not consistent with how the agencies were treating other technologies. We agree that

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[167] See Section III. for a discussion of how GEM will model a more advanced trailer beginning with the 2027 model year.

[168] The agencies project that more than enough aerodynamic component vendors will take advantage of proposed optional pre-approval process to make testing optional for trailer manufacturer.

natural gas vehicles should be treated consistently with other technologies and so are not adopting the proposed provision.

For tractors, we will continue the same mathematical approach in GEM to assign ⅓ of a total weight decrease to a payload increase and ⅔ of the total weight decrease to a vehicle mass decrease. For Phase 1, these ratios were based on the average frequency that a tractor operates at its gross combined weight rating. We will also use these ratios for trailers in Phase 2. For vocational chassis, for which Phase 1 did not address weight reduction, we will assign ½ of a total weight decrease to a payload increase and ½ of the total weight decrease to a vehicle mass decrease.

(h) GEM Duty Cycles for Tractor, Vocational Chassis and Trailer Certification

In Phase 1, there are three GEM vehicle duty cycles that represent stop-and-go city driving (ARB Transient), urban highway driving (55 mph), and rural interstate highway driving (65 mph). In Phase 1 these cycles were time-based. That is, they were specified as a function of simulated time and the duty cycles ended once the specified time elapsed in simulation. The agencies proposed to continue to use these three drive cycles in Phase 2, but with some revisions. 80 FR 40187. We are finalizing revisions similar but not identical to those that were proposed. First, GEM will simulate these cycles on a distance-based specification, rather than on a time-based specification. A distance-based specification ensures that even if a vehicle in simulation does not always achieve the target vehicle speed, the vehicle will have to continue in simulation for a longer period to complete the duty cycle. This ensures that vehicles are evaluated over the complete distance of the duty cycle and not just the portion of the duty cycle that a vehicle completes in a given time period. A distance-based duty cycle specification also facilitates a straightforward specification of road grade as a function of distance along the duty cycle. As noted in above, for Phase 2, the agencies have enhanced the 55 mph and 65 mph duty cycles by adding representative road grade to exercise the simulated vehicle's engine, transmission, axle, and tires in a more realistic way. A flat road grade profile over a constant speed test does not properly simulate a transmission with respect to shifting gears, and may have the unintended consequence of enabling underpowered vehicles or excessively down-sped drivetrains to generate credits, when in actuality the engine does not remain down-sped in-use when the vehicle encounters road grades. The road grade profile being finalized is the same hill and valley profile for both the 55 mph and 65 mph duty cycles, and is based on statistical analysis of the United States' national distribution of road grades. Although the final profile is different than that proposed, the agencies provided notice of the analysis that was used to generate the final profile.[169] In written comments, we received in-use engine data from some manufacturers, and based on this information we made minor adjustments to the road grade to ensure that engines simulated in GEM operated similarly to that reported in the in-use engine data submitted to us. See Section III.E.(2)(b) of this document and Chapter 3.4.2.1 of the RIA for more details on development of the road grade profile. We believe that the enhancement of the 55 mph and 65 mph duty cycles with road grade is consistent with the NAS recommendation regarding road grade.[170]

(i) Workday Idle Operation for Vocational Chassis Certification

In the Phase 1 program, reduction in idle emissions was recognized only for sleeper cab tractors, and only with respect to hoteling idle, where a driver needs power to operate heating, ventilation, air conditioning and other electrical equipment in order to use the sleeper cab to eat, rest, or conduct other business. As described in Section V, GEM for Phase 2 will recognize technologies that reduce workday idle emissions, such as automatic stop-start systems, daytime parked idle automatic engine shutdown systems, and transmissions that either automatically or inherently shift to neutral at idle while in drive. Many vocational vehicle applications operate on patterns implicating workday idle cycles, and the agencies use test procedures in GEM to account specifically for these cycles and potential idle controls. GEM will recognize these idle controls in two ways. For technologies like neutral-idle transmissions and stop-start systems that address idle that occurs during vehicle operation when the vehicle is stopped at a stop light, GEM will interpolate lower fuel rates from the engine map during the idle portions of the ARB Transient and during a separate GEM ''drive idle cycle.'' For technologies like start-stop and auto-shutdown that eliminate some of the idle that occurs when a vehicle is stopped or parked, GEM will assign a value of zero fuel rate during a separate GEM ''parked idle cycle.'' The idle cycles will be weighted along with the 65 mph, 55 mph, and ARB Transient duty cycles, according to the new vocational chassis duty cycle weighting factors. These weighting factors are different for each of the three vocational chassis speed categories for Phase 2. For tractors, only neutral idle and hotel idle will be addressed in GEM.

(2) Experimental Validation of GEM

The core simulation algorithms in GEM have not changed significantly since the proposal. Most of the changes since proposal focused on streamlining how manufacturers input data into GEM; revising to the drive cycles in GEM; and updating how GEM weights these different drive cycles to determine a composite fuel consumption value. These changes did not alter the fundamental way that GEM simulates varying vehicle ''road load'' and how GEM converts vehicle speed to engine speed and then interpolates engine maps to determine vehicle fuel consumption and CO_2 emissions.

Refinements to GEM since the time of proposal that did alter GEM's simulation performance include modifying the default transmissions' shift strategies and their power losses. Another key refinement was cycle average mapping engines for simulation of the ARB Transient cycle. Each time the agencies made such modifications to GEM, GEM's correlation to the agencies collection of laboratory-generated engine and vehicle data was checked. Potential refinements to GEM were accepted if GEM's correlation was improved versus this set of experimental data. If potential refinements resulted in GEM's correlation to the experimental data

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[169] See National Renewable Energy Laboratory report ''EPA GHG Certification of Medium- and Heavy-Duty Vehicles: Development of Road Grade Profiles Representative of US Controlled Access Highways'' dated May 2015 and EPA memorandum ''Development of an Alternative, Nationally Representative, Activity Weighted Road Grade Profile for Use in EPA GHG Certification of Medium- and Heavy-Duty Vehicles'' dated May 13, 2015, both available in Docket EPA–HQ–OAR–2014–0827. This docket also includes file NREL_SyntheticAndLocalGradeProfiles.xlsx which contains numerical representations of all road grade profiles described in the NREL report.

[170] NAS 2010 Report. Page 189. ''A fundamental concern raised by the committee and those who testified during our public sessions was the tension between the need to set a uniform test cycle for regulatory purposes, and existing industry practices of seeking to minimize the fuel consumption of medium and heavy-duty vehicles designed for specific routes that may include grades, loads, work tasks or speeds inconsistent with the regulatory test cycle. This highlights the critical importance of achieving fidelity between certification values and real-world results to avoid decisions that hurt rather than help real-world fuel consumption.''

becoming worse, those potential changes were rejected. Chapter 4.3.2 of the RIA details the GEM validation that was performed to determine if potential changes to GEM should be accepted or rejected. The first step of the validation process involves simulating vehicles in GEM using engine fuel maps and transmission shifting strategies obtained from manufacturers and comparing GEM results to experiments conducted with the same engines and transmissions. This first step re-validates all of the non-powertrain elements of GEM, which were already validated in Phase 1. The second step is to use GEM's default transmissions' shift strategies in simulation[171] and then compare GEM results to powertrain tests of several transmissions. The only difference between the first and second step is the shifting strategy and powertrain energy loss assumptions. This step facilitates tuning of GEM's default transmission models so that they correlate well to a variety of real transmissions. The third step is to compare GEM simulations to real-world in-use recorded data from actual vehicles. This is the most challenging step because the experimental data includes real-world effects of wind, road grade, and driver behavior in traffic. The most important element of this third step is not *absolute* correlation, but rather, *relative* correlation, which demonstrates that when a technology is added to a real vehicle, the relative improvement in the real world is simulated in GEM with a high degree of correlation.

In the first validation step, the agencies compared GEM to over 130 vehicle variants, consistent with the recommendation made by the NAS in their Phase 2-First Report.[172] As described in Chapter 4 of the RIA, good agreement was observed between GEM simulations and test data over a wide range of vehicles. In general, the model simulations agreed with experimental test results within ±5 percent on an absolute basis. As pointed out in Chapter 4.3.2 of the RIA, relative accuracy is more relevant to the intent of this rulemaking, which is to accelerate the adoption of *additional* fuel efficiency improving technologies. Consistent with the intent of this rulemaking, all of the numeric standards for tractors, trailers and vocational chassis are derived from running GEM first with Phase 1 ''baseline'' technology packages and then with various Phase 2 technology packages. The differences between these GEM results are examined to determine final stringencies. In other words, the agencies used the same final version of GEM to establish the numeric standards as will be used by manufacturers to demonstrate compliance. Therefore, it is most important that GEM accurately reflects *relative* changes in emissions for each added technology. In other words, for vehicle certification purposes it is less important that GEM's absolute value of the fuel consumption or CO_2 emissions be accurate compared to laboratory testing of the same vehicle. The ultimate purpose of GEM is to evaluate *changes* or *additions* in technology, and compliance is demonstrated on a relative basis to the numeric standards that were also derived from GEM. Nevertheless, the agencies concluded that the absolute accuracy of GEM is generally within ±5 percent, as shown in Figure II.2 2. Chapter 4.3.2 of the RIA shows that *relative* accuracy is even better, ±2–3 percent.

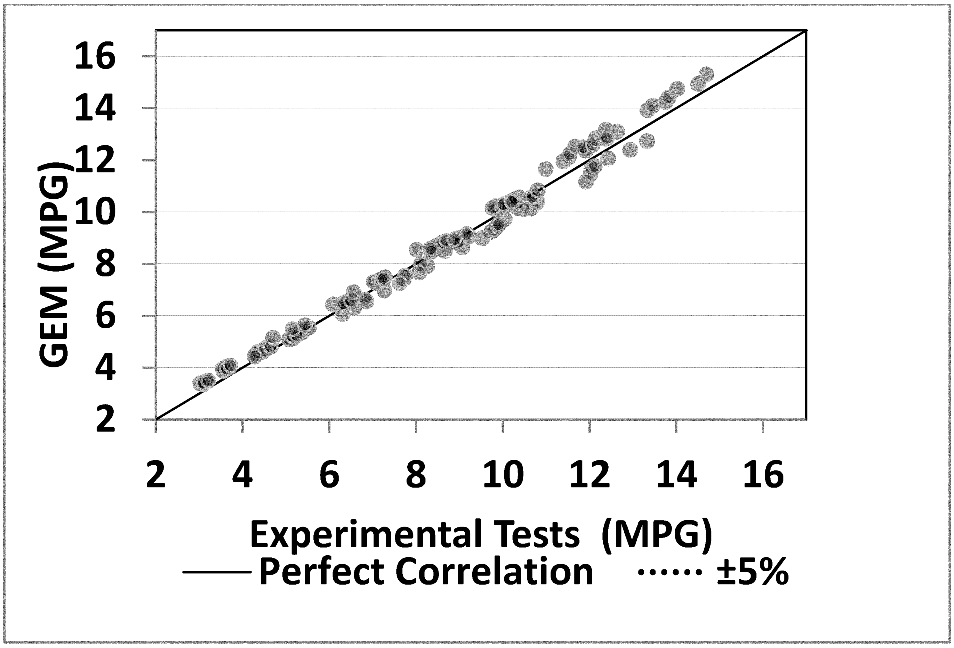

Figure II.2 GEM Validation Data

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[171] K. Newman, J. Kargul, and D. Barba, ''Development and Testing of an Automatic Transmission Shift Schedule Algorithm for Vehicle Simulation, ''*SAE Int. J. Engines* 8(3):2015, doi:*10.4271/2015–01–1142.*

[172] National Academy of Science. ''Reducing the Fuel Consumption and GHG Emissions of Medium- and Heavy-Duty Vehicles, Phase Two, First Report.'' 2014. Recommendation1.2.

In addition to this successful validation against experimental results, the agencies have also conducted a peer review of the GEM source code. This peer review has been submitted to Docket number EPA–HQ–OAR–2014–0827.

The second validation step was to repeat the first step's GEM simulations with the agencies' default transmission shift strategies.[171] It was expected that GEM's absolute accuracy would decrease because these shift strategies were tuned for best average performance and for a particular transmission. Nevertheless, it was shown that relative accuracy did not suffer; therefore, the agencies deemed the GEM default shift strategies acceptable for GEM certification purposes. Further details of this validation step are presented in Chapter 4.3.2.3 of the RIA and in a SwRI final report.[162]

As explained above and in Chapter 4.3.2.3 of the RIA, it is challenging to achieve absolute correlation between any computer simulation and real-world vehicle operation. Therefore, the agencies focused on relative comparisons. Following the SAE standard procedure SAE J1321 ''Type II,'' two trucks have been tested and these real-world results were compared to GEM simulations. In summary, the relative comparisons between GEM simulations and the real-world testing of trucks showed a 2.4 percent difference. The details of this testing and correlation analysis is presented in Chapter 4.3.2.3 of the RIA.

In conclusion, the agencies completed a number of validation steps to ensure that GEM demonstrates a reasonable degree of absolute accuracy, but more importantly a high degree of relative accuracy, versus both laboratory and real-world experimental data.

(3) Supplements to GEM Simulation

As in Phase 1, for most tractors and vocational vehicles, compliance with the Phase 2 g/ton-mile vehicle standards could be evaluated by directly comparing the GEM result to the standard. However, in Phase 1, manufacturers incorporating innovative or advanced technologies could apply improvement factors to lower the GEM result before comparing to the standard.[173] For example, a manufacturer incorporating a launch-assist mild hybrid that was pre-approved for a 5 percent benefit would apply a 0.95 improvement factor to its GEM results for such vehicles. In this example, a GEM result of 300 g/ton-mile will be reduced to 285 g/ton-mile.

For Phase 2, the agencies largely continue the existing Phase 1 innovative technology approach, but we name it ''off-cycle'' to better reflect its purpose.

(a) Off-Cycle Technology Procedures

In Phase 1 the agencies adopted an emissions credit generating opportunity that applied to new and innovative technologies that reduce fuel consumption and CO_2 emissions, which were not in common use with heavy-duty vehicles before model year 2010 and are not reflected over the test procedures or GEM (*i.e.,* the benefits are ''off-cycle''). See 76 FR 57253. As was the case in the development of Phase 1, the agencies continue this approach for technologies and concepts with CO_2 emissions and fuel consumption reduction potential that might not be adequately captured over the Phase 2 duty cycles or are not inputs to GEM. Note, however, that the agencies now refer to these technologies as off-cycle rather than innovative. Comments were generally supportive of continuing this provision. See Section I.C(1)(c) of this document and Section 1 of the RTC for more discussion of innovative and off-cycle technologies.

We recognize that the Phase 1 testing burden associated with the innovative technology credit provisions discouraged some manufacturers from applying. To streamline recognition of many technologies, default values have been integrated directly into GEM. For example, automatic tire inflation systems have fixed default values, and such technologies are now recognized through a post-simulation adjustment approach, discussed in Chapter 4 of the RIA. This is similar to the technology ''pick list'' from our light-duty programs. See 77 FR 62833–62835 (October 15, 2012). If manufacturers wish to receive additional credit beyond these fixed values, then the off-cycle technology credit provisions provide a regulatory path toward that additional recognition.

Beyond the additional technologies that the agencies have added to GEM, the agencies also believe there are several emerging technologies that are being developed today, but will not be accounted for in GEM because we do not have enough information about these technologies to assign fixed values to them in GEM. Any credits for these technologies will need to be based on the off-cycle technology credit generation provisions. These require the assessment of real-world fuel consumption and GHG reductions that can be measured with verifiable test methods using representative operating conditions typical of the engine or vehicle application.

As in Phase 1, the agencies continue to provide two paths for approval of the test procedure to measure the CO_2 emissions and fuel consumption reductions of an off-cycle technology used in the HD tractor. See 40 CFR 1037.610 and 49 CFR 535.7. The first path does not require a public approval process of the test method. A manufacturer can use ''pre-approved'' test methods for HD vehicles including the A-to-B chassis testing, powertrain testing or on-road testing. A manufacturer may also use any developed test procedure which has known quantifiable benefits. A test plan detailing the testing methodology is required to be approved by the agencies prior to collecting any test data. The agencies will also continue the second path which includes a public approval process of any testing method which could have uncertain benefits (*i.e.,* an unknown usage rate for a technology). Furthermore, the agencies are modifying our provisions to better clarify the documentation required to be submitted for approval aligning them with provisions in 40 CFR 86.1869–12, and NHTSA separately prohibits credits from technologies addressed by any of its crash avoidance safety rulemakings (*i.e.,* congestion management systems).

Sections III and V separately describe tractor and vocational vehicle technologies, respectively, that the agencies anticipate may qualify for these off-cycle credit provisions.

(4) Production Vehicle Testing for Comparison to GEM

As described in Section III.E.(2)(j), The agencies are requiring tractor manufacturers to annually chassis test five production vehicles over the GEM cycles to verify that relative reductions simulated in GEM are being achieved in production. See 40 CFR 1037.665. We do not expect absolute correlation between GEM results and chassis testing. GEM makes many simplifying assumptions that do not compromise its usefulness for certification, but do cause it to produce emission rates different from what would be measured during a chassis dynamometer test. Given the limits of correlation possible between GEM and chassis testing, we would not expect such testing to accurately reflect whether a vehicle was compliant with the GEM standards. Therefore, we are not applying GHG compliance liability to such testing. Rather, this testing will be for data collection and informational purposes only. The agencies will continue to evaluate in-use compliance

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[173] 40 CFR 1036.610, 1036.615, 1037.610, and 1037.615.

by verifying GEM inputs and testing in-use engines. (Note that NTE standards for criteria pollutants may apply for some portion of the test cycles.)

(5) Use of GEM in Establishing the Phase 2 Numerical Standards

As in Phase 1, the agencies are setting specific numerical standards against which tractors and vocational vehicles will be certified using GEM (box trailers will use a GEM-based equation, and some trailers and custom chassis vocational vehicles may optionally use a non-GEM certification path). Although these standards are performance-based standards, which do not specifically require the use of any particular technologies,[174] the agencies established these standards by evaluating specific vehicle technology packages using the final version of Phase 2 GEM. We note that that this means the final numerical standards are not directly comparable to the proposed standards, which were based on an intermediate version of GEM, rather than on the final version.

(a) Relation to In-Use Emissions

The purpose of this rulemaking is to achieve in-use emission and fuel consumption reductions by requiring manufacturers to demonstrate that they meet the promulgated emission standards. Thus, it is important that GEM simulations be reasonably representative of in-use operation. Testing that is unrepresentative of actual in-use operation does not necessarily tell us anything about whether any emission reductions occur. However, we recognize that certain simplifications are necessary for practical simulations. In the past, EPA has addressed this issue by including in our testing regulations a process by which EPA can work with manufacturers to adjust test procedures to make them more representative of in-use operation. For engine testing, this provision is in 40 CFR 1065.10(c)(1), where EPA requires manufacturers to notify us in cases in which they determine that the specified test procedures would result in measurements that do not represent in-use operation.

Although we are not adopting an equivalent provision for GEM at this time, we expect similar principles to apply. To the extent that GEM fails to represent in-use emission, we would expect to work with manufacturers to address the issue—under the existing regulations where possible, or by promulgating a new rulemaking.

We recognize that many compromises must be made between the practicality of testing/simulation and the matching of in-use operation. We have considered many aspects of the test procedures in this respect for the engines, vehicles, and emission controls of which we are currently aware. We have concluded that the procedures will generally result in emission simulations that are sufficiently representative of in-use emissions, even though not all in-use operation will occur during simulation. Nevertheless, we have identified several areas that deserve some additional discussion.

GEM is structured to simulate a single vehicle weight (curb weight plus payload) per regulatory subcategory. However, we know that actual in-use weights will rarely be exactly the same as the simulated weights. Nevertheless, since the representativeness of the simulated weights (or lack thereof) is being fully considered in the setting of the standards, there would be no need to modify the procedures to account for different curb weights or payloads.

GEM simulates vehicle emissions over three drive cycles plus two idle cycles, and weights the cycle results based on the type of vehicle being certified. These cycles and weightings reflect *fleet average* driving patterns and the agencies do not expect them to fully match driving patterns for *individual* vehicles. Thus, we would generally not consider GEM's cycles as unrepresentative for vehicles with different in-use driving patterns. However, if new information became available that demonstrated that GEM's cycles somehow did not reflect fleet average driving patterns, the agencies would consider such information in the context of the principles of representative testing, described above.

Finally, GEM includes default values for axle and transmission efficiency derived from baseline technologies. However, we generally expect manufacturers to use more efficient axles and transmissions for Phase 2 vehicles. As noted above, based on comments, the agencies are allowing manufacturers to optionally input measured efficiencies to better represent these more efficient technologies. We would not consider GEM unrepresentative if manufacturers chose to use the default values rather than measure these efficiencies directly.

(b) Relation to Powertrain Testing

As already noted, GEM correlates very well with powertrain testing. To the extent they differ, it would be expected to be primarily related to how transmission performance is modeled in GEM. Although GEM includes a sophisticated model of transmissions, it cannot represent a transmission better than a powertrain test of the same transmission. Thus, the agencies consider powertrain testing to be as good as or better than GEM run using engine-only fuel maps; hence the provision in the final rules allowing results from powertrain testing to be used as a GEM input.

In some respects, powertrain testing can be considered to be a reference method for this rulemaking. Because manufacturers have the option to perform powertrain testing instead of engine-only fuel mapping, the stringency of the final standards can be traced to powertrain testing. In other words, methods that can be shown to be equivalent to powertrain testing can be considered to be consistent with the testing that was used as the basis of the final Phase 2 standards.

In a related context, it may be useful in the future to consider equivalency to powertrain testing as an appropriate criterion for evaluating changes to GEM to address new technologies. Consider, for example, a new technology that is not represented in GEM, but that is reflected in powertrain testing. The agencies could determine that it would be appropriate to modify GEM to reflect the technology rather than to require manufacturers to perform powertrain testing. In such a case, the agencies would not consider the modification to GEM to impact the effective stringency of the Phase 2 standards because the new version of GEM would be equivalent to performing powertrain testing.

D. Engine Test Procedures and Engine Standards

In addition to the Phase 1 GEM-based vehicle certification of tractors and vocational chassis, the agencies also set Phase 1 separate CO_2 and fuel efficiency standards for the engines installed in tractors and vocational chassis. EPA also set Phase 1 separate engine standards for capping methane (CH_4) and nitrous oxide (N_2O) emissions (essentially capping emissions at current emission levels). Compliance with all of these Phase 1 separate engine standards is demonstrated by measuring these emissions during an engine dynamometer test procedure. For Phase 1 the agencies use the same test procedure specified for EPA's existing heavy-duty engine emissions standards (*e.g.,* NO_X and PM standards). These Phase 1 engine standards are specified in terms of brake-specific (g/bhp-hr) fuel, CO_2, CH_4 and N_2O emissions limits. Since the test procedure already

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[174] The sole exception being the design-based standards for non-aero and partial aero trailers.

specified how to measure fuel consumption, CO_2 and CH_4, few changes were needed to utilize the test procedure for Phase 1, the most notable change being a modification specifying how to measure N_2O.

There are some differences in how these non-GHG test procedures are applied in Phase 1 and Phase 2. In EPA's non-GHG engine emissions standards, heavy-duty engines must meet brake-specific standards for emissions of total oxides of nitrogen (NO_X), particulate mass (PM), non-methane hydrocarbon (NMHC), and carbon monoxide (CO). These standards must be met by all engines both over a 13-mode steady-state duty cycle called the ''Supplemental Emissions Test'' (SET)[175] and over a composite of a cold-start and a hot-start transient duty cycle called the ''Federal Test Procedure'' (FTP). In contrast, for Phase 1 the agencies require that engines specifically installed in tractors meet fuel efficiency and CO_2 standards over only the SET but not the composite FTP. This requirement was intended to reflect that tractor engines typically operate near steady-state conditions versus transient conditions. See 76 FR 57159. For Phase 2 the agencies are finalizing, as proposed, slight changes to the 13-modes' weighting factors to better reflect in-use engine operation. These weighting factors apply only for determining SET fuel consumption and CO_2 emissions. No changes are being made to the weighting factors for EPA's non-GHG emission standards. The agencies adopted the converse for engines installed in vocational vehicles. That is, these engines must meet fuel efficiency and CO_2 standards over the composite FTP but not the SET. This requirement was intended to reflect that vocational vehicle engines typically operate under transient conditions versus steady-state conditions (76 FR 57178). For both tractor and vocational vehicle engines in Phase 1, EPA set CH_4 and N_2O emissions cap standards over the composite FTP only and not over the SET duty cycle. See Section II.D. for details on this final action's engine test procedures for Phase 2.

In response to the agencies' proposed engine standards, we received a number of public comments. The agencies considered those comments, and the following list summarizes key changes we've made in response, and more detailed descriptions of these changes are presented in Chapter 2.7 of the RIA:

- Recalculated the SET baseline using the new Phase 2 SET weighting factors.
- Recalculated the FTP baseline, based on MY 2016 FTP certification data from Cummins, DTNA, Volvo, Navistar, Hino, Isuzu, Ford, GM and FCA. These included HHD, MHD, and LHD engines.
- Projected how manufacturers would modify maximum fuel rates as a function of speed to strategically relocate SET mode points to achieve lowest SET results.
- Projected a higher market penetration of WHR in 2027, versus what we proposed.
- Decreased our projected impact of engine technology dis-synergies by increasing the magnitude of our so-called ''dis-synergy factors;'' accounting for these changes by increasing the research and development costs needed for this additional optimization.

The following section first describes the engine test procedures used to certify engines to the Phase 2 separate engine standards. Sections that follow describe the Phase 2 CO_2, N_2O and CH_4 separate engine standards and their feasibility.

(1) Engine Test Procedures

(a) SET Cycle Weighting

The SET cycle was adopted by EPA in 2000 and modified in 2005 from a discrete-mode test to a ramped-modal cycle to broadly cover the most significant part of the speed and torque map for heavy-duty engines, defined by three non-idle speeds and three relative torques. The low speed is called the ''A speed,'' the intermediate speed is called the ''B speed,'' and the high speed is called the ''C speed.'' As is shown in Table II–1, the SET cumulatively weights these three speeds at 23 percent, 39 percent, and 23 percent.

TABLE II–1—SET MODES WEIGHTING FACTOR IN PHASE 1

Speed, % Load	Weighting factor in Phase 1 (%)
Idle	15
A, 100	8
B, 50	10
B, 75	10
A, 50	5
A, 75	5
A, 25	5
B, 100	9
B, 25	10
C, 100	8
C, 25	5
C, 75	5
C, 50	5
Total	100
Cumulative A Speed	23
Cumulative B Speed	39
Cumulative C Speed	23

The C speed is typically in the range of 1800 rpm for current heavy heavy-duty engine designs. However, it is becoming much less common for engines to operate at such a high speeds in real-world driving conditions, and especially not during cruise vehicle speeds in the 55 to 65 mph vehicle speed range. This trend has been corroborated by engine manufacturers' in-use data that has been submitted to the agencies in comments and presented at technical conferences.[176] Thus, although the current SET represents highway operation better than the FTP cycle, it could be improved by adjusting its weighting factors to better reflect modern trends in in-use engine operation. Furthermore, the most recent trends indicate that manufacturers are configuring drivetrains to operate engines at speeds down to a range of 1050–1200 rpm at a vehicle speed of 65 mph.

To address this trend toward in-use engine down-speeding, the agencies are finalizing as proposed refined SET weighting factors for the Phase 2 CO_2 emission and fuel consumption standards. The new SET mode weightings move most of the C weighting to ''A'' speed, as shown in Table II–2. To better align with in-use data, these changes also include a reduction of the idle speed weighting factor. These new mode weightings do not apply to criteria pollutants or to the Phase 1 CO_2 emission and fuel consumption standards.

TABLE II–2—NEW SET MODES WEIGHTING FACTOR IN PHASE 2

Speed/% load	Weighting factor in Phase 2 (%)
Idle	12
A, 100	9
B, 50	10
B, 75	10
A, 50	12
A, 75	12
A, 25	12
B, 100	9

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[175] The SET cycle is also referred to as the ''ramped-modal cycle'' because, for criteria pollutants, it is performed as a continuous cycle with ramped transitions between the individual modes of the SET.

[176] ''OEM perspective—Meeting EPA/NHTSA GHG/Efficiency Standards'', 7th Integer Emissions Summit USA 2014, Volvo Group North America.

TABLE II–2—NEW SET MODES WEIGHTING FACTOR IN PHASE 2—Continued

Speed/% load	Weighting factor in Phase 2 (%)
B, 25	9
C, 100	2
C, 25	1
C, 75	1
C, 50	1
Total	100
Total A Speed	45
Total B Speed	38
Total C Speed	5

(b) Engine Test Provisions for SET, FTP, and Engine Mapping for GEM Inputs

Although GEM does not apply directly to engine certification, Phase 2 will require engine manufacturers to generate and certify full load and motoring torque curves and engine fuel rate maps for input into GEM for tractor and vocational chassis manufacturers to demonstrate compliance to their respective standards. The full load and motoring torque curve procedures were previously defined in 40 CFR part 1065, and these are already required for non-GHG emissions certification. The Phase 2 final default test procedure for generating an engine map for GEM's 55 mph and 65 mph drive cycles is the ''steady-state'' mapping procedure. However, the agencies are finalizing an option for manufacturers to use the ''cycle average'' mapping procedure for GEM's 55 mph and 65 mph drive cycles. The test procedure for generating an engine map for GEM's ARB Transient drive cycle is the ''cycle-average'' mapping procedure, and the agencies are not finalizing any other mapping options for the ARB Transient drive cycle. Note that if an engine manufacturer elects to conduct powertrain testing to generate inputs for GEM, then steady-state and cycle-average engine maps would not be required for those GEM vehicle configurations to which the powertrain test inputs would apply. The steady-state and cycle-average test procedures are specified in 40 CFR parts 1036 and 1065. The technical and confidential business information motivations for finalizing these test procedures are explained in II. B. (2), along with a summary of comments we received.

One important consideration is the need to correct measured fuel consumption rates for the carbon and energy content of the test fuel. As proposed, we will continue the Phase 1 approach, which is specified in 40 CFR 1036.530. We are specifying a similar approach to GEM fuel maps in Phase 2.

As proposed, the agencies are requiring that engine manufacturers certify fuel maps for GEM, as part of their certification to the engine standards. However, there were a number of manufacturer comments strongly questioning the particular proposed requirement that engine manufacturers provide these maps to vehicle manufacturers starting in MY 2020 for the certification of vehicles commercially marketed as MY 2021 vehicles in calendar year 2020. This is a normal engine and vehicle manufacturing process, where many vehicles may be produced with engines having an earlier model year than the commercial model year of the vehicle. For example, we expect that some MY 2021 vehicles will be produced with MY 2020 engines. Thus, we proposed to require engine manufacturers to begin providing GEM fuel maps for MY 2020 engines so that vehicle manufacturers could run GEM to certify MY 2021 vehicles with MY 2020 engines. EMA and some of its members commented that MY 2020 engines should not be subject to Phase 2 requirements, based on NHTSA's statutory 4-year lead-time requirement and because the potential higher fuel consumption of MY 2020 (*i.e.,* Phase 1) engine maps could force vehicle manufacturers to install additional technologies that were not projected by the agencies for compliance. The agencies considered these comments along with the potential cost savings for manufacturers to align the timing of both their engines' and vehicle's Phase 2 product plans and certification paths. The agencies also considered how this situation would repeat in MY 2024 and MY 2027 and possibly with future standards as well. Based on these considerations, we have decided that it would be more appropriate to harmonize the engine and vehicle standards, starting in MY 2021 so that vehicle manufacturers will not need fuel maps for 2020 engines. Thus, we are not finalizing the requirement to provide fuel maps for MY 2020 engines. However, we are requiring fuel maps for all MY 2021 engines, even those (*e.g.,* small businesses) for which the Phase 2 engine and vehicle standards have been delayed. See 40 CFR 1036.150.

The current engine test procedures also require the development of regeneration emission rate and frequency factors to determine infrequent regeneration adjustment factors (IRAFs) that account for the emission changes for *criteria* pollutants during an exhaust emissions control system regeneration event. In Phase 1 the agencies adopted provisions to exclude CO_2 emissions and fuel consumption due to regeneration. However, for Phase 2, we are requiring the inclusion of CO_2 emissions and fuel consumption due to regeneration over the FTP and SET (RMC) cycles, as determined using the IRAF provisions in 40 CFR 1065.680. While some commenters opposed this because of its potential impact on stringency, we do not believe this will significantly impact the stringency of these standards because manufacturers have already made great progress in reducing the frequency and impact of regeneration emissions since 2007. Rather, the agencies are including IRAF CO_2 emissions for Phase 2 to prevent these emissions from increasing in the future to the point where they would otherwise become significant. Manufacturers qualitatively acknowledged the likely already small and decreasing magnitude of IRAF CO_2 emissions in their comments. For example, EMA stated, ''the rates of infrequent regenerations have been going down since the adoption of the Phase 1 standards'' and that IRAF ''contributions are minor.'' Nevertheless, we believe it is prudent to begin accounting for regeneration emissions to discourage manufacturers from adopting criteria emissions compliance strategies that could reverse this trend. Manufacturers expressed concern about the additional test burden, but the only additional requirement would be to measure and report CO_2 emissions for the same tests they are already performing to determine IRAFs for other pollutants.

At the time of the proposal, we did not specifically adjust baseline levels to include additional IRAF emissions because we believed them to be negligible and decreasing. Commenters opposing this proposed provision provided no data to dispute this belief. We continue to believe that regeneration strategies can be engineered to maintain these negligible rates. Thus, we do not believe they are of fundamental significance for our baselines in the FRM. Highway operation includes enough high temperature operation to make active regenerations unnecessary. Furthermore, recent improvements in exhaust after-treatment catalyst formulations and exhaust temperature thermal management strategies, such as intake air throttling, minimize CO_2 IRAF impacts during non-highway operation, where active regeneration might be required. Finally, as is discussed in Section II.D.(2), recent significant efficiency improvements over the FTP cycle suggest that FTP emissions may actually be even lower than we have estimated in our updated FTP baselines, which would provide additional margin for manufacturers to manage any minor CO_2 IRAF impacts that may occur.

We are not including fuel consumption due to after-treatment regeneration in the creation of fuel maps used in GEM for vehicle compliance. We believe that the IRAF requirements for the separate SET and FTP engine standards, along with market forces that already exist to minimize regeneration events, will create sufficient incentives to reduce fuel consumption during regeneration over the entire fuel map.

(c) Powertrain Testing

The agencies are finalizing a powertrain test option to afford a robust mechanism to quantify the benefits of CO_2 reducing technologies that are a part of the powertrain (conventional or hybrid), that are not captured in the GEM simulation. Among these technologies are integrated engine and transmission control and hybrid systems. We are finalizing a number of improvements to the test procedure in 40 CFR 1037.550. As proposed we are finalizing the requirement for Phase 2 hybrid powertrains to mapped using this powertrain test method. The agencies are also finalizing modifications to 40 CFR 1037.550 to separate out the hybrid specific testing protocols.

To limit the amount of testing under this rule, powertrains can be divided into families and are tested in a limited number of simulated vehicles that will cover the range of vehicles in which the powertrain will be used. A matrix of 8 to 9 tests will be needed per vehicle cycle, to enable the use of the powertrain results broadly across all the vehicles in which the powertrain will be installed. The individual tests differ by the vehicle that is being simulated during the test. These are discussed in detail in Chapter 3.6 of the RIA.

(i) Powertrain Test Procedure

The agencies are expanding upon the test procedures defined 40 CFR 1037.550 for Phase 1 hybrid vehicles. The Phase 2 expansion will migrate the current Phase 1 test procedure to a new 40 CFR 1037.555 and will modify the current test procedure in 40 CFR 1037.550, allowing its use for Phase 2 only. The Phase 2 modifications relative to 40 CFR 1037.550 include the addition of the rotating inertia of the driveline and tires, and the axle efficiency. This revised procedure also requires that each of the powertrain components be cooled so that the temperature of each of the components is kept in the normal operation range. We are extending the powertrain procedure to PHEV powertrains.

Powertrain testing contains many of the same requirements as engine dynamometer testing. The main differences are where the test article connects to the dynamometer and the software that is used to command the dynamometer and operator demand setpoints. The powertrain procedure finalized in Phase 2 allows for the dynamometer(s) to be connected to the powertrain either upstream of the drive axle or at the wheel hubs. The output of the transmission is upstream of the drive axle for conventional powertrains. In addition to the transmission, a hydraulic pump or an electric motor in the case of a series hybrid may be located upstream of the drive axle for hybrid powertrains. If optional testing with the wheel hub is used, two dynamometers will be needed, one at each hub. Beyond these points, the only other difference between powertrain testing and engine testing is that for powertrains, the dynamometer and throttle setpoints are not set by fixed speed and torque targets prescribed by the cycle, but are calculated in real time by the vehicle model. The powertrain test procedure requires a forward calculating vehicle model, thus the output of the model is the dynamometer speed setpoints. The vehicle model calculates the speed target using the measured torque at the previous time step, the simulated brake force from the driver model, and the vehicle parameters (tire rolling resistance, drag area, vehicle mass, rotating mass, and axle efficiency). The operator demand that is used to change the torque from the engine is controlled such that the powertrain follows the vehicle speed target for the cycle instead of being controlled to match the torque or speed setpoints of the cycle. The emission measurement procedures and calculations are identical to engine testing.

(ii) Engine Test Procedures for Replicating Powertrain Tests

As described in Section II.B.(2)(b), the agencies are finalizing the proposed powertrain test option to quantify the benefits of CO_2-reducing powertrain technologies. This option is very similar to the cycle average mapping approach, although these powertrain test results would be used to override both the engine and transmission (and possibly axle) simulation portions of GEM, not just the engine fuel map. The agencies are requiring that any manufacturer choosing to use this option also measure engine speed and engine torque during the powertrain test so that the engine's performance during the powertrain test could be replicated in a non-powertrain engine test cell. Manufacturers would be required to measure or calculate, using good engineering judgment, the engine shaft output torque, which would be close-coupled to the transmission input shaft during a powertrain test. Subsequent engine testing then could be conducted using the normal part 1065 engine test procedures as specified in 40 CFR 1037.551, and g/bhp-hr CO_2 results could be compared to the levels the manufacturer reported during certification. Such testing could apply for both confirmatory and selective enforcement audit (SEA) testing. This would simplify both the certification and SEA testing.

As proposed, engine manufacturers certifying powertrain performance (instead of or in addition to the multi-point fuel maps) will be held responsible for powertrain test results. If the engine manufacturer does not certify powertrain performance and instead certifies only the steady-state and/or cycle-average fuel maps, it will held responsible for fuel map performance rather than the powertrain test results. Engine manufacturers certifying both will be responsible for both.

Some commenters objected to the potential liability for such engine-only tests. However, it appears they do not understand our intent. This provision states clearly that this approach could be used only where ''the test engine's operation represents the engine operation observed in the powertrain test.'' Also, since the manufacturers perform all SEA testing themselves, this would be an option for the manufacturer rather than something imposed by EPA. Thus, this concern should be limited to the narrow circumstance in which EPA performs confirmatory engine testing of an engine that was certified using powertrain testing, follows the manufacturer's specified engine test cycle, and ensures that the test accurately represents the engine's performance during the powertrain test. However, it is not clear why this would be problematic. It is entirely reasonable to assume that testing the engine in this way would result in equivalent emission results. To the extent manufacturer concerns remain, each manufacturer would be free to certify their engines based on engine-only fuel maps rather than powertrain testing.

(d) CO_2 From Urea SCR Systems

For diesel engines utilizing urea SCR emission control systems for NO_X

reduction, the agencies will allow, but not require, correction of the final engine (and powertrain) fuel maps to account for the contribution of CO_2 from the urea injected into the exhaust. This urea typically contributes 0.2 to 0.5 percent of the total CO_2 emissions measured from the engine, and up to 1 percent at certain map points. Since current urea production methods use gaseous CO_2 captured from the atmosphere (along with NH_3), CO_2 emissions from urea consumption does not represent a net carbon emission. This adjustment is necessary so that fuel maps developed from CO_2 measurements will be consistent with fuel maps from direct measurements of fuel flow rates. This adjustment is also necessary to fully align EPA's CO_2 standards with NHTSA's fuel consumption standards. Failing to account for urea CO_2 tailpipe emissions would result in reporting higher fuel consumption than what was actually consumed. Thus, we are only allowing this correction for emission tests where CO_2 emissions are determined from direct measurement of CO_2 and not from fuel flow measurement, which would not be impacted by CO_2 from urea.

We note that this correction will be voluntary for manufacturers, and we expect that some manufacturers may determine that the correction is too small to be of concern. The agencies will use this correction for CO_2 measurements with any engines for which the engine manufacturer applied the correction for its fuel maps during certification.

We are not allowing this correction for engine test results with respect to the engine CO_2 standards. Both the Phase 1 standards and the new standards for CO_2 from diesel engines are based on test results that included CO_2 from urea. In other words, these standards are consistent with using a test procedure that does not correct for CO_2 from urea.

(2) Engine Standards for CO_2 and Fuel Consumption

We are largely maintaining the existing Phase 1 regulatory structure for engine standards, which had separate standards for spark-ignition engines (such as gasoline engines) and compression-ignition engines (such as diesel engines), and for HHD, MHD and LHD engines, but we are changing how these standards will apply to alternative fuel engines as described in Section XII.A.2.

Phase 1 applied different test cycles depending on whether the engine is used for tractors, vocational vehicles, or both, and we are continuing this approach. Tractor engines are subject to standards over the SET, while vocational engines are subject to standards over the FTP. Table II–3 shows the Phase 1 standards for diesel engines.

TABLE II–3—PHASE 1 MY 2017 DIESEL ENGINE CO_2 AND FUEL CONSUMPTION STANDARDS

Units	HHD SET	MHD SET	HHD FTP	MHD FTP	LHD FTP
g/bhp-hr	460	487	555	576	576
gal/100 bhp-hr	4.5187	4.7839	5.4519	5.6582	5.6582

In the Phase 2 proposal we assumed that these numeric values of the Phase 1 standards were the baselines for Phase 2. We applied our technology assessments to these baselines to arrive at the Phase 2 standards for MY 2021, MY 2024 and MY 2027. In other words, for the Phase 2 proposal we projected that starting in MY 2017 engines would, on average, just meet the Phase 1 standards and not over-comply. However, based on comments we received on how to consistently apply our new SET weighting factors in our analysis and based on recent MY 2016 engine certification data, we are updating our Phase 2 baseline assumptions for both the SET and FTP.

First, with respect to the SET, in the proposal we compared our proposed Phase 2 standards, which are based on these new Phase 2 weighting factors, to the Phase 1 numeric standards, which are based on the current Phase 1 weighting factors. Because we continue to use the same 13-mode brake specific CO_2 and fuel consumption numeric values we used for the proposal to represent the performance of a MY 2017 baseline engine, we are not projecting a different technology level in the baseline. Rather, this is simply correcting an ''apples-to-oranges'' comparison from the proposal by applying the Phase 2 weighting factors to the MY 2017 baseline engine. This was pointed out to us by UCS, ICCT and EDF in their public comments. While this did not impact our technology effectiveness or cost analyses, it did impact the numeric value of our baseline to which we reference the effectiveness of applying technologies to the 13 individual modes of the SET. Because the revised SET weighting factors result in somewhat lower brake specific CO_2 and fuel consumption numeric results for the composite baseline SET value, this correction, in turn, lowers the numerical values of the final Phase 2 SET standards. Making this particular update did not result in a change to the relative stringency of the final Phase 2 numeric engine standards (relative to MY 2017 baseline performance), but our updated feasibility analysis did; see Section II.D.(2)(a) below).

Second, the agencies made adjustments to the FTP baselines, but these adjustments were not made because of a calculation error. Rather, MY 2016 FTP certification data showed an unexpected step-change improvement in engine fuel consumption and CO_2 emissions. These data were not available at the time of proposal, so the agencies relied upon the MY 2017 Phase 1 standard as a baseline. EDF publicly commented in response to the NODA that the more recent certification data revealed this new step-change. MY 2016 certification data submitted to the agencies [177] as well as to ARB [178] show that many engines from many manufacturers already not only achieve the Phase 1 FTP standards, but some were also below the MY 2027 standards proposed for Phase 2. This was not the case for the SET, where most manufacturers are still not yet complying with the MY 2017 Phase 1 SET standards. In view of this situation for the FTP, the agencies are adjusting the Phase 2 FTP baseline to reflect this shift. The underlying reasons for this shift are mostly related to manufacturers optimizing their SCR thermal management strategy over the FTP in ways that we (mistakenly) thought they already had in MY 2010 (*i.e.,* the Phase 1 baseline). As background, the FTP includes a cold-start, a hot-start and significant time spent at engine idle. During these portions of the FTP, the NO_X SCR system can cool down and lose NO_X reducing efficiency. One simplistic strategy to maintain SCR temperature is to inefficiently consume additional fuel, such that the fuel energy is lost to the

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[177] *https://www3.epa.gov/otaq/certdata.htm#oh.*

[178] *http://www.arb.ca.gov/msprog/onroad/cert/mdehdehdv/2016/2016.php.*

exhaust system in the form of heat. There are more sophisticated strategies to maintain SCR temperature, however, but these apparently required additional time from MY 2010 for research, development and refinement. In updating these baseline values, the agencies did consider the concerns raised by manufacturers about the potential impact of IRAFs on baseline emissions.

As just noted, at the time of Phase 1 we had not realized that these improvements were not already in the Phase 1 baseline. These include optimizing the use of an intake throttle to decrease excess intake air at idle and SCR catalyst reformulation to maintain SCR efficiency at lower temperatures. Based on this information, which was provided to the agencies by engine manufacturers, but only after we specifically requested this information, the agencies concluded that in Phase 1 we did not account for how much further these kinds of improvements could still impact FTP fuel consumption. Conversely, only by reviewing the new MY 2016 certification data did we realize how little SCR thermal management optimization actually occurred for the engine model years that we used to establish the Phase 1 baseline—namely MY 2009 and MY 2010 engines. Because we never accounted for this kind of improvement in our Phase 2 proposal's stringency analysis for meeting the Phase 2 proposed FTP standards, this baseline shift does not alter our projected effectiveness and market adoption rates from the proposal. Therefore, we continue to apply the same improvements that we proposed, but we apply them to the updated FTP baseline. See Section II.D.(5) for a discussion on how this impacts carry-over of Phase 1 emission credits.

Table II–4 shows the Phase 2 diesel engine final CO_2 baseline emissions. Note that the gasoline engine CO_2 baseline for Phase 2 is the same as the Phase 1 HD gasoline FTP standard, 627 g/bhp-hr. More detailed analyses on these Phase 2 baseline values of tractor and vocational vehicles can be found in Chapter 2.7.4 of RIA.

TABLE II–4—PHASE 2 DIESEL ENGINE FINAL CO_2 AND FUEL CONSUMPTION BASELINE EMISSIONS

Units	HHD SET	MHD SET	HHD FTP	MHD FTP	LHD FTP
g/bhp-hr	455	481	525	558	576
gal/100 bhp-hr	4.4695	4.7250	5.1572	5.4813	5.6582

As described below, the agencies are adopting standards for new compression-ignition engines for Phase 2, commencing in MY 2021, that will require additional reductions in CO_2 emissions and fuel consumption beyond the Phase 2 baselines. The agencies are not adopting new CO_2 or fuel consumption *engine* standards for new heavy-duty gasoline engines. Note, however, that we are projecting some small improvement in gasoline engine performance that will be recognized over the vehicle cycles (that is, reflected in the stringency of certain of the vocational vehicle standards). See Section V.B.2.a below.

For diesel engines to be installed in Class 7 and 8 combination tractors, the agencies are adopting the SET standards shown in Table II–5.[179] The MY 2027 SET standards for engines installed in tractors will require engine manufacturers to achieve, on average, a 5.1 percent reduction in fuel consumption and CO_2 emissions beyond the Phase 2 baselines. We are also adopting SET standards in MY 2021 and MY 2024 that will require tractor engine manufacturers to achieve, on average, 1.8 percent and 4.2 percent reductions in fuel consumption and CO_2 emissions, respectively, beyond the Phase 2 baselines.

TABLE II–5—PHASE 2 HEAVY-DUTY TRACTOR ENGINE STANDARDS FOR ENGINES [180] OVER THE SET CYCLE

Model year	Standard	Heavy heavy-duty	Medium heavy-duty
2021–2023	CO_2 (g/bhp-hr)	447	473
	Fuel Consumption (gallon/100 bhp-hr)	4.3910	4.6464
2024–2026	CO_2 (g/bhp-hr)	436	461
	Fuel Consumption (gallon/100 bhp-hr)	4.2829	4.5285
2027 and Later	CO_2 (g/bhp-hr)	432	457
	Fuel Consumption (gallon/100 bhp-hr)	4.2436	4.4892

For diesel engines to be installed in vocational chassis, the agencies are adopting the FTP standards shown in Table II–6. The MY 2027 FTP standards for engines installed in vocational chassis will require engine manufacturers to achieve, on average, a 4.2 percent reduction in fuel consumption and CO_2 emissions beyond the Phase 2 baselines. We are also adopting FTP standards in MY 2021 and MY 2024 that will require vocational chassis engine manufacturers to achieve, on average, 2.3 percent and 3.6 percent reductions in fuel consumption and CO_2 emissions, respectively, beyond the Phase 2 baselines.

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[179] The agencies note that the CO_2 and fuel consumption standards for Class 7 and 8 combination tractors do not cover gasoline or LHDD engines, as those are not used in Class 7 and 8 combination tractors.

[180] Tractor engine standards apply to all tractor engines, without regard to the actual fuel (*e.g.,* diesel or natural gas) or engine-cycle classification (*e.g.,* compression-ignition or spark-ignition).

TABLE II–6—VOCATIONAL DIESEL (CI) ENGINE STANDARDS OVER THE HEAVY-DUTY FTP CYCLE

Model year	Standard	Heavy heavy-duty [181]	Medium heavy-duty diesel [181]	Light heavy-duty diesel [182]
2021–2023	CO_2 (g/bhp-hr)	513	545	563
	Fuel Consumption (gallon/100 bhp-hr)	5.0393	5.3536	5.5305
2024–2026	CO_2 (g/bhp-hr)	506	538	555
	Fuel Consumption (gallon/100 bhp-hr)	4.9705	5.2849	5.4519
2027 and Later	CO_2 (g/bhp-hr)	503	535	552
	Fuel Consumption (gallon/100 bhp-hr)	4.9411	5.2554	5.4224

(a) Feasibility of the Diesel (Compression-Ignition) Engine Standards

In this section, the agencies discuss our assessment of the feasibility of the engine standards and the extent to which they conform to our respective statutory authorities and responsibilities. More details on the technologies discussed here can be found in RIA Chapter 2.3. The feasibility of these standards is further discussed in RIA Chapter 2.7 for tractor and vocational vehicle engines. While the projected technologies are discussed here separately, as is discussed at the beginning of this Section II.D, the agencies also accounted for dis-synergies between technologies. Note that Section II.D.(2)(e) discusses the potential for some manufacturers to achieve greater emission reductions by introducing new engine platforms, and how and why these reductions are reflected in the tractor and vocational *vehicle* standards.

Based on the technology analysis described below, the agencies project that a technology path exists that will allow engine manufacturers to meet the final Phase 2 standards by 2027, and to meet the MY 2021 and 2024 standards. The agencies also project that these manufacturers will be able to meet these standards at a reasonable cost and without adverse impacts on in-use reliability.

In general, engine performance for CO_2 emissions and fuel consumption can be improved by improving the internal combustion process and by reducing energy losses. More specifically, the agencies have identified the following key means by which fuel efficiency can be improved:

- Combustion optimization
- Turbocharger design and optimization
- Engine friction and other parasitic loss reduction
- Exhaust after-treatment pressure drop reduction
- Intake air and exhaust system pressure drop reduction (including EGR system)
- Engine down-sizing to improve core engine efficiency
- Engine down-speeding over the SET, and in-use, by lug curve shape optimization
- Waste heat recovery system installation and optimization
- Physics model based electronic controls for transient performance optimization

The agencies are gradually phasing in the separate engine standards from 2021 through 2027 so that manufacturers can gradually introduce these technology improvements. For most of these, the agencies project manufacturers could begin applying these technologies to about 45–50 percent of their heavy-duty engines by 2021, 90–95 percent by 2024, and ultimately apply them to 100 percent of their heavy-duty engines by 2027. However, for some of these improvements (such as waste heat recovery and engine downsizing) we project lower application rates in the Phase 2 time frame. This phase-in structure is consistent with the normal manner in which manufacturers introduce new technology to manage limited R&D budgets as well as to allow them to work with fleets to fully evaluate in-use reliability before a technology is applied fleet-wide. The agencies believe the phase-in schedule will allow manufacturers to complete these normal processes. See RIA 2.3.9.

Based on our technology assessment described below, the engine standards appear to be consistent with the agencies' respective statutory authorities. All of the technologies with high penetration rates above 50 percent have already been demonstrated to some extent in the field or in research laboratories, although some development work remains to be completed. We note that our feasibility analysis for these engine standards is not based on projecting 100 percent application for any technology until 2027. We believe that projecting less than 100 percent application is appropriate and gives us additional confidence that the 2021 and 2024 MY standards are feasible.

Because this analysis considers reductions from engines meeting the Phase 1 standards, it assumes manufacturers will continue to include the same compliance margins as in Phase 1. In other words, a manufacturer currently declaring FCLs 10 g/bhp-hr above its measured emission rates (in order to account for production and test-to-test variability) will continue to do the same in Phase 2. Both the costs and benefits are determined relative to these baselines, and so are reflective of these compliance margins.

The agencies have carefully considered the costs of applying these technologies, which are summarized in Section II.D.(2)(d). These costs appear to be reasonable on both a per engine basis, and when considering payback periods.[183] The engine technologies are discussed in more detail below. Readers are encouraged to see the RIA Chapter 2.7 for additional details (and underlying references) about our feasibility analysis.

(i) Combustion Optimization

Although manufacturers are making significant improvements in combustion to meet the Phase 1 engine standards, the agencies project that even more improvement is possible after 2018. For example, improvements to fuel injection systems will allow more flexible fuel injection capability with higher injection pressure, which can provide more opportunities to improve engine fuel efficiency. Further optimization of piston bowls and injector tips will also improve engine performance and fuel efficiency. We project that a reduction of up to 1.0 percent is feasible in the 2024 model year through the use of

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[181] Heavy heavy-duty engine standards apply to all heavy heavy-duty engines, without regard to the actual fuel (*e.g.,* diesel or natural gas) or engine-cycle classification (*e.g.,* compression-ignition or spark-ignition).

[182] The agencies are not adopting new CO_2 or fuel consumption *engine* standards for new heavy-duty gasoline engines. Therefore, the Phase 2 HD gasoline FTP standard is the same as the Phase 1 HD gasoline FTP standard, 627 g/bhp-hr, 7.0552 gallon/100 bhp-hr.

[183] See Section IX.M for additional information about payback periods.

these technologies, although it will likely apply to only 95 percent of engines until 2027.

Another important area of potential improvement is advanced engine control incorporating model based calibration to reduce losses of control during transient operation. Improvements in computing power and speed will make it possible to use much more sophisticated algorithms that are more predictive than today's controls. Because such controls are only beneficial during transient operation, they will reduce emissions over the FTP cycle, over the ARB Transient cycle's cycle-average mapping procedure, and during in-use operation, but this technology will not reduce emissions over the SET cycle or over the steady-state engine mapping procedure. Thus, the agencies are projecting model based control reductions only for vocational engines' FTP standards and for projecting improvements captured by the cycle-average mapping over the ARB Transient cycle. Although this control concept is not currently available and is still under development, we project model based controls achieving a 2 percent improvement in transient emissions. Based on model based controls already in widespread use in engine laboratories for the calibration of simpler controllers and based on recent model based control development under the DOE SuperTruck partnership (*e.g.,* DTNA's SuperTruck engine's model based controls), we project that such controls could be in limited production for some engine models by 2021. We believe that some vocational chassis applications would particularly benefit from these controls in-use (*e.g.,* urban applications with significant in-use transient operation). Therefore, we project that a modest amount of engine models will have these controls by MY 2021. We also project that manufacturers will learn more from the in-use operation of these technology leading engines, and manufacturers will be able to improve these controls even further, such that they would additionally benefit other vocational applications, such as multi-purpose and regional applications. By 2027, we project that 40 percent of all vocational diesel engines will incorporate model-based controls at a 2 percent level of effectiveness.

(ii) Turbocharging System

Many advanced turbocharger technologies can be brought into production in the time frame between 2021 and 2027, and some of them are already in production, such as mechanical or electric turbo-compounding, more efficient variable geometry turbines, and Detroit Diesel's patented asymmetric turbocharger. A turbo-compound system, like those installed on some of Volvo's EURO VI compliant diesels and on some of DTNA's current U.S. offerings (supplied to DTNA by a division of Cummins), extracts energy from the exhaust to provide additional power. Mechanical turbo-compounding includes a power turbine located downstream of the turbine which in turn is connected to the crankshaft to supply additional power. On-highway demonstrations of this technology began in the early 1980s. It was used first in heavy duty production in the U.S. by Detroit Diesel for their DD15 and DD16 engines and reportedly provided a 3 to 5 percent fuel consumption reduction. Results are duty cycle dependent, and require significant time at high load to realize an in-use fuel efficiency improvement. Lightly loaded vehicles on flat roads or at low vehicle speeds can expect little or no benefit. Volvo reports two to four percent fuel consumption improvement in line haul applications.[184] Because of turbo-compound technology's drive cycle dependent effectiveness, the agencies are only projecting a market penetration of 10 percent for all tractor engines, at slightly less than 2 percent effectiveness over the SET. The agencies are considering turbo-compound to be mutually exclusive with WHR because both technologies seek to extract additional usable work from the same waste heat and are unlikely to be used together.

(iii) Engine Friction and Parasitic Losses

The friction associated with each moving part in an engine results in a small loss of engine power. For example, frictional losses occur at bearings, in the valve train, and at the piston ring-cylinder interface. Taken together such losses represent a measurable fraction of all energy lost in an engine. For Phase 1, the agencies projected a 1–2 percent reduction in fuel consumption due to friction reduction. However, new information leads us to project that an additional 1.4 percent reduction is possible for some engines by 2021 and all engines by 2027. These reductions are possible due to improvements in bearing materials, lubricants, and new accessory designs such as variable-speed pumps.

(iv) After-Treatment Optimization

All heavy duty diesel engine manufacturers are already using diesel particulate filters (DPFs) to reduce particulate matter (PM) and selective catalytic reduction (SCR) to reduce NO_X emissions. The agencies see two areas in which improved after-treatment systems can also result in lower fuel consumption. First, increased SCR efficiency could allow re-optimization of combustion for better fuel consumption because the SCR would be capable of reducing higher engine-out NO_X emissions. We don't expect this to be significant, however. Manufacturers already optimize the DEF (urea) consumption and fuel consumption to achieve the lowest cost of operation; taking into account fuel consumption, DEF consumption and the prices of fuel and DEF. Therefore, if manufacturers re-optimized significantly for fuel consumption, it is possible that this would lead to higher net operating costs. This scenario is highly dependent upon fuel and DEF prices, so projecting this technology path is uncertain. Second, improved designs could reduce backpressure on the engine to lower pumping losses. If manufacturers have opportunities to lower backpressure within the size constraints of the vehicle, the agencies project that manufacturers will opt to lower after-treatment back pressure. The agencies project the combined impact of these improvements would be 0.6 percent over the SET.

Note that this improvement is independent of cold-start improvements made recently by some manufacturers with respect to vocational engines. Thus, the changes being made to the FTP baseline engines do not reduce the likelihood of the benefits of re-optimizing after-treatment projected here.

(v) Engine Intake and Exhaust Systems

Various high efficiency air handling for both intake air and exhaust systems could be produced in the 2020 and 2024 time frame. To maximize the efficiency of such processes, induction systems may be improved by manufacturing more efficiently designed flow paths (including those associated with air cleaners, chambers, conduit, mass air flow sensors and intake manifolds) and by designing such systems for improved thermal control. Improved turbocharging and air handling systems will likely include higher efficiency EGR systems and intercoolers that reduce frictional pressure losses while maximizing the ability to thermally control induction air and EGR. EGR systems that often rely upon an adverse pressure gradient (exhaust manifold pressures greater than intake manifold pressures) must be reconsidered and their adverse pressure gradients

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[184] *http://www.volvotrucks.us/powertrain/d13/.*

minimized. Other components that offer opportunities for improved flow efficiency include cylinder heads, ports and exhaust manifolds to further reduce pumping losses by about 1 percent over the SET.

(vi) Engine Downsizing and Down Speeding

Proper sizing of an engine is an important component of optimizing a vehicle for best fuel consumption. This Phase 2 rule will require reductions in road load due to aerodynamic resistance, tire rolling resistance and weight, which will result in a drop in the vehicle power demand for most operation. This drop moves the engine operating points down to a lower load zone, which can move the engine away from operating near its peak thermal efficiency (a.k.a. the ''sweet spot''). Engine downsizing combined with engine down speeding can allow the engine to move back to higher loads and a lower speed zone, thus achieving better fuel efficiency in the real world. However, because of the way engines are tested, little of the benefit of engine downsizing would be detected during engine testing (if power density remains the same) because the engine test cycles are de-normalized based on the full torque curve. Thus, the separate engine standards are not the appropriate standards for recognizing the benefits of engine downsizing. Nevertheless, we project that some small benefit can be measured over the engine test cycles depending on the characteristics of the engine fuel map and how the SET points are determined as a function of the engine's lug curve.

After the proposal we received comments recommending that we should recognize some level of engine down speeding within the separate engine standards. Based on this comment and some additional confidential business information that we received, we believe that engine lug curve reshaping to optimize the locations of the 13-mode points is a way that manufacturers can demonstrate some degree of engine down-speeding over the engine test. As pointed out in Chapter 2.3.8 and 2.7.5 of the RIA, down speeding via lug curve reshaping alone can provide SET reductions in the range of 0.4 percent depending on the engine map characteristics.

(vii) Waste Heat Recovery

More than 40 percent of all energy loss in an engine is lost as heat to the exhaust and engine coolant. For many years, manufacturers have been using turbochargers to convert some of this waste heat in the exhaust into usable mechanical power that is then used to compress the intake air. Manufacturers have also been developing a Rankine cycle-based system to extract additional heat energy from the engine. Such systems are often called waste heat recovery (WHR) systems. The possible sources of waste heat energy include the exhaust, recirculated exhaust gases, compressed charge air, and engine coolant. The basic approach with WHR is to use waste heat from one or more of these sources to evaporate a working fluid, which is passed through a turbine or equivalent expander to create mechanical or electrical power, then re-condensed.

For the proposal, the agencies projected that by 2027, 15 percent of tractor engines would employ WHR systems with an effectiveness of better than three percent. We received many comments on this projection, which are discussed briefly below and in more detail in the RTC. In particular, we note that some of the comments included confidential data related to systems not yet on the market. After carefully considering all of these comments, we have revised our projections to increase the effectiveness, decrease costs, and project higher adoption rates than we proposed.

Prior to the Phase 1 Final Rule, the NAS estimated the potential for WHR to reduce fuel consumption by up to 10 percent.[185] However, the agencies do not believe such levels will be achievable within the Phase 2 time frame. There currently are no commercially available WHR systems for diesel engines, although research prototype systems are being tested by some manufacturers. American Trucking Association, Navistar, DTNA, OOIDA, Volvo, and UPS commented that because WHR is still in the prototype stage, it should not be assumed for setting the stringency of the tractor engine standards. Many of these commenters pointed to the additional design and development efforts that will be needed to reduce cost, improve packaging, reduce weight, develop controls, select an appropriate working fluid, implement expected OBD diagnostics, and achieve the necessary reliability and durability. Some stated that the technology has not been thoroughly tested or asked that more real-world data be collected before setting standards based on WHR. Some of these commenters provided confidential business information pertaining to their analysis of WHR system component costs, failure modes, and projected warranty cost information.

Alternatively, a number of commenters including Cummins, ICCT, CARB, ACEEE, EDF, Honeywell, ARB and others stated that the agencies should increase the assumed application rate of WHR in the final rule and the overall stringency of the engine standards. They argued the agencies' WHR technology assessment was outdated and too conservative, the fuel savings and GHG reduction estimation for WHR were too low, and the agencies' cost estimates were based on older WHR systems where costs were confounded with hybrid component costs and that these have since been improved upon. In addition, the agencies received CBI information supporting the arguments of some of these commenters.

Cummins stated the agencies underestimated the commercial viability of WHR and that we overstated the development challenges and timing in the NPRM. They said WHR can provide a 4 to 5 percent improvement in fuel consumption on tractor drive cycles and that WHR would be commercially viable and available in production as early as 2020 and will exceed the agencies' estimates for market penetration over the period of the rule. According to Cummins, the reliability of their WHR system has improved with each generation of the technology and they have developed a smaller system footprint, improved integration with the engine and vehicle and a low-GWP working fluid, resulting in a much more compact and integrated system. They added that their system would be evaluated in extended customer testing by the end of 2015, and that results of that experience will inform further technology development and product engineering leading to expected commercial product availability in the 2020 timeframe. Furthermore, they said multiple product development cycles over the implementation timeframe of the rule would provide opportunities for further development for reduced cost and improved performance and reliability.

Some commenters, including EDF, said the agencies' assumed design had little in common with the latest designs planned for production. They cited several publications, including the NAS 21st Century Truck Program report #3 and stated WHR effectiveness is much higher than the agencies estimated. Gentham cited an ICCT study saying that up to a 12 percent fuel consumption reduction from a 2010 baseline engine is possible with the application of advanced engine technologies and WHR.

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[185] *See* 2010 NAS Report, page 57.

The agencies recognize that much work remains to be done, but we are providing significant lead time to bring WHR to market. Based on our assessment of each manufacturer's work to date, we are confident that a commercially-viable WHR capable of reducing fuel consumption by over three percent will be available in the 2021 to 2024 time frame. Concerns about the system's cost and complexity may remain high enough to limit the use of such systems in this time frame. Moreover, packaging constraints and lower effectiveness under transient conditions will likely limit the application of WHR systems to line-haul tractors. Refer to RIA Chapter 2.3.9 for a detailed description of these systems and their applicability. For our analysis of the engine standards, the agencies project that WHR with the Rankine technology could be used on 1 percent of tractor engines by 2021, on 5 percent by 2024, and 25 percent by 2027, with nearly all being used on sleeper cabs. We project this sharper increase in market adoption in the 2027 timeframe because we have noted that most technology adoption rate curves follow an S-shape: Slow initial adoption, then more rapid adoption, and then a leveling off as the market saturates (not always at 100 percent).[186] We assumed an S-shape curve for WHR adoption, where we project a steeper rise in market adoption in and around the 2027 timeframe. Given our averaging, banking and trading program flexibilities and that manufacturers may choose from a range of other technologies, we believe that manufacturers will be able to meet the 2027 standards, which we based on a 25 percent WHR adoption in tractor engines. Although we project these as steps, it is more likely that manufacturers will try to gradually increase the WHR adoption in MY 2025 and MY 2026 from the 5 percent in 2024 to generate emission credits to smooth the transition to the 2027 standards.

Commenters opposing the agencies' WHR projections argued that the real-world GHG and fuel consumption savings will be less than in prototype systems. DTNA said a heat rejection increase of 30 percent to 40 percent with WHR systems will require larger radiators, resulting in more aerodynamic drag and lower fuel savings from WHR systems. DTNA cited a Volvo study showing a 2 percent loss of efficiency with the larger frontal areas needed to accommodate heat rejection from WHR systems. Daimler stated effectiveness may be lower than expected since there is large drop off in fuel savings when the tractor is not operating on a steady state cycle and the real world performance of WHR systems will be hurt by transient response issues. Daimler and ACEEE said the energy available from exhaust and other waste heat sources could diminish as tractor aerodynamics improve, thus lowering the expected fuel savings from WHR. Daimler said because of this, WHR estimated fuel savings was overestimated by the agencies. Navistar said WHR working fluids will have a significant GHG impact based on their high global warming potential. They commented that fuel and GHG reductions will be lower in the real world with the re-weighting of the RMC which results in lower engine load, and thus lower available waste heat. However, none of these commenters have access to the full range of data available to the agencies, which includes CBI.

It is important to note that the net cost and effectiveness of future WHR systems depends on the sources of waste heat. Systems that extract heat from EGR gases may provide the side benefit of reducing the size of EGR coolers or eliminating them altogether. To the extent that WHR systems use exhaust heat, they increase the overall cooling system heat rejection requirement and likely require larger radiators. This could have negative impacts on cooling fan power needs and vehicle aerodynamics. Limited engine compartment space under the hood could leave insufficient room for additional radiator size increasing. Many of these issues disappear if exhaust waste heat is not recovered from the tailpipe and brought under the hood for conversion to mechanical work. In fact, it is projected that if a WHR system only utilizes heat that was originally within the engine compartment (*e.g.,* EGR cooler heat, coolant heat, oil heat, etc.), then any conversion of that heat to mechanical heat actually reduces the heat rejection demand under the hood; potentially leading to smaller radiators and lower frontal area, which would actually lead toward improved aerodynamic performance. Refer to RIA Chapter 2.3.9 for more discussion.

Several commenters stated that costs are highly uncertain for WHR technology, but argued that the agencies' assumption of a $10,523 cost in 2027 are likely significantly lower than reality. Volvo estimated a cost of $21,700 for WHR systems. Volvo said that in addition to hardware cost being underestimated, the agencies had not properly accounted for other costs such as the R&D needed to bring the technology into production within a vehicle. Volvo said they would lose $17,920 per unit R&D alone, excluding other costs such as materials and administrative expenses. Daimler said that costs almost always inflate as the complexity of real world requirements drive up need for more robust designs, sensors, controls, control hardware, and complete vehicle integration. They added that development costs will be large and must be amortized over limited volumes. Furthermore, OOIDA said the industry experience with such complex systems is that maintenance, repair, and down-time cost can be much greater than the initial purchase cost. ATA and OOIDA said that potential downtime associated with an unproven technology is a significant concern for the industry.

On the other hand, some commenters argued that the agencies had actually overestimated WHR costs in the proposal. These commenters generally argued that engineering improvements to the WHR systems that will go into production in the Phase 2 time frame would lower costs, in particular by reducing components. The agencies largely agree with these commenters and we have revised our analysis to reflect these cost savings. See RIA 2.11.2.15 for additional discussion.

(viii) Technology Packages for Diesel Engines Installed in Tractors

This Section (a)(viii) describes technology packages that the agencies project could be applied to Phase 1 tractor engines to meet the Phase 2 SET separate engine standards. Section II.D.(2)(e) also describes additional improvements that the agencies project some engine manufacturers will be able to apply to their engines.

We received comments on the tractor engine standards in response to the proposal and in response to the NODA. These comments can be grouped into two general themes. One theme expressed by ARB, non-governmental environmentally focused organizations, Cummins and some technology suppliers like Honeywell, recommended higher engine stringencies, up to 10–15 percent in some comments. Another theme, generally expressed by vertically integrated engine and vehicle manufacturers supported either no Phase 2 engine standards at all, or they supported the proposal's standards, but none of these commenters supported standards that were more stringent than what we proposed. An example of the contrast between these two themes can be shown in one report submitted to the docket and another submission rebutting the statements made in the

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[186] NACFE 2015 Annual Fleet Fuel Study.

report. The report was submitted to the agencies by the Environmental Defense Fund (EDF).[187] On the other hand, four vertically integrated engine and vehicle manufacturers, DTNA, Navistar, Paccar, and Volvo, submitted a rebuttal to EDF's findings.[188] Some of these individual vehicle manufacturers also provided their own comments on EDF's report.[189] [190] Cummins also provided comments and recommended stringencies somewhere between EDF's recommendations and the integrated manufacturers' rebuttal. Cummins recommended achieving reductions by 2030 in the range of 9–15 percent. CARB's recommendation from their comments [191] is 7.1 percent in 2024.

The agencies carefully considered this wide range of views, and based on the best data available, the agencies modified some of our technology projections between the proposal and the final rule.

Table II–5 lists our projected technologies together with our projected effectiveness and market adoption rates for tractor engines. The reduction values shown as ''SET reduction'' are relative to our Phase 2 baseline values, as shown in Table II–7. It should be pointed out that the reductions in Table II–7 are based on the Phase 2 final SET weighting factors, shown in Table II–2. RIA Chapter 2.7.5 details the reasoning supporting our projection of improvements attributable to this fleet average technology package.

TABLE II–7—PROJECTED TRACTOR ENGINE TECHNOLOGIES AND REDUCTION

SET mode	SET weighted reduction (%) 2020–2027	Market penetration (2021) (%)	Market penetration (2024) (%)	Market penetration (2027) (%)
Turbo compound with clutch	1.9	5	10	10
WHR (Rankine cycle)	3.6	1	5	25
Parasitic/Friction (Cyl Kits, pumps, FIE), lubrication	1.5	45	95	100
After-treatment (lower dP)	0.6	30	95	100
EGR/Intake & exhaust manifolds/Turbo/VVT/Ports	1.1	45	95	100
Combustion/FI/Control	1.1	45	95	100
Downsizing	0.3	10	20	30
		Overall reductions (%)		
Weighted reduction (%)	....	1.7	4.0	4.8
Down speeding optimization on SET	....	0.1	0.2	0.3
Total % reduction	....	1.8	4.2	5.1

The weighted reductions shown in this table have been combined using the ''Π-formula,'' which has been augmented to account for technology dis-synergies that occur when combining multiple technologies. A 0.85 dis-synergy factor was used for 2021, and a 0.90 dis-synergy factor was used for 2024 and 2027.[192] RIA Chapter 2.7.4 provides details on the ''Π-formula'' and an explanation for how the dis-synergy factors were determined. Some commenters argued that use of a single dis-synergy factor for all technologies is inappropriate. While we agree that it would be preferable to have a more detailed analysis of the dis-synergy between each pair or group of technologies, we do not have the information necessary to conduct such an analysis. In the absence of such information, the simple single value approach is a reasonable approximation. Moreover, we note that the degree of dis-synergy is sufficiently small to make the impact of any errors on the resulting standards negligible.

Figure II.3 2018 HHD Figure II.4 are the samples of the HHD engine fuel maps used for the agencies' MY 2018 baseline engine and MY 2027 sleeper cab engine for tractors. As can be seen from these two figures, the torque curve shapes are different. This is because engine down speeding optimization for the SET is taken into consideration, where the engine peak torque is increased and the engine speed is shifted to lower speed. All maps used by GEM for all vehicles are shown in Chapter 2.7 of the RIA.

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[187] Environmental Defense Fund, Greenhouse Gas Emission and Fuel Efficiency Standards for Medium-Duty and Heavy-Duty Engines and Vehicles—Phase 2—Notice of Data Availability,'' Docket: ID No. EPA–HQ–OAR–2014–0817, October 1, 2015.

[188] Daimler Trucks North America, Navistar, Inc, Paccar Inc, and Volvo Group,'' Greenhouse Gas Emission and Fuel Efficiency Standards for Medium-Duty and Heavy-Duty Engines and Vehicles—Phase 2—Notice of Data Availability,'' Docket: ID No. EPA–HQ–OAR–2014–0817, April 1, 2016.

[189] Navistar, Inc., Greenhouse Gas Emission and Fuel Efficiency Standards for Medium-Duty and Heavy-Duty Engines and Vehicles—Phase 2—Notice of Data Availability,'' Docket: ID No. EPA–HQ–OAR–2014–0817, April 1, 2016.

[190] Daimler Trucks North America LLC, Detroit Diesel Corporation, Greenhouse Gas Emission and Fuel Efficiency Standards for Medium-Duty and Heavy-Duty Engines and Vehicles—Phase 2—Notice of Data Availability,'' Docket: ID No. EPA–HQ–OAR–2014–0817, April 1, 2016.

[191] California Air Resources Board (CARB), Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2 (Docket ID No. EPA–HQ–OAR–2014–0827 and Docket ID No. NHTSA–2014–0132).

[192] As used in the agencies' analyses, dis-synergy factors less than one reflect dis-synergy between technologies that reduce the overall effectiveness, while dis-synergy factors greater than one would indicate synergy that improves the overall effectiveness.

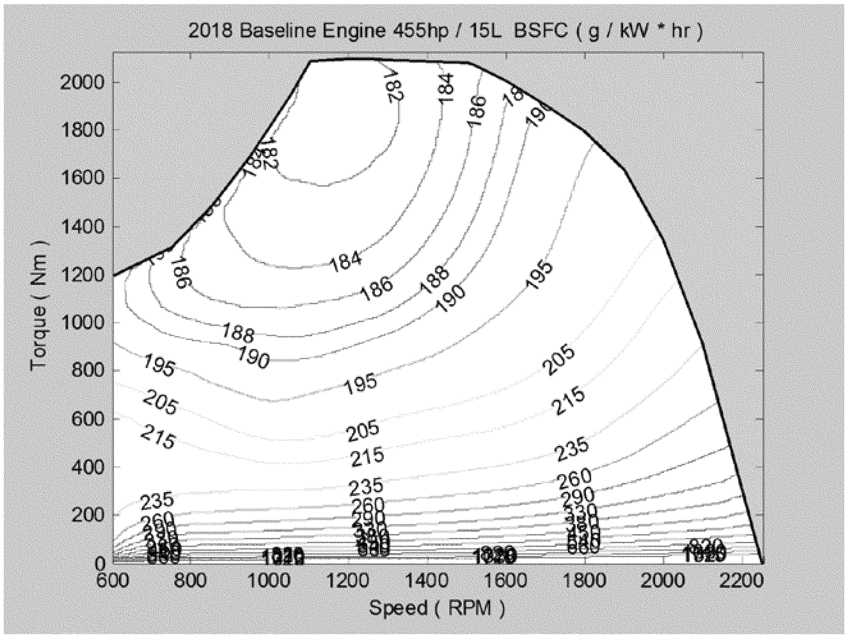

Figure II.3 2018 HHD Baseline Engine Fuel Map.

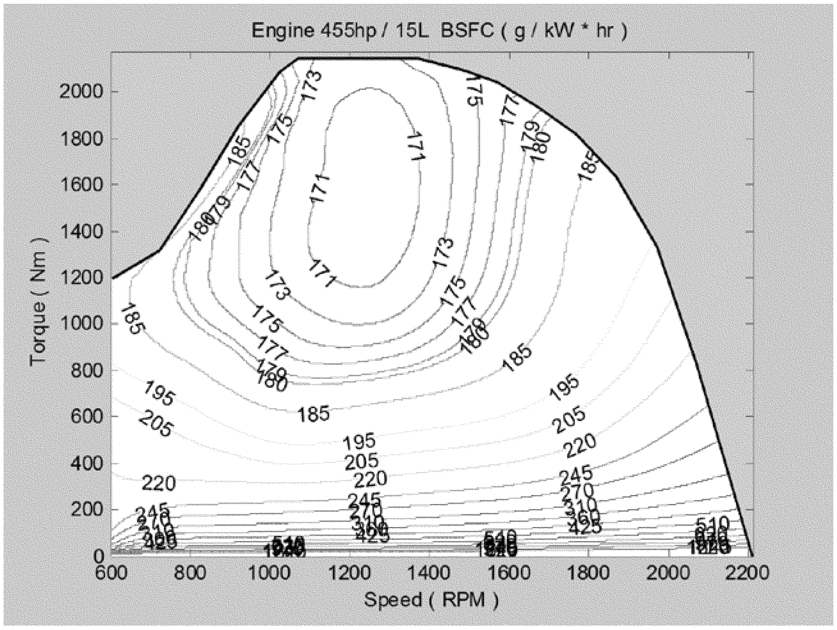

Figure II.4 2027 HHD Engine Fuel Map for a Sleeper Cab Tractor Vehicle.

(ix) Technology Packages for Diesel Engines Installed in Vocational Vehicles

For diesel engines (and other compression-ignition engines) used in vocational vehicles, the MY 2021 standards will require engine manufacturers to achieve, on average, a 2.3 percent reduction in fuel consumption and CO_2 emissions beyond the Phase 2 FTP baselines. Beginning in MY 2024, the agencies are requiring a 3.6 percent reduction in fuel consumption and CO_2 emissions beyond the Phase 2 FTP baselines for all diesel engines including LHD, MHD, and HHD, and beginning in MY 2027 this increases to 4.2 percent, on average. The agencies have based these FTP standards on the performance of reduced parasitic and friction losses, improved after-treatment, combustion optimization, superchargers and variable geometry turbochargers, physics model-based controls, improved EGR pressure drop, and variable valve timing (only in LHD and MHD engines).

The percent reduction for the MY 2021, MY 2024, and MY 2027 standards is based on the combination of technology effectiveness and the respective market adoption rates projected.

Most of the potential engine technologies discussed previously for tractor engines can also be applied to vocational engines. However, neither of the waste heat technologies, Rankine cycle nor turbo-compound, are likely to be applied to vocational engines because they are less effective under transient operation, which is weighted more heavily for all of the vocational sub-categories. Given the projected cost and complexity of such systems, we believe that for the Phase 2 time frame manufacturers will focus their WHR development work on tractor applications (which will have better payback for operators), rather than on vocational applications. In addition, the benefits due to engine downsizing, which can be realized in some tractor engines, may not be realized at all in in the vocational sector, again because this control technology produces few benefits under transient operation.

One of the most effective technologies for vocational engines is the optimization of transient controls with physics model based control, which would replace current look-up table based controls. These are described more in detail in Chapter 2.3 of the RIA. We project that more advanced transient controls, including different levels of model based control, discussed in Chapter 2.3 of the RIA, would continue to progress and become more broadly applicable throughout the Phase 2 timeframe.

Other effective technologies include parasitic load/friction reduction, as well as improvements to combustion, air handling systems, turbochargers, and after-treatment systems. Table II–8 below lists those potential technologies together with the agencies' projected market penetration rates for vocational engines. Again, similar to tractor engines, the technology reduction and market penetration rates are estimated by combining manufacturer-submitted confidential business information, together with estimates reflecting the agencies' judgment, which is informed by historical trends in the market adoption of other fuel efficiency improving technologies. The reduction values shown as ''percent reduction'' are relative to the Phase 2 FTP baselines, which are shown in Table II–3. The overall reductions combine the technology reduction values with their market adoption rates. The same set of the dis-synergy factors as the tractor are used for MY 2021, 2024, and 2027.

TABLE II–8—PROJECTED VOCATIONAL ENGINE TECHNOLOGIES AND REDUCTION

Technology	Percent reduction 2020–2027	Market penetration 2021 (%)	Market penetration 2024 (%)	Market penetration 2027 (%)
Model based control	2.0	25	30	40
Parasitic/Friction	1.5	60	90	100
EGR/Air/VVT/Turbo	1.0	60	90	100
Improved AT	0.5	30	60	100
Combustion Optimization	1.0	60	90	100
Weighted reduction (%)-L/M/HHD		2.3	3.6	4.2

Figure II.5 is a sample of a 2018 baseline engine fuel map for a MHD vocational engine.

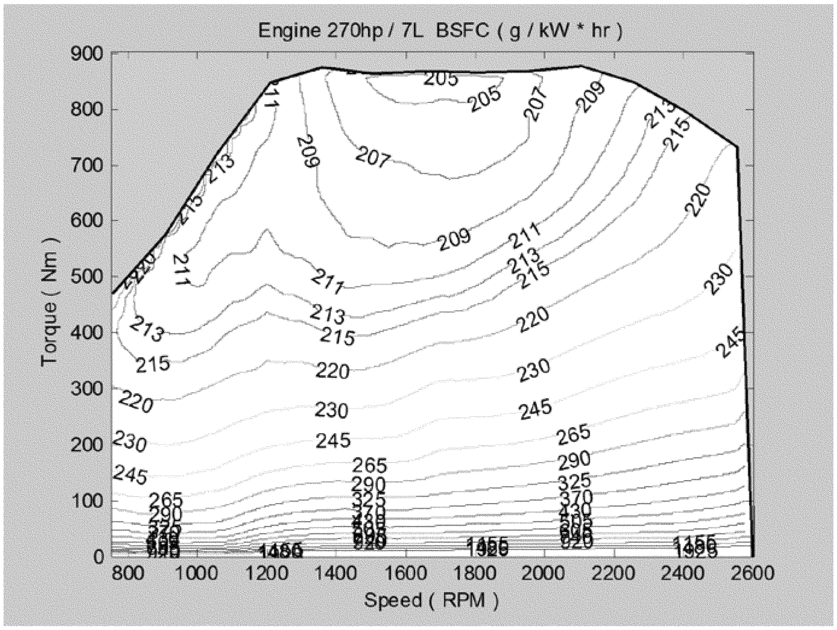

Figure II.5 2018 MHD engine fuel map

(x) Summary of the Agencies' Analysis of the Feasibility of the Diesel Engine Standards

The HD Phase 2 standards are based on projected adoption rates for technologies that the agencies regard as the maximum feasible for purposes of EISA section 32902 (k) and appropriate under CAA section 202(a) based on the technologies discussed above and in RIA Chapter 2. The agencies believe these technologies can be adopted at the estimated rates for these standards within the lead time provided, as discussed in RIA Chapter 2.7. The 2021 and 2024 MY standards are phase-in standards on the path to the 2027 MY standards, and these earlier standards were developed using less aggressive application rates and therefore have lower technology package costs than the 2027 MY standards.

As described in Section II.D.(2)(d) below, the costs to comply with these standards are estimated to range from $275 to $1,579 per engine. This is slightly higher than the costs for Phase 1, which were estimated to be $234 to $1,091 per engine. Although the agencies did not separately determine fuel savings or emission reductions due to the engine standards apart from the vehicle program, it is expected that the fuel savings will be significantly larger than these costs, and the emission reductions will be roughly proportional to the technology costs when compared to the corresponding vehicle program reductions and costs. Thus, we regard these standards as cost-effective. This is true even without considering payback period. The phase-in 2021 and 2024 MY standards are less stringent and less costly than the 2027 MY standards. Given that the agencies believe these standards are technologically feasible, are highly cost effective, and highly cost effective when accounting for the fuel savings, and have no apparent adverse potential impacts (*e.g.,* there are no projected negative impacts on safety or vehicle utility), they appear to represent a reasonable choice under section 202(a) of the CAA and the maximum feasible under NHTSA's EISA authority at 49 U.S.C. 32902(k)(2).

(b) Basis for Continuing the Phase 1 Spark-Ignited Engine Standard

For gasoline vocational engines, we are not adopting more stringent *engine* standards. Today most SI-powered vocational vehicles are sold as incomplete vehicles by a vertically integrated chassis manufacturer, where the incomplete chassis shares most of the same technology as equivalent complete pickups or vans, including the powertrain. Another, even less common way that SI-powered vocational vehicles are built is by a non-integrated chassis manufacturer purchasing an engine from a company that also produces complete and/or incomplete HD pickup trucks and vans. Gasoline engines used in vocational vehicles are generally the same engines as are used in the complete HD pickups and vans in the Class 2b and 3 weight categories, although the operational demands of vocational vehicles often require use of the largest, most powerful SI engines, so that some engines fitted in complete pickups and vans are not appropriate for use in vocational vehicles. Given the relatively small sales volumes for gasoline-fueled vocational vehicles, manufacturers typically cannot afford to invest significantly in developing separate technology for these engines.

The agencies received many comments suggesting that technologies be applied to increase the stringency of the SI engine standard. These comments were essentially misplaced, since the agencies already had premised the Phase 1 SI MY 2016 FTP engine standards on 100 percent adoption of these technologies. The commenters thus did not identify any additional engine technologies that the agencies did not already consider and account for in setting the MY 2016 FTP engine standard. Therefore, the Phase 1 SI engine FTP standard for these engines will remain in place. However, as noted above, projected engine improvements are being reflected in the stringency of the vehicle standard for the vehicle in which the engine will be installed. In part this is because the GEM cycles result in very different engine operation than what occurs when an engine is run over the engine FTP cycle. We believe that certain technologies will show a fuel consumption and CO_2 emissions reduction during GEM cycles that do not occur over the engine FTP. We received comments on engine technologies that can be recognized over the GEM vehicle cycles. As a result, the Phase 2 gasoline-fueled vocational vehicle standards are predicated on adoption of advanced engine friction reduction and cylinder deactivation. To the extent any SI engines do not incorporate the projected engine technologies, manufacturers of SI-powered vocational vehicles would need to achieve equivalent reductions from some other vehicle technology to meet the vehicle standards. See Section V.C of this Preamble for a description of how we applied these technologies to develop the vocational vehicle standards. See Section VI.C of this Preamble for a description of the SI engine technologies that have been considered in developing the HD pickup truck and van standards.

(c) Engine Improvements Projected for Vehicles Over the GEM Duty Cycles

As part of the certification process for the Phase 2 vehicle standards, tractor and vocational vehicle manufacturers will need to represent their vehicles' actual engines in GEM. Although the vehicle standards recognize the same engine technologies as the separate engine standards, each have different test procedures for demonstrating compliance. As explained earlier in Section II.D.(1), compliance with the tractor separate *engine* standards is determined from a composite of the Supplemental Engine Test (SET) procedure's 13 steady-state operating points. Compliance with the vocational vehicle separate *engine* standards is determined over the Federal Test Procedure's (FTP) transient engine duty cycle. In contrast, compliance with the vehicle standards is determined using GEM, which calculates composite results over a combination of 55 mph, 65 mph, ARB Transient and idle vehicle cycles. Each of these duty cycles emphasize different engine operating points; therefore, they can each recognize certain technologies differently. Hence, these engine improvements can be readily recognized in GEM and appropriately reflected in the stringency of the vehicle standards. It is important to note, however, that the tractor vehicle standards presented in Section III project that some (but not all) tractor engines will achieve greater reductions than required by the engine standards. This was reflected in the agencies' feasibility analysis using projected engine fuel maps that represent engines having fuel efficiency better than what is required by the engine standards. Similarly, the vocational vehicle standards in presented in Section V project that the average vocational engine will achieve greater reductions than required by the engine standards. These additional reductions are recognized by GEM and are reflected in the stringency of the respective vehicle standards.

Our first step in aligning our engine technology assessment at both the engine and vehicle levels was to separately identify how each technology impacts performance at each of the 13 individual test points of the SET steady-state engine duty cycle. For example, engine friction reduction technology is expected to have the greatest impact at the highest engine speeds, where frictional energy losses are the greatest.

As another example, turbocharger technology is generally optimized for best efficiency at steady-state cruise vehicle speed. For an engine, this is near its lower peak-torque speed and at a moderately high load that still offers sufficient torque reserve to climb modest road grades without frequent transmission gear shifting. The agencies also considered the combination of certain technologies causing dis-synergies with respect to engine efficiency at each of these test points. See RIA Chapter 2.3 and 2.7 for further details. Chapter 2.8 and 2.9 of the RIA details how the engine fuel maps are created for both tractor and vocational vehicles used for GEM as the default engine fuel maps.

(d) Engine Technology Package Costs for Tractor and Vocational Engines (and Vehicles)

As described in Chapters 2 and 7 of the RIA, the agencies estimated costs for each of the engine technologies discussed here. All costs are presented relative to engines projected to at least comply with the model year 2017 standards—*i.e.,* relative to our Phase 2 baseline engines. Note that we are not presenting any costs for gasoline engines (SI engines) in this section because we are not changing the SI engine standards. However, we are including a cost for additional engine technology as part of the vocational vehicle analysis in Section V.C.2.(e) (and appropriately so, since those engine improvements are reflected in the stringency of the vocational vehicle standard).

Our engine cost estimates include a separate analysis of the incremental part costs, research and development activities, and additional equipment. Our general approach used elsewhere in this action (for HD pickup trucks, gasoline engines, Class 7 and 8 tractors, and Class 2b–8 vocational vehicles) estimates a direct manufacturing cost for a part and marks it up based on a factor to account for indirect costs. *See also* 75 FR 25376. We believe that approach is appropriate when compliance with the standards is achieved generally by installing new parts and systems purchased from a supplier. In such a case, the supplier is conducting the bulk of the research and development on the new parts and systems and including those costs in the purchase price paid by the original equipment manufacturer. Consequently, the indirect costs incurred by the original equipment manufacturer need not reflect significant cost to cover research and development since the bulk of that effort is already completed. For the MHD and HHD diesel engine segment, however, the agencies believe that OEMs will incur costs not associated with the purchase of parts or systems from suppliers or even the production of the parts and systems, but rather the development of the new technology by the original equipment manufacturer itself. Therefore, the agencies have directly estimated additional indirect costs to account for these development costs. The agencies used the same approach in the Phase 1 HD rule. EPA commonly uses this approach in cases where significant investments in research and development can lead to an emission control approach that requires no new hardware. For example, combustion optimization may significantly reduce emissions and cost a manufacturer millions of dollars to develop but would lead to an engine that is no more expensive to produce. Using a bill of materials approach would suggest that the cost of the emissions control was zero reflecting no new hardware and ignoring the millions of dollars spent to develop the improved combustion system. Details of the cost analysis are included in the RIA Chapter 2.7. To reiterate, we have used this different approach because the MHD and HHD diesel engines are expected to comply in part via technology changes that are not reflected in new hardware but rather reflect knowledge gained through laboratory and real world testing that allows for improvements in control system calibrations—changes that are more difficult to reflect through direct costs with indirect cost multipliers. Note that these engines are also expected to incur new hardware costs as shown in Table II–9 through Table II–12. EPA also developed the incremental piece cost for the components to meet each of the 2021 and 2024 standards. The costs shown in Table II–13 include a low complexity ICM of 1.15 and assume the flat-portion of the learning curve is applicable to each technology.

(i) Tractor Engine Package Costs

TABLE II–9—MY 2021 TRACTOR DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$7	$7
Valve Actuation	84	84
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	3	3
Turbocharger (improved efficiency)	9	9
Turbo Compounding	51	51
EGR Cooler (improved efficiency)	2	2
Water Pump (optimized, variable vane, variable speed)	44	44
Oil Pump (optimized)	2	2
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	2	2
Fuel Rail (higher working pressure)	5	5
Fuel Injector (optimized, improved multiple event control, higher working pressure)	5	5
Piston (reduced friction skirt, ring and pin)	1	1
Valve train (reduced friction, roller tappet)	39	39
Waste Heat Recovery	71	71
“Right sized” engine	−41	−41
Total	284	284

Note: “Right sized” diesel engine is a smaller, less costly engine than the engine it replaces.

TABLE II–10—MY 2024 TRACTOR DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$14	$14
Valve Actuation	169	169
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	6	6
Turbocharger (improved efficiency)	17	17
Turbo Compounding	93	93
EGR Cooler (improved efficiency)	3	3
Water Pump (optimized, variable vane, variable speed)	85	85
Oil Pump (optimized)	4	4
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	4	4
Fuel Rail (higher working pressure)	9	9
Fuel Injector (optimized, improved multiple event control, higher working pressure)	10	10
Piston (reduced friction skirt, ring and pin)	3	3
Valve train (reduced friction, roller tappet)	77	77
Waste Heat Recovery	298	298
"Right sized" engine	−82	−82
Total	712	712

Note: "Right sized" diesel engine is a smaller, less costly engine than the engine it replaces.

TABLE II–11—MY 2027 TRACTOR DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$15	$15
Valve Actuation	172	172
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	6	6
Turbocharger (improved efficiency)	17	17
Turbo Compounding	89	89
EGR Cooler (improved efficiency)	3	3
Water Pump (optimized, variable vane, variable speed)	85	85
Oil Pump (optimized)	4	4
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	4	4
Fuel Rail (higher working pressure)	9	9
Fuel Injector (optimized, improved multiple event control, higher working pressure)	10	10
Piston (reduced friction skirt, ring and pin)	3	3
Valve train (reduced friction, roller tappet)	77	77
Waste Heat Recovery	1,208	1,208
"Right sized" engine	−123	−123
Total	1,579	1,579

Note: "Right sized" diesel engine is a smaller, less costly engine than the engine it replaces.

(ii) Vocational Diesel Engine Package Costs

TABLE II–12—MY 2021 VOCATIONAL DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Light HD	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$8	$8	$8
Valve Actuation	93	93	93
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	6	3	3
Turbocharger (improved efficiency)	10	10	10
EGR Cooler (improved efficiency)	2	2	2
Water Pump (optimized, variable vane, variable speed)	58	58	58
Oil Pump (optimized)	3	3	3
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	3	3	3
Fuel Rail (higher working pressure)	8	6	6
Fuel Injector (optimized, improved multiple event control, higher working pressure)	8	6	6
Piston (reduced friction skirt, ring and pin)	1	1	1
Valve train (reduced friction, roller tappet)	70	52	52
Model Based Controls	29	29	29
Total	298	275	275

TABLE II–13—MY 2024 VOCATIONAL DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Light HD	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$14	$14	$14
Valve Actuation	160	160	160
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	10	6	6
Turbocharger (improved efficiency)	16	16	16
EGR Cooler (improved efficiency)	3	3	3
Water Pump (optimized, variable vane, variable speed)	81	81	81
Oil Pump (optimized)	4	4	4
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	4	4	4
Fuel Rail (higher working pressure)	11	9	9
Fuel Injector (optimized, improved multiple event control, higher working pressure)	13	10	10
Piston (reduced friction skirt, ring and pin)	2	2	2
Valve train (reduced friction, roller tappet)	97	73	73
Model Based Controls	32	32	32
Total	446	413	413

TABLE II–14—MY 2027 VOCATIONAL DIESEL ENGINE COMPONENT COSTS INCLUSIVE OF INDIRECT COST MARKUPS AND ADOPTION RATES

[2013$]

	Light HD	Medium HD	Heavy HD
After-treatment system (improved effectiveness SCR, dosing, DPF)	$15	$15	$15
Valve Actuation	172	172	172
Cylinder Head (flow optimized, increased firing pressure, improved thermal management)	10	6	6
Turbocharger (improved efficiency)	17	17	17
EGR Cooler (improved efficiency)	3	3	3
Water Pump (optimized, variable vane, variable speed)	85	85	85
Oil Pump (optimized)	4	4	4
Fuel Pump (higher working pressure, increased efficiency, improved pressure regulation)	4	4	4
Fuel Rail (higher working pressure)	11	9	9
Fuel Injector (optimized, improved multiple event control, higher working pressure)	14	10	10
Piston (reduced friction skirt, ring and pin)	3	3	3
Valve train (reduced friction, roller tappet)	102	77	77
Model Based Controls	41	41	41
Total	481	446	446

(e) Feasibility of Additional Engine Improvements

While the agencies' technological feasibility analysis for the engine standards focuses on what is achievable for existing engine platforms, we recognize that it could be possible to achieve greater reductions by designing entirely new engine platforms. Unlike existing platforms, which are limited with respect to peak cylinder pressures (precluding certain efficiency improvements), new platforms can be designed to have higher cylinder pressure than today's engines. New designs are also better able to incorporate recent improvements in materials and manufacturing, as well as other technological developments. Considered together, it is likely that a new engine platform could be about 2 percent better than engines using older platforms. Moreover, the agencies have seen CBI data that suggests improvement of more than 3 percent are possible. However, because designing and producing a new engine platform requires hundreds of millions of dollars in capital investment and significant lead time for research and development, it would not be appropriate to project that each engine manufacturer could complete a complete redesign of all of its engines within the Phase 2 time frame. Unlike light-duty, heavy-duty sales volumes are not large enough to support short redesign cycles. As a result, it can take 20 years for a manufacturer to generate the necessary return on the investment associated with an engine redesign. Forcing a manufacturer to redesign its engines prematurely could easily result in significant financial strain on a company.

On the other hand, how far the various manufacturers are into their design cycles suggests that one or more manufacturers will probably introduce a new engine platform during the Phase 2 time frame. This would not enable other engine manufacturers to meet more stringent standards, and thus it would not be an appropriate basis to justify more stringent engine standards (and certainly not engine standards reflecting 100 percent use of technologies premised on existence of new platforms). However, the availability of some more efficient engines on the market will provide the opportunity for *vehicle* manufacturers to lower their average fuel consumption as measured by GEM. Vehicle manufacturers can use a mix of newer and older engine designs to achieve an average engine performance significantly better than what is required by the engine standards. Thus, the vehicle standards can reflect engine platform improvements (which are amenable to measurement in GEM), without necessarily forcing each manufacturer to achieve these additional reductions, which may be achievable only for new engine platforms.

As discussed in Section III.D.(1)(b)(i), the agencies project that at least one engine manufacturer (and possibly more) will have completed a redesign for tractor engines by 2027. Accordingly, we project that 50 percent of tractor engines in 2027 will be redesigned engines and be 1.6 percent more efficient than required by the engine standards, so the average engine would be 0.8 percent better. However, we could have projected the same overall improvement by projecting 25 percent of engine getting 3.2 percent better. Based on the CBI information available to us, we believe projecting a 0.8 percent improvement is reasonable, but may be somewhat conservative.

Adding this 0.8 percent improvement to the 5.1 percent reduction *required* by the standards means we project the average 2027 tractor engine would be 5.9 percent better than Phase 1. Because engine improvements for tractors are applied separately for day cabs and sleeper cabs in the vehicle program, we estimated separate improvements for them here. Specifically, we project a 5.4 percent reduction for day cabs and a 6.4 percent reduction in fuel consumption in sleeper cabs beyond Phase 1. It is important to also note that manufacturers that do not achieve this level would be able to make up for the difference by applying one of the many other tractor vehicle technologies to a greater extent than we project, or to achieve greater reductions by optimizing technology efficiency further. We are not including the cost of developing these new engines in our cost analysis because we believe these engines are going to be developed due to market forces (*i.e.,* the new platform, already contemplated) rather than due to this rulemaking.

We are making a similar new engine platform projection for vocational vehicles. This is because many of tractor and vocational engines, such as HHD, would likely share the same engine hardware with the exception of WHR. In addition, the model based control discussed in Chapter 2.3 of the RIA could integrate engines better with transmissions on the vehicle side. We believe manufacturers will first focus their efforts on improving tractor engines but still believe that the 2027 vocational engine will be significantly better than required by the engine standards.

(3) EPA Engine Standards for N_2O

EPA will continue to apply the Phase 1 N_2O engine standard of 0.10 g/bhp-hr and a 0.02 g/bhp-hr default deterioration factor to the Phase 2 program. EPA adopted the cap standard for N_2O as an engine-based standard because the agency believes that emissions of this GHG are technologically related solely to the engine, fuel, and emissions after-treatment systems, and the agency is not aware of any influence of vehicle-based technologies on these emissions. Note that NHTSA did not adopt standards for N_2O because these emissions do not impact fuel consumption in a significant way.

In the proposal we considered reducing both the standard and deterioration factor to 0.05 and 0.01 g/bhp-hr respectively because engines certified in model year 2014 were generally meeting the proposed standard. We also explained the process behind N_2O formation in urea SCR after-treatment systems and how that process could be optimized to elicit additional N_2O reductions. 80 FR 40203. While we have seen some reductions and a few increases in engine family certified N_2O levels across the 2014, 2015, and 2016 model years, the majority have remained unchanged.

While we still believe that further optimization of SCR systems is possible to reduce N_2O emissions, as demonstrated for some engine families, we do not know to what extent further optimization can be achieved given the tradeoffs required to meet the Phase 2 CO_2 standards. These tradeoffs potentially include advancing fuel injection timing to reduce CO_2 emissions resulting in an increase in NO_X emissions at the engine outlet before the after-treatment, increasing the needed NO_X reduction efficiency of the SCR system. We will continue to assess N_2O emissions as SCR technology evolves and CO_2 emission reductions phase in, and we will revisit the standard at a later date to further control N_2O emission. This will likely be included in the upcoming rule to consider more stringent NO_X standards.

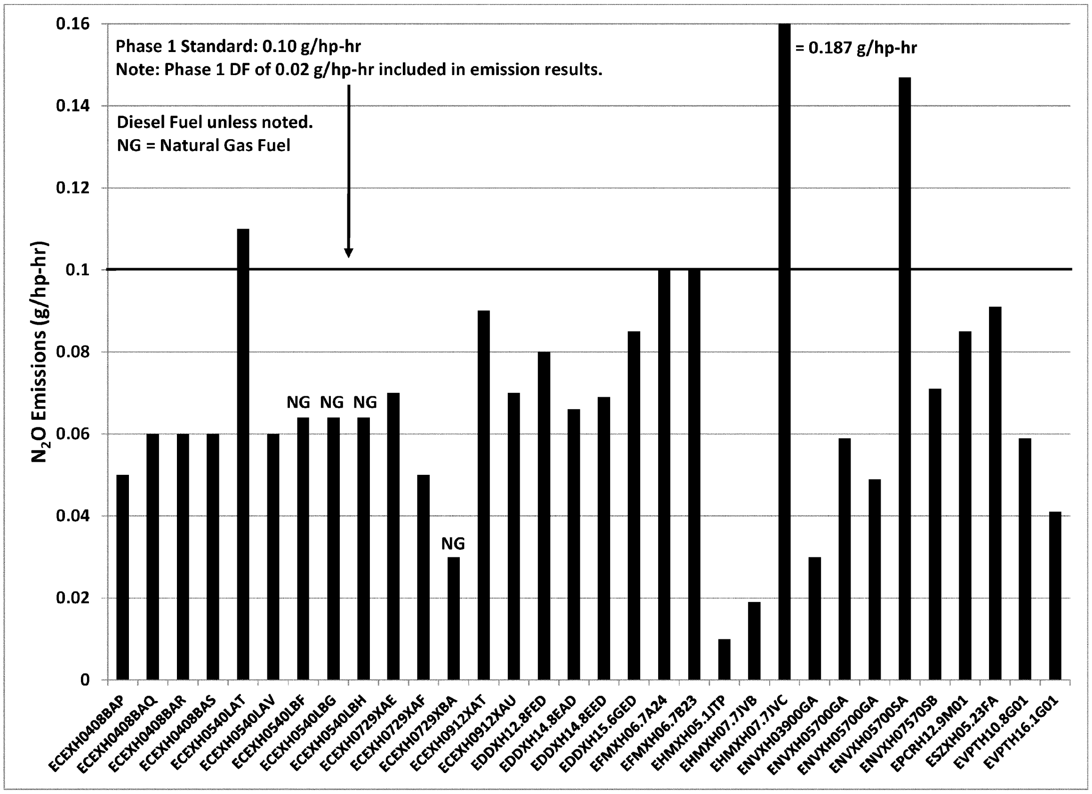

Figure II.6 EPA 2014 Certification Database N_2O Emission Results for 24 Engines.

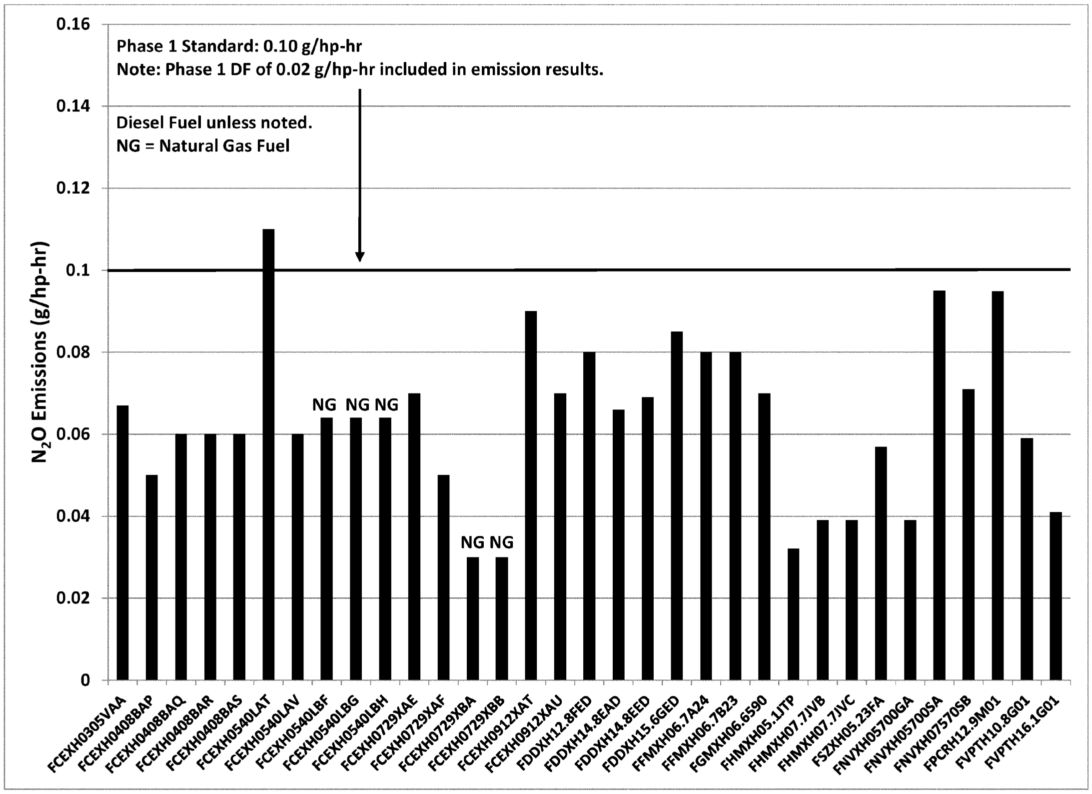

Figure II.7 EPA 2015 Certification Database N_2O Emission Results for 24 Engines.

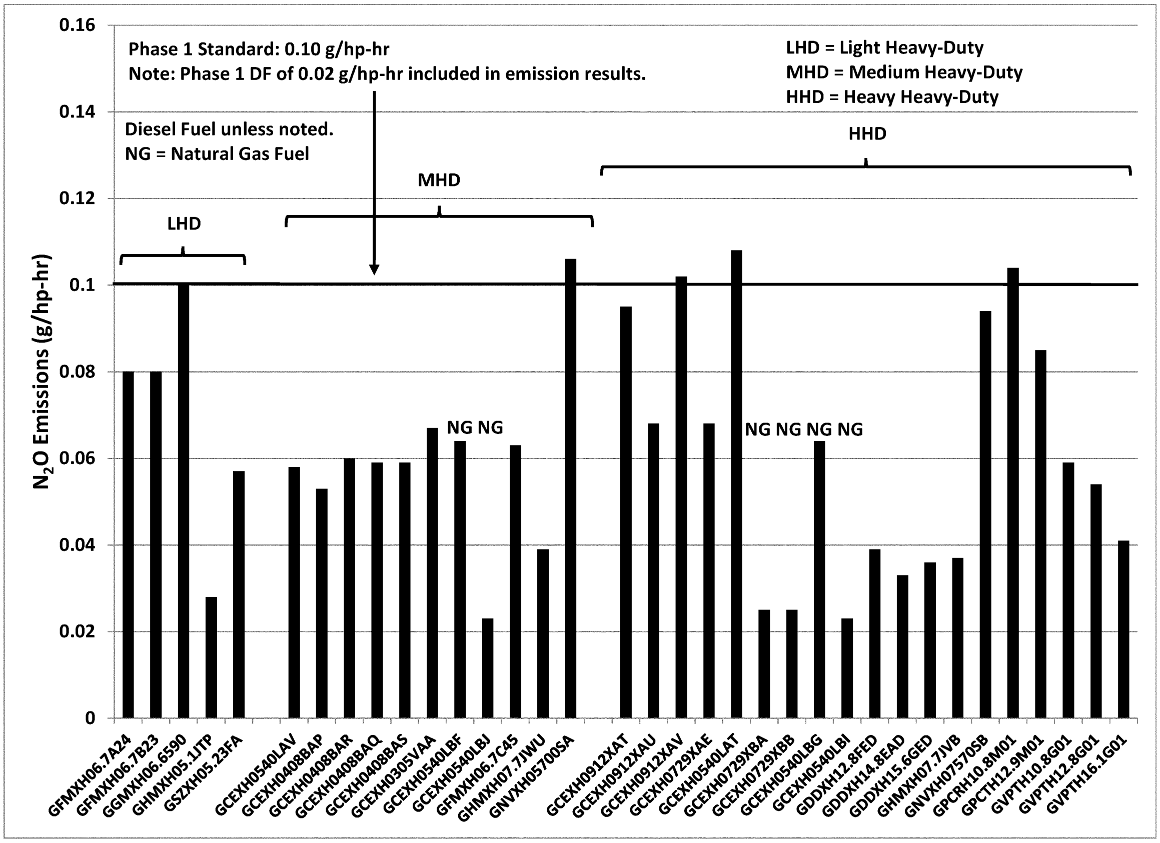

Figure II.8 EPA 2016 Certification Database N_2O Emission Results for 24 Engines.

(4) EPA Engine Standards for Methane

EPA will continue to apply the Phase 1 methane engine standards to the Phase 2 program. EPA adopted the cap standards for CH_4 (along with N_2O standards) as engine-based standards because the agency believes that emissions of this GHG are technologically related solely to the engine, fuel, and emissions after-treatment systems, and the agency is not aware of any influence of vehicle-based technologies on these emissions. We are applying these cap standards against the FTP duty-cycle because the FTP cycle is the most stringent with respect to emissions of these pollutants and we do not believe that a reduction is stringency from the current Phase 1 standards is warranted. Note that NHTSA did not adopt standards for CH_4 (or N_2O) because these emissions do not impact fuel consumption in a significant way.

EPA continues to believe that manufacturers of most engine technologies will be able to comply with the Phase 1 CH_4 standard with no technological improvements. We note that we are not aware of any new technologies that would have allowed us to adopt more stringent standards at this time.

(5) Compliance Provisions and Flexibilities for Engine Standards

The agencies are continuing most of the Phase 1 compliance provisions and flexibilities for the Phase 2 engine standards.

(a) Averaging, Banking, and Trading

The agencies' general approach to averaging is discussed in Section I. We did not propose to offer any new or special credits to engine manufacturers to comply with any of the separate engine standards. Except for early credits, the agencies are retaining all Phase 1 credit flexibilities and limitations to continue for use in the Phase 2 engine program.

As discussed below and as proposed, EPA is changing the useful life for LHD engines for GHG emissions from the current 10 years/110,000 miles to 15 years/150,000 miles to be consistent with the useful life of criteria pollutants recently updated in EPA's Tier 3 rule. In order to ensure that banked credits maintain their value in the transition from Phase 1 to Phase 2, EPA and NHTSA are adopting the proposed adjustment factor of 1.36 (*i.e.,* 150,000 mile ÷ 110,000 miles) for credits that are carried forward from Phase 1 to the MY 2021 and later Phase 2 standards. Without this adjustment factor the change in useful life would have effectively resulted in a discount of banked credits that are carried forward from Phase 1 to Phase 2, which is not the intent of the change in the useful life. See Sections V and VI for additional discussion of similar adjustments of vehicle-based credits.

Finally, the agencies are limiting the carryover of certain Phase 1 engine credits into the Phase 2 program. As described in Section II.D.(2) the agencies made adjustments to the FTP baselines, to address the unexpected step-change improvement in engine fuel consumption and CO_2 emissions. The underlying reasons for this shift are mostly related to manufacturers optimizing their SCR thermal management strategy over the FTP in ways that we (mistakenly) thought they already had in MY 2010 (*i.e.,* the Phase 1 baseline). At the time of Phase 1 we had not realized that these improvements were not already in the Phase 1 baseline. This issue does not apply for SET emissions, and thus only significantly impacts engines certified exclusively to the FTP standards (rather than both FTP and SET standards). To prevent manufacturers from diluting the Phase 2 engine program with credits generated relative to this incorrect baseline, we are not allowing engine credits generated against the Phase 1 FTP standards to be carried over into the Phase 2 program.

(b) Changing Global Warming Potential (GWP) Values in the Credit Program for CH_4 and N_2O

The Phase 1 rule included a compliance flexibility that allowed heavy-duty manufacturers and conversion companies to comply with the respective methane or nitrous oxide standards by means of over-complying with CO_2 standards (40 CFR 1036.705(d)). The heavy-duty rules allow averaging only between vehicles or engines of the same designated type (referred to as an ''averaging set'' in the rules). Specifically, the Phase 1 heavy-duty rulemaking added a CO_2 credits program which allowed heavy-duty engine manufacturers to average and bank emission credits to comply with the methane and nitrous oxide requirements after adjusting the CO_2 emission credits based on the relative GWP equivalents. To establish the GWP equivalents used by the CO_2 credits program, the Phase 1 rule incorporated the IPCC Fourth Assessment Report GWP values of 25 for CH_4 and 298 for N_2O, which are assessed over a 100 year lifetime.

EPA will continue this provision for Phase 2. However, since the Phase 1 rule was finalized, a new IPCC report has been released (the Fifth Assessment Report), with new GWP estimates. This caused us to look again at the relative GWP equivalency of methane and nitrous oxide and to seek comment on whether the methane and nitrous oxide GWPs used to establish the equivalency value for the CO_2 Credit program should be updated to those established by IPCC in its Fifth Assessment Report. 80 FR 40206. The Fifth Assessment Report provides four 100 year GWP values for methane ranging from 28 to 36 and two 100 year GWP values for nitrous oxide, either 265 or 298.

EPA is updating the GWP value to convert CO_2 credits for use against the methane standard. We are using a GWP of 34 for the value of methane reductions relative to CO_2 reductions. (The GWP remains 298 for N_2O). The use of this new methane GWP will not begin until MY 2021, when the Phase 2 engine standards begin. This provides sufficient lead time for both the agencies and manufacturers to update systems, and also ensures that manufacturers would be able make any necessary design changes. The choice of when to commence use of this GWP value for our engines standards does not prejudice the choice of other GWP values for use in regulations and other purposes in the near term. Further discussion is found in Section XI.D.2.a.

(c) In-Use Compliance and Useful Life

Consistent with section 202(a)(1) and 202(d) of the CAA, for Phase 1, EPA established in-use standards for heavy-duty engines. Based on our assessment of testing variability and other relevant factors, we established in-use standards by adding a 3 percent adjustment factor to the full useful life CO_2 emissions and fuel consumption results measured in the EPA certification process to address measurement variability inherent in comparing results among different laboratories and different engines. See 40 CFR part 1036. The agencies are not changing this for Phase 2 SET and FTP engine standard compliance.

In Phase 1, EPA set the useful life for engines and vehicles with respect to GHG emissions equal to the respective useful life periods for criteria pollutants. In April 2014, as part of the Tier 3 light-duty vehicle final rule, EPA extended the regulatory useful life period for criteria pollutants to 150,000 miles or 15 years, whichever comes first, for Class 2b and 3 pickup trucks and vans and some light-duty trucks (79 FR 23414, April 28, 2014). As proposed, EPA is applying the same useful life of 150,000 miles or 15 years for the Phase 2 GHG standards for engines primarily intended for use in vocational vehicles with a GVWR at or below 19,500 lbs. NHTSA will use the same useful life values as EPA for all heavy-duty vehicles.

As proposed, we will continue the regulatory allowance in 40 CFR 1036.150(g) that allows engine manufacturers to use assigned deterioration factors (DFs) for most engines without performing their own durability emission tests or engineering analysis. However, the engines will still be required to meet the standards in actual use without regard to whether the manufacturer used the assigned DFs. This allowance is being continued as an interim provision and may be discontinued for later phases of standards as more information becomes known. Manufacturers are allowed to use an assigned additive DF of 0.0 g/bhp-hr for CO_2 emissions from any conventional engine (*i.e.,* an engine not including advanced or off-cycle technologies). Upon request, we could allow the assigned DF for CO_2 emissions from engines including advanced or off-cycle technologies, but only if we determine that it would be consistent with good engineering judgment. We believe that we have enough information about in-use CO_2 emissions from conventional engines to conclude that they will not increase as the engines age. However, we lack such information about the more advanced technologies. For technologies such as WHR that are considered advanced in the context of Phase 1, but would be treated as a more ordinary technology by the end of Phase 2, we plan to work with manufacturers to determine if using the assigned zero DF would be appropriate.

(d) Alternate CO_2 Standards

In the Phase 1 rulemaking, the agencies allowed certification to alternate CO_2 engine standards in model years 2014 through 2016. This flexibility was intended to address the special case of needed lead time to implement new standards for a previously unregulated pollutant. Since that special case does not apply for Phase 2, we are not adopting a similar flexibility in this rulemaking.

(e) Approach to Standards and Compliance Provisions for Natural Gas Engines

EPA is also making certain clarifying changes to its rules regarding classification of natural gas engines. This relates to standards for all emissions, both greenhouse gases and criteria pollutants. These clarifying changes are intended to reflect the status quo, and therefore should not have any associated costs.

EPA emission standards have always applied differently for gasoline-fueled and diesel-fueled engines. The regulations in 40 CFR part 86 implement these distinctions by dividing engines into Otto-cycle and Diesel-cycle technologies. This approach led EPA to categorize natural gas engines according to their design history. A diesel engine converted to run on natural gas was classified as a diesel-cycle engine; a gasoline engine converted to run on natural gas was classified as an Otto-cycle engine.

The Phase 1 rule described our plan to transition to a different approach, consistent with EPA's non-road programs, in which we divide engines into compression-ignition and spark-ignition technologies based only on the thermodynamic operating characteristics of the engines.[193] However, the Phase 1 rule included a provision allowing us to continue with

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[193] See 40 CFR 1036.108.

the historic approach on an interim basis.

Under the existing EPA regulatory definitions of ''compression-ignition'' and ''spark-ignition,'' a natural gas engine would generally be considered compression-ignition if it operates with lean air-fuel mixtures and uses a pilot injection of diesel fuel to initiate combustion, and would generally be considered spark-ignition if it operates with stoichiometric air-fuel mixtures and uses a spark plug to initiate combustion.

EPA's basic premise here is that natural gas engines performing similar in-use functions as diesel engines should be subject to similar regulatory requirements. The compression-ignition emission standards and testing requirements reflect the operating characteristics for the full range of heavy-duty vehicles, including substantial operation in long-haul service characteristic of tractors. The spark-ignition emission standards and testing requirements do not include some of those provisions related to use in long-haul service or other applications where diesel engines predominate, such as steady-state testing, Not-to-Exceed standards, and extended useful life. We believe it would be inappropriate to apply the spark-ignition standards and requirements to natural gas engines that are being used in applications mostly served by diesel engines today. We therefore proposed to replace the interim provision described above with a differentiated approach to certification of natural gas engines across all of the EPA standards—for both GHGs and criteria pollutants. 80 FR 40207. Under the proposed amendment, we would require manufacturers to divide all their natural gas engines into primary intended service classes, as we already require for compression-ignition engines, whether or not the engine has features that otherwise could (in theory) result in classification as SI under the current rules. We proposed that any natural gas engine qualifying as a medium heavy-duty engine (19,500 to 33,000 lbs. GVWR) or a heavy heavy-duty engine (over 33,000 lbs. GVWR) would be subject to all the emission standards and other requirements that apply to compression-ignition engines. However, based on comments, we are finalizing this change only for heavy heavy-duty engines. Commenters identified medium heavy-duty applications in which SI alternative fuel engines compete significantly with gasoline engines, which is not consistent with the premise of the proposal. Thus, we are not finalizing the proposed change for medium heavy-duty engines.

Table II–15 describes the provisions that apply differently for compression-ignition and spark-ignition engines:

TABLE II–15—REGULATORY PROVISIONS THAT ARE DIFFERENT FOR COMPRESSION-IGNITION AND SPARK-IGNITION ENGINES

Provision	Compression-ignition	Spark-ignition
Transient duty cycle	40 CFR part 86, Appendix I, paragraph (f)(2) cycle; divide by 1.12 to de-normalize.	40 CFR part 86, Appendix I, paragraph (f)(1) cycle.
Ramped-modal test (SET)	yes	no.
NTE standards	yes	no.
Smoke standard	yes	no.
Manufacturer-run in-use testing	yes	no.
ABT—pollutants	NO_X, PM	NO_X, NMHC.
ABT—transient conversion factor	6.5	6.3.
ABT—averaging set	Separate averaging sets for light, medium, and heavy HDDE	One averaging set for all SI engines.
Useful life	110,000 miles for light HDDE,[a] 185,000 miles for medium HDDE, 435,000 miles for heavy HDDE.	110,000 miles.[a]
Warranty	50,000 miles for light HDDE, 100,000 miles for medium HDDE, 100,000 miles for heavy HDDE.	50,000 miles.
Detailed AECD description	yes	no.
Test engine selection	highest injected fuel volume	most likely to exceed emission standards.

Note:

[a] As proposed, useful life for light heavy-duty diesel and spark ignition engines is being increased to 150,000 miles for GHG emissions, but remains at 110,000 for criteria pollutant emissions.

The onboard diagnostic requirements already differentiate requirements by fuel type, so there is no need for those provisions to change based on the considerations of this section.

We are not aware of any currently certified engines that will change from compression-ignition to spark-ignition under this approach. Nonetheless, because these proposed changes could result in a change in standards for engines currently under development, we believe it is appropriate to provide additional lead time. We will therefore continue to apply the existing interim provision through model year 2020.[194] Starting in model year 2021, all the provisions will apply as described above for heavy heavy-duty engines. Manufacturers will not be permitted to certify any engine families using carryover emission data if a particular engine model switched from compression-ignition to spark-ignition, or vice versa. However, as noted above, in practice these vehicles are already being certified as CI engines, so we view these changes as clarifications ratifying the current status quo.

These provisions will apply equally to engines fueled by any fuel other than gasoline or ethanol, should such engines be produced in the future. Given the current and historic market for vehicles above 33,000 lbs. GVWR, the agencies believe any alternative-fueled vehicles in this weight range will be competing primarily with diesel vehicles and should be subject to the same requirements as them. See Sections XI and XII for additional discussion of natural gas fueled engines.

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[194] Section 202(a)(2), applicable to emissions of greenhouse gases, does not mandate a specific period of lead time, but EPA sees no reason for a different compliance date here for GHGs and criteria pollutants. This is also true with respect to the closed crankcase emissions discussed in the following subsection. Also, as explained in section I.E.i.e, EPA interprets the phrase ''classes or categories of heavy duty vehicles or engines'' in CAA section 202(a)(3)(C) to refer to categories of vehicles established according to features such as their engine cycle (spark-ignition or compression-ignition).l.

(f) Crankcase Emissions From Natural Gas Engines

EPA proposed to require that all natural gas-fueled engines have closed crankcases, rather than continuing the provision that allows venting to the atmosphere all crankcase emissions from all compression-ignition engines. 80 FR 40208. However, EPA is not finalizing the proposed requirement at this time.

Open crankcases have been allowed as long as these vented crankcase emissions are measured and accounted for as part of an engine's tailpipe emissions. This allowance has historically been in place to address the technical limitations related to recirculating diesel-fueled engines' crankcase emissions, which have high PM emissions, back into the engine's air intake. High PM emissions vented into the intake of an engine can foul turbocharger compressors and after cooler heat exchangers. In contrast, historically EPA has mandated closed crankcase technology on all gasoline fueled engines and all natural gas spark-ignition engines.[195] The inherently low PM emissions from these engines posed no technical barrier to a closed crankcase mandate. However, after considering the comments on this issue, we now believe that there are practical reasons why we should not close natural gas crankcases without also requiring closed crankcases for other compression-ignition engines. Because current natural gas engines are generally produced from diesel engine designs that are not designed to operate with closed crankcases, we have concerns that sealing the crankcase on the natural gas versions will require substantial development effort, and the seals may not function properly. Thus, we expect to update our regulations for crankcase emissions from all compression ignition engines at the same time in a future rulemaking.

(g) Compliance Margins

Some commenters suggested that the agencies should apply a compliance margin to confirmatory and SEA test results to account for variability of engine maps and emission tests. However, EPA's past practice has been to base the standards on technology projections that assume manufacturers will apply compliance margins to their test results for certification. In other words, they design their products to have emissions below the standards by some small margin so that test-to-test or lab-to-lab variability would not cause them to exceed any applicable standards. Consequently, EPA has typically not set standards precisely at the lowest levels achievable, but rather at slightly higher levels—expecting manufacturers to target the lower levels to provide compliance margins for themselves. The agencies have applied this approach to the Phase 2 standards. Thus, the feasibility and cost analyses reflect the expectation that manufacturers will target lower values to provide compliance margins.

The agencies have also improved the engine test procedures and compliance provisions to reduce the agencies' and the manufacturers' uncertainty of engine test results. For example, in the agencies' confirmatory test procedures we are requiring that the agencies use the average of at least three tests (*i.e.,* the arithmetic mean of a sample size of at least three test results) for determining the values of confirmatory test results for any GEM engine fuel maps. We are only doing this for GEM engine fuel maps because these are relatively new tests, compared to Phase 1 testing or EPA's other emissions standards. Therefore, this provision does not apply to any other emissions testing. For all other emissions testing besides GEM engine fuel maps the agencies' maintain our usual convention of utilizing a sample size of one for confirmatory testing. For GEM engine fuel mapping this at least triples the test burden for the agencies to conduct confirmatory testing, but it also decreases confirmatory test result uncertainty by at least 42 percent.[196] Based on improvements like this one, and others described in Section 1.4 of the RTC, we believe that SET, FTP and GEM's steady-state, cycle-average and powertrain test results will have an overall uncertainty of +/−1.0 percent. To further protect against falsely high emissions results or false failures due to this remaining level of test procedure uncertainty, we have included a +1 percent compliance margin into our stringency analyses of the engine standards and the GEM fuel map inputs used to determine the tractor and vocational vehicle standards. In other words we set Phase 2 engine and vehicle standards 1 percent less stringent than if we had not considered this test procedure uncertainty.

In addition to the test procedure improvements and the +1 percent margin we incorporated into our standards, the agencies are also committed to a process of continuous improvement of test procedures to further reduce test result uncertainty. To contribute to this effort, in mid-2016 EPA committed $250,000 to fund research to further evaluate individual sources of engine mapping test procedure uncertainty. This work will occur at SwRI. Should the results of this work or other similar future work indicate test procedure improvements that would further reduce test result uncertainty, the agencies will incorporate these improvements through appropriate guidance or through technical amendments to the regulations via a notice and comment rulemaking. If we determine in the future through the SwRI work or other work that such improvements eliminate the need to require the agencies to conduct triplicate confirmatory testing of GEM engine fuel maps, we will promulgate technical amendments to the regulations to remove this requirement. If we determine in the future through the SwRI work or other work that the +1.0 percent we factored into our stringency analysis was inappropriately low or high, we will promulgate technical amendments to the regulations to address any inappropriate impact this +1.0 percent had on the stringency of the engine and vehicle standards.[197] In addition, whenever the agencies determine whether or not confirmatory test results are statistically significantly different from manufacturers' declared values, the agencies will use good engineering judgment to appropriately factor into such determinations the results of this SwRI work and/or any other future work that quantifies our test procedures' uncertainty.

III. Class 7 and 8 Combination Tractors

Class 7 and 8 combination tractors-trailers contribute the largest portion of the total GHG emissions and fuel consumption of the heavy-duty sector, approximately 60 percent, due to their large payloads, their high annual miles traveled, and their major role in national freight transport.[198] These vehicles

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[195] See 40 CFR 86.008–10(c).

[196] The statistical formula for standard error, which is a well-accepted measure of uncertainty, is the standard deviation times the reciprocal of the square root of the sample size. For a sample size of three, the reciprocal of the square root of three is approximately 0.58, which results in a 42% reduction in uncertainty, versus a sample size of one.

[197] Note that this +1.0 percent compliance margin built into the standards, or any other future determination of test procedure uncertainty, does not impact the agencies' technology feasibility or cost-benefit analyses for this rulemaking.

[198] The on-highway Class 7 and 8 combination tractor-trailers constitute the vast majority of this regulatory category. A small fraction of combination tractors are used in off-road applications and are regulated differently, as described in Section III.C.

program an off-cycle credit program rather than an innovative technology program (although there is little, if any, difference in practice). In other words, beginning in 2021 MY all technologies that are not accounted for in the GEM test procedure (including powertrain testing) could be considered off-cycle, including those technologies that may have been considered innovative technologies in Phase 1 of the program. The agencies proposed to maintain the requirement that, in order for a manufacturer to receive credits for Phase 2, the off-cycle technology would still need to meet the requirement that it was not in common use prior to MY 2010. However, the final provisions will not require manufacturers to make such a demonstration. Rather, the agencies will merely retain the authority to deny a request if we determine that a technology was in common use in 2010 and was thus part of the Phase 1 baseline (and thus also the Phase 2 baseline). For additional information on the treatment of off-cycle technologies see Section I.C.1.c. as well as the discussion of off-cycle credits in each of the Phase 2 standard chapters.

(3) Post Useful Life Modifications

Under 40 CFR part 1037, it is generally prohibited for any person to remove or render inoperative any emission control device installed to comply with the requirements of part 1037. However, in 40 CFR 1037.655 EPA clarifies that certain vehicle modifications are allowed after a vehicle reaches the end of its regulatory useful life. This section applies for all vehicles subject to 40 CFR part 1037 and will thus apply for trailers regulated in Phase 2. EPA proposed to continue this provision and requested comment on it. 80 FR 40252.

This section states (as examples) that it is generally allowable to remove tractor roof fairings after the end of the vehicle's useful life if the vehicle will no longer be used primarily to pull box trailers, or to remove other fairings if the vehicle will no longer be used significantly on highways with vehicle speed of 55 miles per hour or higher. More generally, this section clarifies that owners may modify a vehicle for the purpose of reducing emissions, provided they have a reasonable technical basis for knowing that such modification will not increase emissions of any other pollutant. This essentially requires the owner to have information that will lead an engineer or other person familiar with engine and vehicle design and function to reasonably believe that the modifications will not increase emissions of any regulated pollutant. Thus, this provision does not provide a blanket allowance for modifications after the useful life.

This section also makes clear that no person may ever disable a vehicle speed limiter prior to its expiration point, or remove aerodynamic fairings from tractors that are used primarily to pull box trailers on highways. It is also clear that this allowance does not apply with respect to engine modifications or recalibrations.

This section does not apply with respect to modifications that occur within the useful life period, other than to note that many such modifications to the vehicle during the useful life and to the engine at any time are presumed to violate section 202(a)(3)(A) of the Act. EPA notes, however, that this is merely a presumption, and it does not prohibit modifications during the useful life where the owner clearly has a reasonable technical basis for knowing that the modifications would not cause the vehicle to exceed any applicable standard.

The agencies did not receive comments opposing the proposed regulation, and is adopting it as proposed.

(4) Other Interim Provisions

In HD Phase 1, EPA adopted provisions to delay the full onboard diagnostics (OBD) requirements for heavy-duty hybrid powertrains until the 2016 and 2017 model years (see 40 CFR 86.010–18(q)). In discussions with manufacturers during the development of Phase 2, the agencies have learned that meeting the on-board diagnostic requirements for criteria pollutant engine certification continues to be a potential impediment to adoption of hybrid systems. See Section XIII.A.1 for a discussion of regulatory changes to reduce the non-GHG certification burden for engines paired with hybrid powertrain systems.

The Phase 1 advanced technology credits were adopted to promote the implementation of advanced technologies, such as hybrid powertrains, Rankine cycle engines, all-electric vehicles, and fuel cell vehicles (see 40 CFR 1037.150(p)). As the agencies stated in the Phase 1 final rule, the Phase 1 standards were not premised on the use of advanced technologies but we expected these advanced technologies to be an important part of the Phase 2 rulemaking (76 FR 57133, September 15, 2011). The HD Phase 2 heavy-duty engine and tractor standards are premised on the use of Rankine-cycle engines; therefore, the agencies believe it is no longer appropriate to provide extra credit for this technology. While the agencies have not premised the HD Phase 2 tractor standards on hybrid powertrains, fuel cells, or electric vehicles, we also foresee some limited use of these technologies in 2021 and beyond. We proposed in Phase 2 to not provide advanced technology credits in Phase 2 for any technology, but received many comments supporting the need for such incentive. As described in Section I.C.1.b, the agencies are finalizing credit multipliers for plug-in battery electric hybrids, all-electric, and fuel cell vehicles.

(5) Phase 1 Flexibilities Not Adopted for Phase 2

In Phase 1, the agencies adopted an early credit mechanism to create incentives for manufacturers to introduce more efficient engines and vehicles earlier than they otherwise would have planned to do (see 40 CFR 1037.150(a)). The agencies did not propose to extend this flexibility to Phase 2 because the ABT program from Phase 1 will be available to manufacturers in 2020 model year and this will displace the need for early credits. However, the agencies are adopting provisions in the final Phase 2 rule that provide early credit opportunities for a limited set of technologies (see 40 CFR 1037.150(y)(2); see also 40 CFR 1037.150(y)(1) and (3) providing early credit flexibilities to certain vocational vehicles).

IV. Trailers

As mentioned in Section III, trailers pulled by Class 7 and 8 tractors (together considered ‘‘tractor-trailers’’) account for approximately 60 percent of the heavy-duty sector's total CO_2 emissions and fuel consumption. Because neither trailers nor the tractors that pull them are useful by themselves, it is the combination of the tractor and the trailer that forms the useful vehicle. Although trailers do not directly generate exhaust emissions or consume fuels (except for the refrigeration units on refrigerated trailers), their designs and operation nevertheless contribute substantially to the CO_2 emissions and diesel fuel consumption of the tractors pulling them. See also Section I.E above.

The agencies are finalizing standards for trailers specifically designed to be drawn by Class 7 and 8 tractors when coupled to the tractor's fifth wheel. Although many other vehicles are known commercially as trailers, this trailer program does not apply to those that are pulled by vehicles other than tractors, and those that are coupled to vehicles exclusively by pintle hooks or hitches instead of a fifth wheel. These standards are expressed in terms of CO_2 emissions and fuel consumption, and as described in more detail in Section IV.C.(2), apply to specific trailer subcategories. In general, the final standards are based on the same technology as the proposed standards—primarily better tires (including tire pressure management) for all regulated trailers and aerodynamic improvements for box vans (dry and refrigerated). Most of the changes from the proposal are intended to simplify and clarify the implementation of these standards. See Section IV.B. for an overview of the final program, and the rest of this Section IV for more detailed discussions.

This rulemaking establishes the first EPA regulations covering trailer manufacturers for CO_2 emissions (or any other emissions), and the first fuel consumption regulations by NHTSA for these manufacturers. The agencies have designed this program to be a unified national program, so that when a trailer model complies with EPA's standards it will also comply with NHTSA's standards, and vice versa.

A. The Trailer Industry

(1) Industry Characterization

The trailer industry encompasses a wide variety of trailer applications and designs. Among these are box vans (dry and refrigerated vans of various sizes) and ''non-box'' trailers, including platform (*e.g.,* lowboys, flatbeds), tanks, container chassis, bulk, dump, grain, and many specialized types of trailers, such as car carriers, pole trailers, and logging trailers. Most trailers are designed for predominant use on paved streets, roads, and highways. A relatively small number of trailers are designed with unique capabilities and features for dedicated use in off-road applications.

The trailer manufacturing industry is very competitive, and manufacturers are highly responsive to their customers' diverse demands. The wide range of trailer designs and features reflects the broad variety of customer needs, chief among them typically being the ability to maximize the amount of freight the trailer can transport. Other design goals reflect the numerous, more specialized customer needs.

Box vans (*i.e.,* dry and refrigerated) are the most common type of trailer and are made in many different lengths, generally ranging from 28 feet to 53 feet. While all have a rectangular shape, they can vary widely in basic construction design (internal volume and weight), materials (steel, fiberglass composites, aluminum, and wood) and the number and configuration of axles (usually two axles closely spaced, but number and spacing of axles can be greater). Box van designs may also include additional features, such as one or more side doors, out-swinging or roll-up rear doors, side or rear lift gates, and numerous types of undercarriage accessories (such as access ramps, dolly storage, spare tire storage, or mechanical lifts).

Non-box trailers are often uniquely designed to transport a specific type of freight. Platform trailers carry cargo that may not be easily contained within or loaded into/unloaded from a box van, such as large, non-uniform equipment or machine components. Tank trailers are often sealed or pressurized enclosures designed to carry liquids, gases or bulk, dry solids and semi-solids. There are also a number of other specialized trailers such as grain, dump, livestock trailers, or logging.

Chapter 1 of the RIA includes a more thorough characterization of the trailer industry. The agencies have considered the variety of trailer designs and applications in developing the CO_2 emissions and fuel consumption standards for trailers. As is described later in this Section IV, the agencies have excluded most types of specialized trailers from the Phase 2 regulations.

(2) Context for the Trailer Provisions

(a) Summary of Trailer Consideration in Phase 1

In the Phase 1 program, the agencies did not regulate trailers, but discussed how we might do so in the future (see 76 FR 57362). In proposing the Phase 1 program, the agencies solicited general comments on controlling CO_2 emissions and fuel consumption through future trailer regulations (see 75 FR 74345–74351). The agencies considered those comments in developing today's rules.

(b) SmartWay Program

For several years, EPA's voluntary SmartWay Transport Partnership program has been encouraging businesses to take actions that reduce fuel consumption and CO_2 emissions while cutting costs. The SmartWay program works with the shipping, logistics, and carrier communities to identify cleaner strategies and technologies for moving goods across their transportation supply chains. It is a voluntary, market-based program that provides carbon footprint and other air emissions performance information to partners who submit annual partner reports. SmartWay Partners commit to assessing, tracking, and improving environmental performance over time, by adopting fuel-saving practices and technologies. SmartWay also provides technical assistance, provides recognition incentives and encourages the use of best practices that enable companies to readily incorporate fuel and emission reduction strategies into their freight supply chains.

Annually, SmartWay trucking fleet partners report type and amount of fuel consumption, tons of goods moved, type and model year of equipment used, miles driven, speed profiles and other data. Using EPA MOVES model emission factors and other EPA resources, SmartWay's assessment and tracking tools convert this information to an objective ranking of a company's environmental efficiency, enabling each participating company to benchmark performance relative to its competitors. Logistics companies, multimodal firms and shippers use this information to calculate their corporate emissions from goods movement, which can be included in annual carbon reporting protocols and sustainability reports.

EPA's SmartWay program has accelerated the availability and market penetration of advanced, fuel efficient technologies and operational practices. In conjunction with the SmartWay Partnership Program, EPA established a testing, verification, and designation program, the SmartWay Technology Program, to help freight companies identify the equipment, technologies, and strategies that save fuel and lower emissions. SmartWay verifies the performance of aerodynamic equipment, low rolling resistance tires and other technologies and maintains lists of verified technologies on its Web site. Trailer aerodynamic technologies are grouped in performance bins that represent one percent, four percent, five percent or nine percent fuel savings relative to a typical long-haul tractor-trailer at 65-mph cruise conditions. As a shorthand description and to encourage saving fuel with multiple available technologies, EPA established criteria to describe tractors and trailers as SmartWay designated if they are equipped with specific technologies. Historically, a 53-foot dry van trailer equipped with verified aerodynamic devices totaling at least five percent fuel savings, and SmartWay verified tires, qualifies as a ''SmartWay Designated Trailer.'' In 2014, EPA expanded the program to include the aerodynamic bin for nine percent or more fuel savings and these trailers when also equipped with verified tires qualify as ''SmartWay Designated Elite Trailer.'' The 2014 updates also expanded the use of aerodynamic technologies and SmartWay-designated trailer eligibility to include 53-foot refrigerated van trailers in addition to 53-foot dry van trailers.

The SmartWay Technology Program continues to improve the industry understanding of technologies, test methods and quality of data fleet stakeholders need to achieve fuel savings and environmental goals. EPA bases its SmartWay verification protocols on common industry test methods with additional criteria to achieve performance objectives and cost effective industry acceptance. Historically, SmartWay's aerodynamic equipment verification protocol was based on the TMC type II and SAE J1321 test procedures, which measures fuel consumption as test vehicles drive laps around a test track. Under SmartWay's 2014 updates, EPA expanded the aerodynamic technology verification program to allow additional testing options. The updates included a new, more stringent 2014 track test protocol based on industry updates to the TMC RP 1102 (2014) and SAE's 2012 update to its SAE J1321 test method[326] as well as protocols for wind tunnel and coastdown methods. The SmartWay program is also reviewing computational fluid dynamics (CFD) approaches for verification. These new protocols are based on stakeholder input, the latest industry standards (*i.e.,* 2012 versions of the SAE fuel consumption and wind tunnel test[327] methods and 2013 CFD guidance[328]), EPA's own testing and research, and lessons learned from years of communications with manufacturers, testing organizations and trucking companies. Wind tunnel, coastdown, and CFD testing produce values for aerodynamic drag improvements in terms of coefficient of drag (C_D), which is then related to projected fuel savings using a mathematical curve.[329]

The SmartWay Technology Program verifies tires based on test data submitted by tire manufacturers demonstrating the coefficient of rolling resistance (C_{RR}) of their tires using either the SAE J1269 or ISO 28580 test methods. These verified tires have rolling resistance targets for each axle position on the tractor and trailer. SmartWay-verified trailer tires achieve a C_{RR} of 5.1 kg/metric ton or less on the ISO28580 test method. Compared to popular tires used in 2007, an operator who replaces the trailer tires with SmartWay-verified tires can expect fuel consumption savings of one percent or more at a 65-mph cruise. Operators who apply SmartWay-verified tires on both the trailer *and* tractor can achieve three percent fuel consumption savings at 65-mph. As most van trailers and many other trailer types are manufactured with SmartWay verified tires, fleets have confidence in maintaining their fuel performance thru the use of and flexibility to choose other SmartWay verified tires.

Over the last decade, the trucking industry has achieved measureable fuel consumption benefits by adding aerodynamic features and low rolling resistance tires to their trailers. To date, SmartWay has verified over 70 aerodynamic technologies, including ten packages from five manufacturers that have received the Elite performance level. The SmartWay Transport Partnership program has worked with over 3,000 partners, the majority of which are trucking fleets, and broadly throughout the supply-chain industry, since 2004. These relationships, combined with the Technology Program's extensive involvement testing and technology development has provided EPA with significant experience in freight fuel efficiency. Furthermore, the more than 10-year duration of the voluntary SmartWay Transport Partnership has resulted in significant fleet and manufacturer experience with innovating and deploying technologies that reduce CO_2 emissions and fuel consumption.

(c) California Tractor-Trailer Greenhouse Gas Regulation

The state of California passed the Global Warming Solutions Act of 2006 (Assembly Bill 32, or AB32), enacting the state's 2020 greenhouse gas emissions reduction goal into law. Pursuant to this Act, the California Air Resource Board (CARB) was required to begin developing early actions to reduce GHG emissions. As a part of a larger effort to comply with AB32, the California Air Resource Board issued a regulation entitled ''Heavy-Duty Greenhouse Gas Emission Reduction Regulation'' in December 2008.

This regulation reduces GHG emissions by requiring improvement in the efficiency of heavy-duty tractors and 53 feet or longer dry and refrigerated box trailers that operate in California.[330] The program is being phased in between 2010 and 2020. Small fleets have been allowed special compliance opportunities to phase in the retrofits of their existing trailer fleets through 2017. The regulation requires affected trailer fleet owners to either use SmartWay-verified aerodynamic technologies and SmartWay-verified tires or retread tires. The efficiency improvements are achieved through the use of aerodynamic equipment and low rolling resistance tires on both the tractor and trailer. EPA has granted a waiver for this California program.[331]

(d) NHTSA Safety-Related Regulations for Trailers and Tires

NHTSA regulates new trailer safety through regulations. Table IV–1 lists the current regulations in place related to trailers. Trailer manufacturers continue to be required to meet current safety regulations for the trailers they produce. FMVSS Nos. 223 and 224[332] require installation of rear guard protection on trailers. The definition of rear extremity of the trailer in 223 limits installation of rear fairings to a specified zone behind the trailer.

TABLE IV–1—CURRENT NHTSA STATUTES AND REGULATIONS RELATED TO TRAILERS

Reference	Title
49 CFR part 565	Vehicle Identification Number (VIN) Requirements.
49 CFR part 566	Manufacturer Identification.
49 CFR part 567	Certification.
49 CFR part 568	Vehicles Manufactured in Two or More Stages.
49 CFR part 569	Regroovеd Tires.
49 CFR part 571	Federal Motor Vehicle Safety Standards.
49 CFR part 573	Defect and Noncompliance Responsibility and Reports.
49 CFR part 574	Tire Identification and Recordkeeping.
49 CFR part 575	Consumer Information.
49 CFR part 576	Record Retention.

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[326] SAE International, Fuel Consumption Test Procedure—Type II. SAE Standard J1321. Revised 2012–02–06. Available at: *http://standards.sae.org/j1321_201202/*.

[327] SAE International. Wind Tunnel Test Procedure for Trucks and Buses. SAE Standard J1252. Revised 2012–07–16. Available at: *http://standards.sae.org/j1252_201207/*.

[328] SAE International, Guidelines for Aerodynamic Assessment of Medium and Heavy Commercial Ground Vehicles Using Computational Fluid Dynamics. SAE Standard J2966. Issued 2013–09–17. Available at: *http://standards.sae.org/j2966_201309/*.

[329] McCallen, R., et al. Progress in Reducing Aerodynamic Drag for Higher Efficiency of Heavy Duty Trucks (Class 7–8). SAE Technical Paper. 1999–01–2238.

[330] In December 2013, ARB adopted regulations that establish its own parallel Phase 1 program with standards consistent with the EPA Phase 1 tractor standards. On December 5, 2014 California's Office of Administrative Law approved ARB's adoption of the Phase 1 standards, with an effective date of December 5, 2014.

[331] See EPA's waiver of CARB's heavy-duty tractor-trailer greenhouse gas regulation applicable to new 2011 through 2013 model year Class 8 tractors equipped with integrated sleeper berths (sleeper-cab tractors) and 2011 and subsequent model year dry-can and refrigerated-van trailers that are pulled by such tractors on California highways at 79 FR 46256 (August 7, 2014).

[332] 49 CFR 571.223 and 571.224.

NHTSA recognizes that regulatory and market factors that result in changes in trailer weight can potentially have safety ramifications, both positive and negative. NHTSA believes that the appropriate perspective is to evaluate the regulation and market factors in their entirety. One such factor is that incentives in the Phase 2 regulation could result in an average decrease in trailer weight. Since removing weight from trailers allows more cargo to be carried, fewer trips are needed to move the same amount of cargo, and fewer crashes—including fatal crashes—could occur. Fleets and other customers have a natural incentive to request lighter-weight trailers. From the trailer owners' perspective, reducing trailer weight not only allows them to increase cargo when they are near capacity, but also reduces fuel consumption whether the trailer is fully loaded or not. In pre-proposal meetings with trailer manufacturers, companies said that customers are requesting lighter-weight components when possible and manufacturers are installing them.

To further incentivize a shift to lighter weight materials, the Phase 2 program provides two compliance mechanisms, both of which are discussed later in this Preamble (Section IV.D.(1)(d) and Section IV.E.(5)(d), respectively). The first is a list of weight reductions from which manufacturers can select. The list identifies specific lighter-weight components, such as side posts, roof bows, and flooring. Manufacturers using these lighter-weight components achieve fuel consumption and GHG reductions that count toward their compliance calculations. The NPRM identified twelve components, ranging from lighter-weight landing gear (which receives credit for 50 pounds of weight reduction) to aluminum upper coupler assemblies (which receive credit for 430 pounds). See proposed section 1037.515 at 80 FR 40627. In addition, for a lighter-weight component or technology that is not on the list of specific components, the program provides for manufacturers to use the ''off-cycle'' process to recognize the weight reduction (Section IV.E.(5)(d)). Through these mechanisms, the program provides significant flexibility and incentives for trailer light-weighting.

NHTSA also recognizes that the aerodynamic devices that we expect may be adopted to meet the Phase 2 trailer standards inherently add weight to trailers. In comments on the NPRM, TTMA stated that they believe that this weight increase will result in added trips and increased numbers of fatal crashes. By its analysis, this additional weight—which TTMA estimates to be 250 pounds per trailer, will cause some trucks to exceed the trailer weight limits, necessitating additional truck trips to transport freight that could not be moved by the ''weighed-out'' trucks. By TTMA's analysis, these added trips would cause an additional 184 million truck miles per year and would result in 246 crashes and 7 extra fatal crashes, using an assumed crash rate of 134 collisions per 100 million VMT and a 3 percent fatality rate per crash. The agencies evaluated TTMA's estimate of additional fatalities and disagree with some of the assumptions made in the analysis. For example, the fatality rate used was developed in a study conducted for Idaho and is higher than the national average. According to FMCSA's 2014 annual report for ''Large Truck and Bus Crash Facts'' indicates there are less than 1.67 fatalities per 100 million vehicle miles traveled (VMT) by combination trucks in the U.S. for 2014. When multiplied by an estimated 184 million additional truck miles due to weighed-out trucks, the result is an increase of about 3 fatalities, or 2.7 fatal crashes.

Overall, the potential positive safety implications of weight reduction efforts could partially or fully offset safety concerns from added weight of aerodynamic devices. In fact, for this reason, we believe that the Phase 2 trailer program could produce a net safety benefit in the long run due to the potentially greater amount of cargo that could be carried on each truck as a result of trailer weight reduction.

(e) Additional DOT Regulations Related to Trailers

In addition to NHTSA's regulations, DOT's Federal Highway Administration (FHWA) regulates the weight and dimensions of motor vehicles on the National Network.[333] FHWA's regulations limit states from setting truck size and weight limits beyond certain ranges for vehicles used on the National Network. Specifically, vehicle weight and truck tractor-semitrailer length and width are limited by FHWA.[334] EPA and NHTSA do not anticipate any conflicts between FHWA's regulations and those established in this rulemaking.

Utility Trailer Manufacturing Co. (Utility) commented that reducing existing restrictions on trailer size and weight could help encourage the transition to new technologies and trailer designs. However, these size and weight restrictions are under the jurisdiction of FHWA, and are largely controlled by the weight limits established by Congress in 1956 and 1974, the size limits established in the Surface Transportation Assistance Act of 1982, and the size and weight limits established in the Intermodal Surface Transportation Efficiency Act of 1991. Changes to these restrictions would require a broader process involving Congress and federal and state agencies, and is beyond the scope of the Phase 2 trailer program.

Wabash National Corporation (Wabash) stated that the agencies should seek to ensure that today's action harmonizes with safety regulations applicable to trailers. Specifically, Wabash highlighted NHTSA's work on rear impact guard standards and ongoing examination of side impact guards. Wabash stated new or revised requirements for impact guards could increase trailer weight. The agencies have analyzed the issues in the present rulemaking while fully considering NHTSA's safety regulations and rulemakings pertaining to trailers. The subject of a possible side guard requirement is in a research stage. As discussed in a July 2015 document, NHTSA is in the process of evaluating issues relating to side guards and will issue a decision on them at a later date.[335] In December 2015, NHTSA issued a notice of proposed rulemaking proposing to adopt requirements of Transport Canada's standard for underride guards.[336] NHTSA is currently assessing next steps on that proposal, and includes as part of its analysis consideration of impacts of any decisions on the fuel efficiency of the vehicles. With respect to Wabash's comment regarding the additional weight from aerodynamic devices, as discussed in the previous subsection, the agencies believe potential compliance paths incorporating lightweighting could offset the additional weight of aerodynamic devices in whole or in part.

B. Overview of the Phase 2 Trailer Program and Key Changes From the Proposal

The HD Phase 2 program represents the first time CO_2 emission and fuel consumption standards have been established for manufacturers of new trailers. As was proposed (80 FR 40257), the final standards will phase in gradually, beginning in MY 2018. New regulated trailers built on or after January 1, 2018 need to be certified to

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[333] 23 CFR 658.9.

[334] 23 CFR part 658.

[335] 80 FR 43663 (footnote 3) (July 23, 2015).

[336] 80 FR 78417 (December 16, 2015).

the new CO_2 emissions standards.[337] NHTSA fuel consumption standards are voluntary until MY 2021.

EPA and NHTSA proposed a trailer program, using appropriate aspects of the Phase 1 tractor program as a guide, including optional averaging provisions (*i.e.* optional averaging across a manufacturer's trailer fleet) as a flexibility for trailer manufacturers to meet the proposed standards. The comments from the trailer industry were nearly unanimous in opposing averaging. Commenters cited the highly competitive nature of the industry, combined with a wide range of product diversity among companies. Commenters believe that these two factors could result in a program that unfairly benefits the few larger companies with diverse offerings and would be impossible to implement for the many companies with limited product diversity. Additionally, compared to other industry sectors, trailer manufacturers noted that they often have little control over what kinds of trailer models their customers demand and thus limited ability to manage the mix and volume of different products. Specifically, Wabash and Utility stated that the dynamic and customer-driven nature of the industry, with many customer-specific requirements for each trailer order, makes it impossible for a manufacturer to predict what products they will produce in a given year. Utility stated that an averaging program will put manufacturers in the position of having to decide which customers receive trailers with aerodynamic devices and which receive trailers without devices. Utility added that averaging may force manufacturers to absorb the cost of aerodynamic devices, or it could cause customers to go to another manufacturer with sufficient credits to fill an order without using aerodynamic devices. Truck Trailer Manufacturers Association (TTMA) also submitted comments asking the agencies not to adopt averaging provisions. In contrast, Great Dane stated that averaging is an option manufacturers may need and recommended its inclusion in the final rule. The International Council on Clean Transportation (ICCT) said that they generally favor averaging since it gives manufacturers maximum flexibility in meeting standards while allowing for the technology deployment path that best matches a company's business strategy.

In order to balance the advantage of an averaging program in allowing for introduction of the most reasonably stringent standards for trailers with the concerns articulated by manufacturers, the final program accordingly limits the option for trailer manufacturers to apply averaging exclusively to MYs 2027 and later for full-aero box vans only. We believe this delay provides box van manufacturers sufficient time to develop, evaluate and market new technologies and to become familiar with the compliance process and possible benefits of averaging. This will also allow customers to become more familiar with the technologies and to recognize their benefits. See Section IV.E.(5)(b) for more details on the trailer averaging program. In the earlier years of the program, when the program does not provide for averaging, the program does provide each manufacturer with a limited ''allowance'' of trailers that do not need to meet the standards. See Section IV.E.(5)(a) below.

The agencies proposed standards for dry and refrigerated box vans that were performance-based, and that were predicated on a high adoption of aerodynamic technologies, lower rolling resistance (LRR) tires and automatic tire inflation systems (ATIS). We designed the compliance approach for these performance-based standards so that manufacturers would have a degree of choice among aerodynamic, tire, tire pressure, and weight-reduction technologies and could combine them as they wished to achieve the standards. See 80 FR 40257. This final program maintains this flexible approach, adding provisions that include options for using tire pressure monitoring systems (TPMS) and innovative weight-reduction technologies as part of manufacturer compliance strategies. Section IV.E.(2) below discusses the trailer compliance provisions.

We proposed ''partial-aero'' criteria for box vans with work-performing equipment that impeded use of aerodynamic technologies and we proposed that those ''partial-aero'' box vans would not have to adopt the most stringent standards in MY 2027; instead, they would maintain the MY 2024 standards. We also proposed design-based tire standards for non-box trailers that required adoption of LRR tires and ATIS. Finally, in recognition that some specialized box van designs are not very compatible with the aerodynamic technologies, the agencies established ''non-aero'' criteria for box vans. Box vans meeting the ''non-aero'' criteria will be subject to the same requirements as the non-box trailers. 80 FR 40259.

The proposed program was designed to include nearly all trailer types, with a limited number of exemptions or exclusions that we believed indicated off-road, heavy-haul or non-freight transporting operation. TTMA and the American Trucking Associations (ATA) provided comments suggesting that additional trailer types should be excluded from the program based on these trailers' typical operational characteristics. The agencies considered the suggestions of these commenters and of several individual trailer manufacturers, and we recognize that many trailers in the proposed non-box subcategory have unique physical characteristics for specialized operations that may make use of lower rolling resistance (LRR) tires and/or tire pressure systems difficult or infeasible. Instead of focusing on trailer characteristics that indicated off-highway or specialty use, the agencies have identified three specific types of non-box trailers that represent the majority of non-box trailers that are designed for and mostly used in on-road applications: Tank trailers, flatbed trailers, and container chassis. Because of their predominant on-road usage, the tire technologies adopted in this trailer program will be consistently effective for these non-box trailer types. Consequently, the final program as it applies to non-box trailers is limited to tanks, flatbeds, and container chassis. All other non-box trailers, about half of the non-box trailers produced, are excluded from the Phase 2 trailer program, with no regulatory requirements. See Section IV.C.(1) for the regulatory definitions of the trailers included in this program.

Wabash commented that partial-aero vans should be exempt in MY 2021 rather than MY 2027 as proposed, citing the need for multiple devices to meet the later standards. The agencies reconsidered the proposed partial-aero standards in light of this comment and recognize that it would likely be difficult for most manufacturers to meet the proposed MY 2024 standards without the use of multiple devices, and yet partial-aero trailers, by definition, are restricted from using multiple devices. For these reasons, the agencies redesigned the partial-aero standards such that trailers with qualifying work-performing equipment can meet standards that would be achievable with the use of a single aerodynamic device throughout the program, similar to the MY 2018 standards. The partial-aero standards do, however, increase in stringency slightly in MY 2021 to reflect

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[337] For an explanation of how EPA defines ''model year'' for purposes of the trailer program, see Section IV.E.(1)(a).

the broader use of improved lower rolling resistance tires.

The agencies also considered comments from manufacturers that were concerned about the cost and, availability of ATIS for the trailer industry. Wabash, Owner Operator Independent Drivers Association (OOIDA), the Rubber Manufacturers Association (RMA), American Trucking Associations (ATA), and Bendix asked that TPMS be allowed for trailer tire compliance in addition to ATIS. OOIDA said that operators prefer less expensive and easier to operate TPMS to ATIS. Wabash expressed concern that ATIS suppliers would not be able to meet demand should ATIS be required as a compliance mechanism for all trailers, especially in the early years of the program. Great Dane stated that their customers are not seeing consistent benefit of ATIS. ATA commented that trailer manufacturers should be allowed to use TPMS for compliance because they are increasingly effective, and some trailers used in heavy-haul applications would need an additional ATIS air compressor, which adds cost and weight that can be avoided by the use of TPMS. The California Air Resources Board supported the agencies' proposal to allow only ATIS for compliance since TPMS require action on the part of the driver to re-inflate affected tires and thus the benefit of the systems is dependent on driver behavior.

The agencies agree that TPMS generally promote proper tire inflation and that including these lower-cost systems as a compliance option will increase acceptance of the technologies. The final trailer program provides for manufacturers to install either TPMS or ATIS as a part of compliance. For full- and partial-aero trailers, the standards are performance standards, and the GEM-based compliance equation (described below) provides ATIS a slightly greater credit than it does for TPMS, to account for the greater uncertainty about TPM system effectiveness due to the inherent user-interaction required with systems that simply monitor tire pressure. These performance standards are based on the use of ATIS and the numerical values of these standards reflect the 0.2 percent increase in stringency. See Section IV.D.(1)(c) for additional information.

For non-aero box vans and non-box trailers, the standards are design standards, met directly by installation of specified technologies, not by using the compliance equation. As long as a manufacturer of these trailers installs either a TPMS or an ATIS (as well as lower rolling resistance tires meeting the specified threshold), the trailer will comply, and either technology applies equally. We project that most design-based tire standards will be met with the less expensive TPMS, but trailers with ATIS will also comply. The effectiveness values adopted for ATI and TPMS in the trailer program are consistent with those in the tractor and vocational vehicle programs.

The agencies generated the proposed standards with use of EPA's Greenhouse gas Emissions Model (GEM) vehicle simulation tool, but for compliance we created a GEM-based equation that trailer manufacturers would use for compliance. See Section IV.E.(2)(a). We made several improvements to GEM based on public comment, and these improvements impacted the results of the model. We have re-created a compliance equation for trailers based on the updated model and are adopting the new equation as the means for trailer manufacturers to certify their trailers in Phase 2.

The agencies also proposed an aerodynamic device testing compliance path that would allow device manufacturers to submit performance test data directly to EPA for pre-approval. 80 FR 40280. We designed this alternative to reduce the test burden of trailer manufacturers by allowing them to install devices with pre-approved data and to eliminate the need to perform their own testing of the devices. Based on public comment, the agencies are adopting the aerodynamic device testing alternative in the final trailer program and are updating several of the provisions related to submission and verification of test data on those devices. See Section IV.E.(3)(b)(v).

The agencies considered five alternative programs in the proposal and extensively evaluated what were termed Alternative 3 and Alternative 4 in our feasibility analysis. 80 FR 40273. The final stringency of both alternatives was identical and each included three-year stages of increasing stringency. However, Alternative 4 represented an accelerated timeline that reached its final stringency in MY 2024. Alternative 3 included an additional three years to meet its final stringency in MY 2027. Alternative 5 was proposed in four stages, but would have a required much greater application rate of the most advanced aerodynamic devices, including aerodynamic technologies on non-box trailers. The agencies believed this alternative was infeasible for this newly-regulated industry and did not extensively evaluate it.

Public comment from the trailer industry unanimously opposed the accelerated timeline of the proposed Alternative 4. TTMA recommended that the agencies adopt no mandatory requirements, and instead rely on a voluntary program for trailers. OOIDA supported standards less stringent than either Alternatives 3 or 4. Great Dane said that adoption of standards more stringent than Alternative 3 would considerably increase the probability of negative effects on stakeholders. Wabash questioned whether, under the accelerated timeline of Alternative 4, current technologies could be produced for all applications for which they would be needed, and with sufficient reliability. The International Food Service Delivery Association, the Truck Trade Association, and Schneider also opposed Alternative 4 for similar reasons. STEMCO, California Air Resources Board (CARB), ICCT, and American Council for an Energy-Efficient Economy (ACEEE) supported Alternative 4. The Environmental Defense Fund (EDF) supported Alterative 5, but with an accelerated schedule, saying technologies will be available to meet the Alternative 5 standards by 2024.

The final standards adopted for the Phase 2 trailer program have the same four-stage implementation schedule as the proposed Alternative 3, with standards phasing in for MYs 2018, 2021, 2024, and 2027 (NHTSA standards apply beginning in MY 2021). We received comments regarding adjustments to technology adoption rates in our baseline reference cases which the agencies found to be persuasive, and the resulting adjustments are described in Section IV.D.(2)(c). Additionally, the technology effectiveness values and projected adoption rates for each of the four stages of the program were updated in response to comments, to reflect new test data, and to account for a program without averaging.

C. Phase 2 Trailer Standards

These final rules establish, for the first time, a set of CO_2 emission and fuel consumption standards for manufacturers of new trailers that phase in over a period of nine years and continue to reduce CO_2 emissions and fuel consumption in the years to follow. These standards are expressed as overall CO_2 emissions and fuel consumption performance standards, considering the trailer as an integral part of the tractor-trailer vehicle.

The agencies believe that the trailer standards finalized here will implement our respective statutory obligations. That is, we believe that this set of standards represents the maximum feasible alternative within the meaning of section 32902(k) of EISA, and are appropriate under EPA's CAA authority (sections 202(a)(1) and (2)).

These standards have the same implementation schedule as the proposed Alternative 3, with standards phasing in for MYs 2018, 2021, 2024, and 2027. In our consideration of the full range of comments, the agencies have adjusted elements of the proposed Alternative 3 in ways that address some of these comments, as discussed in Section 0 below. As discussed in Section IV.E.(5)(b), the option to apply averaging to meet these standards will be available starting with MY 2027, but will not be available in earlier model years.

The agencies did not propose and are not establishing standards for CO_2 emissions and fuel consumption from the transport refrigeration units (TRUs) used on refrigerated box trailers. Also, EPA is not establishing standards for hydrofluorocarbon (HFC) emissions from TRUs. See Section IV.C.(3) below.

(1) Trailer Designs Covered by the Trailer Program

As described previously, the trailer industry produces many different trailer designs for many different applications. The agencies are introducing standards for a majority of these trailers that phase in from MY 2018 through MY 2027; the NHTSA fuel consumption standards are voluntary until MY 2021. The regulatory definitions of the trailers covered by this program are summarized below and are found in 40 CFR 1037.801 and 49 CFR 571.3.

(a) Box Vans

Box vans are trailers with enclosed cargo space that is permanently attached to the chassis, with fixed sides, nose and roof. Trailers with sides or roofs consisting of curtains or other removable panels are not considered box vans in this program. Box vans with self-contained HVAC systems are considered ''refrigerated vans.'' This definition includes systems that provide cooling, heating or both. Box vans without HVAC systems are considered ''dry vans.''

This rulemaking establishes separate standards for box vans based on length. Box vans of length greater than 50 feet are considered ''long box vans.''[338] All vans 50 feet and shorter are considered ''short box vans.'' The agencies requested comment on the proposed 50-foot demarcation between ''long'' and ''short'' box vans (80 FR 40258). CARB and the Union of Concerned Scientists (UCS) commented on this issue, requesting that the demarcation be changed to 47 feet, such that 48-foot vans would be covered under the long box subcategory. CARB suggested that the performance of aerodynamic technologies such as skirts and boat tails on a 48-foot van would be more similar to the performance of the same technologies on a 53-foot van than on the 28-foot van used to evaluate short box performance. CARB also stated that 48-foot trailers are not pulled in tandem and thus have the potential to adopt rear devices for additional reductions.

The agencies agree that 48-foot vans are aerodynamically similar to longer vans and that 28-foot trailers are often used in tandem, reducing the opportunity for rear aerodynamic features. However, the agencies believe that the *use* of 48-foot vans is more similar to that of shorter trailers than to that of the long-haul vans that make up most the long box subcategory. Trailer manufacturers have indicated that 48-foot vans are mostly used in short-haul operations (*e.g.,* local food service delivery) and consequently they travel less frequently at speeds at which aerodynamic technologies can be most beneficial. Also, 48-foot vans make up a relatively small fraction of long box vans.[339] The agencies thus do not believe that standards predicated on the use of more effective aerodynamic technologies on 48-foot vans will provide a substantial enough additional reduction in CO_2 emissions and fuel consumption to justify more stringent standards for those trailers. For these reasons, the agencies are maintaining the proposed 50-foot demarcation between long and short box vans and are basing the standards for each van size category accordingly.

The trailer program identifies certain types of work-performing equipment manufacturers may install on box vans that may inhibit the use of aerodynamic technologies and thus impede the trailers' ability to meet standards predicated on adoption of aerodynamic technologies. For this program, we consider such trailer equipment to consist of a rear lift gate or rear hinged ramp and any of the following side features: A side lift gate, a side-mounted pull-out platform, steps for side-door access, a drop-deck design, or a belly box or boxes that occupy at least half the length of both sides of the trailer between the centerline of the landing gear and the leading edge of the front wheels. See 40 CFR 1037.107(a)(1) and 49 CFR 571.3.

The agencies have also considered how ''roll-up'' or ''overhead'' rear trailer doors might inhibit the use of rear aerodynamic devices. TTMA, ATA, Great Dane, and Utility stated that roll-up doors are work-performing devices that can inhibit rear aerodynamic technologies. However, the agencies are aware of several existing aerodynamic devices designed to be installed near the rear of a trailer that can function regardless of the type of rear door. Also, in their comments, STEMCO indicated that additional rear aerodynamic technologies would be less likely to enter the market if the trailer program were to include roll-up doors on the list of work-performing devices above and the industry didn't demand an aerodynamic product to work with roll-up doors. The agencies recognize there may currently be limited availability of rear aerodynamic technologies for roll-up door trailers, yet we also understand that innovations and improvements continue for all trailer aerodynamic technologies. For this reason, the final trailer program includes an interim provision—through MY 2023—for box vans with roll-up doors to qualify for non-aero and partial-aero standards (as defined immediately below), by treating such doors as work-performing devices equivalent to rear lift gates. For MY 2024 and later, roll-up doors will not qualify as a work-performing device in this way; however, we expect that manufacturers of trailers with roll-up doors will comply using combinations of new rear aerodynamic technologies, in conjunction with improved trailer side and gap-reducing technologies as appropriate. See 40 CFR 1037.150.

As presented in Section IV.C.(2) below, the agencies are adopting separate standards for each of the same nine box van subcategories introduced in the proposal (80 FR 40256) and for the non-box category discussed below. Full-aero long box dry vans and full-aero long box refrigerated vans are those that are over 50 feet in length and that do not have any of the work-performing equipment discussed immediately above. Similarly, full-aero short box dry vans and full-aero short box refrigerated vans are 50 feet and shorter without any work-performing equipment. We expect these trailers to be capable of meeting the most stringent standards in the trailer program.

Long box dry vans and long box refrigerated vans that have work-performing equipment either on the underside or on the rear of the trailer that would limit a manufacturer's ability

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[338] Most long trailers are 53 feet in length; we are adopting a cut-point of 50 feet to avoid an unintended incentive for an OEM to slightly shorten a trailer design in order to avoid the new regulatory requirements.

[339] Memorandum to Docket EPA–HQ–OAR–2014–0827: Evaluation of 50-Foot Trailer Length Demarcation to Distinguish between Long and Short Box Vans. July 18, 2016.

to install aerodynamic technologies may be designated as partial-aero vans for their given subcategory. The partial-aero standards are based on adoption of tire technologies and a single aerodynamic device throughout the program. Long box dry and refrigerated vans that have work-performing equipment on the underside *and* rear of the trailer may be designated non-aero box vans. Non-aero box vans are a single subcategory that have design-based tire standards.

For short vans, the standards are never predicated on the use of rear devices, since many 28-foot trailers are often pulled in tandem. However, we are not aware of any current legislative or regulatory initiatives that would allow tandem trailers longer than 33 feet in length, and therefore we believe that short vans of length 35 feet and longer are unlikely to be pulled in tandem in the timeframe of these rules. We are adopting separate criteria for partial- and non-aero designation for short vans based on a length threshold of 35 feet. If vans 35 feet or longer have work-performing equipment on the underside of the trailer, we expect manufacturers can install rear devices to meet the full-aero standards, but they have the option to designate these trailers as partial-aero dry or refrigerated short vans with reduced standards that can be met with tire technologies and a single aerodynamic device. If vans 35 feet and longer have work performing equipment on the underside and rear, manufacturers may designate them as non-aero box vans.

Short vans that are less than 35 feet in length are more likely to be pulled in tandem, making most rear aerodynamic devices infeasible. Since gap reducers alone are not sufficiently effective to replace a skirt and the shortest trailers are not expected to install rear devices, both dry and refrigerated vans that are shorter than 35 feet with work-performing equipment on the underside of the trailer may be designated non-aero box vans that can comply with tire technologies only. In addition, refrigerated vans that are shorter than 35 feet cannot install gap reducers because of the TRU. Consequently, all refrigerated vans shorter than 35 feet, irrespective of work-performing equipment, can be designated partial-aero short refrigerated vans whose standards can be met with skirts and tire technologies. See 40 CFR 1037.107(a)(1) and 49 CFR 571.3. Because the types of work-performing equipment identified here generally add significant cost and weight to a trailer, we believe that the reduced standards available for trailers using this equipment are unlikely to provide an incentive for manufacturers to install them simply as a way to avoid the full aero standards.

(b) Non-Box Trailers

All trailers that do not meet the definition of box vans are considered non-box trailers in the trailer program. Several commenters requested a clearer distinction of the trailers that are included in the program. In response, the agencies are limiting the non-box trailer standards to three trailer types that have distinct physical characteristics and are most often driven on-highway: Tank trailers, flatbed trailers, and container chassis. Non-box trailers that do not meet the definitions below are excluded from the trailer program, as discussed in the following section.

Tank trailers are defined for the trailer program as enclosed trailers designed to transport liquids or gases. For example, DOT 406, DOT 407, and DOT 412 tanks would fit this definition. These non-box trailers can be pressurized or designed for atmospheric pressure. Tanks that are infrequently used in transport and primarily function as storage vessels for liquids or gases (*e.g.,* frac tanks) are not included in our definition of tank trailers and are excluded from the program.

Flatbed trailers for purposes of the trailer program are platform trailers with a single, continuous load-bearing surface that runs from the rear of the trailer to at least the trailer's kingpin. Flatbed trailers are designed to accommodate side-loading cargo, and this definition includes trailers that use bulkheads, one or more walls, curtains, straps or other devices to restrain or protect cargo while underway. Note that drop deck and lowboy platform trailers are not considered *continuous* load-bearing surfaces.

Finally, in the trailer program, container chassis are trailers designed to transport temporary containers. The standards apply to all lengths of container chassis, including expandable versions. The regulations do not apply to the containers being transported, unless they are permanently mounted on the chassis.

(c) Excluded Trailers

As in the proposal (80 FR 40259), the final trailer program completely excludes certain trailer types. However, in response to comments and an improved understanding of the industry, the agencies have changed our approach to excluding some trailer types.

In the proposal, we focused on excluding trailers based on characteristics that tended to indicate predominant operation in off-highway applications. The American Trucking Associations (ATA) and the Truck Trailer Manufacturers Association (TTMA) provided comments suggesting that additional trailer types should be excluded from the program based on the trailers' typical operational characteristics, generally because of these trailers' limited on-highway operation. Also, Wabash requested that the program specify clearer criteria for excluding or exempting trailers.

The agencies considered all of the suggestions of the commenters, and we now believe that a different approach to excluding some trailer types is more appropriate. We recognize that many trailer types in the proposed non-box subcategory have many unique physical characteristics and are designed for specialized operations and it would be difficult to create a comprehensive list of traits that indicated off-road use. This wide array of trailer types would have made the proposed approach difficult to implement for both trailer manufacturers and for the agencies, since the usage patterns of many specialty trailer types can vary greatly. Some of these uses, especially off-highway applications, may make use of the proposed tire technologies for compliance difficult or infeasible and may limit their effectiveness. Additionally, the agencies are aware that many manufacturers that build these specialty non-box trailers are small businesses (fewer than 1000 employees), and they would incur a disproportionately large financial burden compared to larger manufacturers if they were subject to the standards.

For these reasons, instead of focusing our approach to excluding trailer types on trailer characteristics that indicated predominant off-highway use, the final program excludes all non-box trailer types except for three specific types that we believe are designed for and mostly used in on-road applications. These types are tanks, flatbeds, and container chassis, as defined in the previous sub-section. We now consider this approach to be much clearer and more straightforward to implement than the proposed approach. Manufacturers of these types of trailers can easily obtain and install LRR tires and tire pressure systems, and achieve the most consistent benefit from use of these technologies. The trailer program excludes all trailers that do not meet the criteria outlined in Section IV.C.(1)(b) above, and specified in 40 CFR 1037.5 and in 49 CFR 535.3(e).

The final rule also excludes certain types of trailers based on design characteristics, consistent with the proposed rule. More precisely, these excluded trailer types are sub-types of otherwise regulated trailer types, such as certain types of box vans. First, the rule excludes trailers intended to haul very heavy loads, as indicated by the number of axles. Specifically, the rules exclude all trailers with four or more axles, and trailers less than 35 feet long with three axles. For example, a 53-foot box van with four axles would be excluded. Also, we agree with Utility that spread-axle trailers may be more susceptible to tire scrubbing, and the program accordingly excludes trailers with an axle spread of at least 120 inches between adjacent axle centerlines. The axle spread exclusion does not apply to trailers with adjustable axles that have the ability to be spaced less than 120 inches apart. Finally, the rules exclude trailers intended for temporary or permanent residence, office space, or other work space, such as campers, mobile homes, and carnival trailers.[340]

Manufacturers of excluded trailers have no reporting or other regulatory requirements under the trailer program. See 40 CFR 1037.5 and 49 CFR 535.3 for complete definitions of the trailer types that the program excludes. However, where the criteria for exclusion identified above may be unclear for specific trailer models, manufacturers are encouraged to ask the agencies to make a determination before production begins.

(2) Fuel Consumption and CO_2 Standards

As described previously in Section I, it is the combination of the tractor and the trailer that form the useful vehicle, and trailer designs substantially affect the CO_2 emissions and fuel consumption of the tractors pulling them. Note that although the agencies are adopting new CO_2 and fuel consumption standards for trailers separately from tractors, we set the numerical level of the trailer standards (see Section IV.D. below) based on operation with ‘‘standard’’ reference tractors in recognition of their interrelatedness. In other words, the regulatory standards refer to the simulated emissions and fuel consumption of a standard tractor pulling the trailer being certified.

Unlike the other sectors covered by this Phase 2 rulemaking, trailer manufacturers do not have experience certifying under the Phase 1 program (or under EPA's criteria pollutant program). Moreover, a large fraction of the trailer industry is composed of small businesses and even the largest trailer manufacturers do not have the same resources available to them as do manufacturers in some of the other heavy-duty sectors. The standards and compliance regime for trailers have been developed with this in mind, and we are confident these standards can be achieved and demonstrated by manufacturers who lack prior experience implementing such standards.

The agencies designed this trailer program to ensure a gradual progression of both stringency and compliance requirements in order to limit the impact on this newly-regulated industry. The agencies are adopting progressively more stringent standards in three-year stages leading up to the MY 2027,[341] and are including several options to reduce compliance burden in the early years as the industry gains experience with the program (see Section IV.E.). EPA will initiate its program in MY 2018 with standards for long box dry and refrigerated vans, which standards can be met with common tire technologies and SmartWay-verified aerodynamic devices and standards for the other regulated trailers based on tire technologies only. In this early stage, we expect that manufacturers of trailers in the other trailer subcategories will meet their standards by using tire technologies only. NHTSA's regulations will be voluntary until MY 2021 as described in Section IV.C.(2).

Standards for the next stages, which begin in MY 2021, gradually increase in stringency for each subcategory, including the introduction of standards for short box vans that we expect will be met by applying both aerodynamic and tire technologies. The standards for partial-aero box vans are less stringent than those for full-aero box vans, reflecting that the standards for partial-aero vans are based on adoption of a single aerodynamic device throughout the program. This is in contrast to the proposed standards for partial-aero vans that were identical to the standards for full-aero vans through MY 2026.

Table IV–2 and Table IV–3 below present the CO_2 and fuel consumption standards, beginning in MY 2018 that the agencies are adopting for full- and partial-aero box vans, respectively. The standards are expressed in grams of CO_2 per ton-mile and gallons of fuel per 1,000 ton-miles to reflect the load-carrying capacity of the trailers.

TABLE IV–2—TRAILER CO_2 AND FUEL CONSUMPTION STANDARDS FOR FULL-AERO BOX VANS

Model year	Subcategory	Dry van		Refrigerated van	
	Length	Long	Short	Long	Short
2018–2020	EPA Standard (CO_2 Grams per Ton-Mile)	81.3	125.4	83.0	129.1
	Voluntary NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.98625	12.31827	8.15324	12.68173
2021–2023	EPA Standard (CO_2 Grams per Ton-Mile)	78.9	123.7	80.6	127.5
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.75049	12.15128	7.91749	12.52456
2024–2026	EPA Standard (CO_2 Grams per Ton-Mile)	77.2	120.9	78.9	124.7
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.58350	11.87623	7.75049	12.24951
2027+	EPA Standard (CO_2 Grams per Ton-Mile)	75.7	119.4	77.4	123.2
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.43615	11.72888	7.60314	12.10216

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[340] Secondary manufacturers who purchase incomplete trailers and complete their construction to serve as trailers are subject to the requirements of 40 CFR 1037.620 and 49 CFR 535.5(e).

[341] These stages are consistent with NHTSA's stability requirements under EISA.

TABLE IV–3—TRAILER CO_2 AND FUEL CONSUMPTION STANDARDS FOR PARTIAL-AERO BOX VANS

Model year	Subcategory	Dry van		Refrigerated van	
	Length	Long	Short	Long	Short
2018–2020	EPA Standard (CO_2 Grams per Ton-Mile)	81.3	125.4	83.0	129.1
	Voluntary NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.98625	12.31827	8.15324	12.68173
2021+	EPA Standard (CO_2 Grams per Ton-Mile)	80.6	123.7	82.3	127.5
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.91749	12.15128	8.08448	12.52456

The agencies are not adopting CO_2 or fuel consumption standards predicated on aerodynamic improvements for non-box trailers or non-aero box vans at any stage of this program. Instead, we are adopting design standards that require manufacturers of these trailers to adopt specific tire technologies and thus to comply without aerodynamic devices. This approach significantly limits the compliance burden for these manufacturers, especially if they do not also manufacture box vans subject to the aerodynamic requirements. The agencies are adopting these design standards in two stages. In MY 2018, the non-box trailer standards require manufacturers to use tires meeting a rolling resistance of 6.0 kg/ton or better and to install tire pressure systems. In MY 2021, non-box trailers will also need tire pressure systems and LRR tires at 5.1 kg/ton (the current SmartWay-verification threshold) or better. The standards require non-aero box vans, which we believe are largely at a baseline rolling resistance 6.0 kg/ton today, to install tire pressure monitoring systems and tires at a rolling resistance of 5.1 kg/ton in MY 2018 and 4.7 kg/ton in MY 2021 and later (there are no further increases in standard stringency for these trailers after MY 2021). For non-box trailers and non-aero box vans, manufacturers may install either TPMS or ATIS for compliance.

Table IV–4 summarizes the two stages of these design standards.

TABLE IV–4—DESIGN-BASED TIRE STANDARDS FOR NON-BOX TRAILERS AND NON-AERO BOX VANS

Model year	Tire technology	Non-box trailers	Non-aero box vans
2018–2020	Tire Rolling Resistance Level (kg/ton)	6.0	5.1
	Tire Pressure System	TPMS or ATIS	TPMS or ATIS
2021+	Tire Rolling Resistance Level (kg/ton)	5.1	4.7
	Tire Pressure System	TPMS or ATIS	TPMS or ATIS

The agencies project that the standards for the entire class of regulated trailers, when fully implemented in MY 2027, will achieve fuel consumption and CO_2 emissions reductions of two to nine percent relative to mostly market-driven adoption absent a national regulatory program (see Section IV.D.(2)). Because of the rapid pace of technological improvement in recent years and the lead time of nearly a decade, the agencies expect that both trailer designs and bolt-on CO_2- and fuel consumption-reducing technologies will advance well beyond the performance of their present-day counterparts. Regardless, we expect that the MY 2027 standards for full-aero box vans could be met with high-performing aerodynamic and tire technologies largely available in the marketplace today. A description of technologies that the agencies considered in developing these rules is provided in Section IV.D., with additional details in RIA Chapter 2.10.

(3) Non-CO_2 GHG Emissions From Trailers

In addition to the impact of trailer design on the CO_2 emissions of tractor-trailer vehicles, EPA recognizes that refrigerated trailers can also be a source of emissions of HFCs. Specifically, HFC refrigerants that are used in transport refrigeration units (TRUs) have the potential to leak into the atmosphere.

In their comments, CARB said they believed that EPA underestimated the potential for TRU refrigerant leakage, and requested that EPA (1) initiate a TRU refrigerant ‘‘usage monitoring program’’ to support future evaluations of leakage; (2) create incentives for low- and zero-emission (*e.g.,* cryogenic) TRUs; and (3) for EPA's SNAP program to phase out the main TRU refrigerant (R404a) when viable alternatives are available. EPA did not propose any action related to TRUs in this rule, and CARB did not provide sufficient information for EPA to introduce new regulatory requirements for TRUs at this time. In general, however, EPA will continue to monitor the state of TRU technology and operation, and may pursue appropriate action if warranted in the future.

We also note that EPA has separately proposed a regulation under Title VI of the CAA, specifically section 608. See 80 FR 69457 (November 9, 2015). This proposal would extend existing regulations on ozone depleting refrigerants to many alternative refrigerants, such as HFCs, which are the most common refrigerants used in TRUs.[342] If finalized as proposed, EPA would require that appliances like TRUs be subject to the applicable requirements of 40 CFR subpart F, including requirements for servicing by a certified technician using certified recovery equipment and for recordkeeping by technicians disposing of such appliances with a charge size between five and fifty pounds, which

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[342] Under the proposal, the regulations would not be extended to equipment using a substitute refrigerant when that use of the refrigerant has been exempted from the venting prohibition, as listed in 40 CFR 82.154(a).

would include TRUs, to help ensure that the refrigerant is not vented.[343]

(4) Lead-Time Considerations

As mentioned earlier, although the agencies did not include standards for trailers in Phase 1, box van manufacturers have been gaining experience with CO_2- and fuel consumption-reducing technologies over the past several years, and the agencies expect that trend to continue, due in part to EPA's SmartWay program and California's Tractor-Trailer Greenhouse Gas Regulation. Most manufacturers of 53-foot box vans have some experience installing these aerodynamic and tire technologies for customers. Manufacturers of trailers other than 53-foot box vans do not have the benefit of programs such as SmartWay to provide a reliable evaluation and promotion of aerodynamic technologies for those trailers and therefore have less experience with those technologies. However, all trailer manufacturers have experience installing tires and the installation process does not change with the use of lower rolling resistance tires. Some manufacturers may not have direct experience with tire pressure systems, but we observe that they are mechanically fairly simple and can be incorporated into trailer production lines without significant process changes.

EPA is adopting CO_2 emission standards for long box vans for MY 2018 that represent stringency levels similar to the current performance level needed for SmartWay's verification and those required for the current California regulation. These standards can be met by adopting off-the-shelf aerodynamic and tire technologies available today. The agencies are adopting less stringent requirements for manufacturers of other highway trailer subcategories beginning in MY 2018 that can be met without use of aerodynamic technologies. Given that these technologies are readily available and are already familiar to the industry, the agencies believe, for both cases, that manufacturers have sufficient lead time to adopt these technologies and to implement the simplified compliance provisions introduced below and described fully in Section IV.E.

NHTSA's direction under EISA is to allow four model years of lead-time for new fuel consumption standards, regardless of the stringency level or availability of flexibilities. Therefore, NHTSA's fuel consumption requirements are not mandatory until MY 2021. Prior to MY 2021, trailer manufacturers could voluntarily participate in NHTSA's program, noting that once they made such a choice, they will need to stay in the program for all succeeding model years.[344]

We believe there are technology pathways available today that manufacturers could use to comply with the standards when they are fully implemented in MY 2027. The agencies designed each three-year stage of the program as a gradual progression of stringency that provides sufficient lead-time for all affected trailer manufacturers to evaluate and adopt CO_2- and fuel consumption-reducing technologies or design trailers to meet these standards while meeting their customers' needs. The agencies believe that the burdens of installing and marketing these CO_2- and fuel consumption-reducing technologies at the stringency levels of this program are not limiting factors in determining necessary lead-time for manufacturers of these trailers. Instead, we expect that the first-time compliance and, in some cases, performance testing, will be more challenging obstacles for this newly regulated industry. For these reasons, the standards phase in over a period of nine years, with flexibilities to minimize the compliance and testing burdens especially in the early years of the program (see Section IV.E.). We are adopting provisions for manufacturers to use a GEM-based compliance equation in lieu of the GEM vehicle simulation tool, which will reduce the number of resources required to learn and implement the model. We are also finalizing compliance provisions that allow trailer manufacturers to use pre-approved aerodynamic test data from aerodynamic device manufacturers, which could eliminate a trailer manufacturer's test burden for compliance. As explained above, non-aero box vans and non-box trailers, which make up almost 20 percent of the regulated trailers, are subject to straightforward design-based tire standards throughout the program that require that they install qualified LRR tires and tire pressure systems with simplified compliance requirements. See Section IV.E. for a full description of the trailer compliance program.

The Rubber Manufacturers Association (RMA) expressed concern that the proposed program would not provide sufficient lead time for the development and production of LRR tire designs for some off-road applications. As discussed above, the final program now excludes all trailer types that would generally be used in off-road applications, including all non-box trailers except tanks, flatbeds, and container chassis. Therefore, trailer types designed for off-road use do not have LRR tire requirements, and the final program should significantly reduce RMA's concerns about available lead time for special tire development. Additionally, we have adjusted the tire performance requirements for the LRR tires of the non-box trailer design standards.

D. Feasibility of the Trailer Standards

As discussed below, the agencies' determination is that the standards presented in Section IV.C.(2), are the maximum feasible and appropriate under the agencies' respective authorities, considering lead time, cost, and other factors. We summarize our analyses in this section, and describe them in more detail in RIA Chapter 2.10.

Our analysis of the feasibility of the CO_2 and fuel consumption standards is based on technology cost and effectiveness values collected from several sources. Our assessment of the trailer program is based on information from:

—Southwest Research Institute evaluation of heavy-duty vehicle fuel efficiency and costs for NHTSA,[345]

—2010 National Academy of Sciences report of Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,[346]

—TIAX's assessment of technologies to support the NAS panel report,[347]

—The analysis conducted by the Northeast States Center for a Clean Air Future, International Council on Clean Transportation, Southwest Research Institute and TIAX for reducing fuel consumption of heavy-

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[343] The Clean Air Act (42 U.S.C. 7671) uses the term ''appliance'' to refer to TRUs and other similar equipment.

[344] NHTSA adopted a similar voluntary approach in the first years of Phase 1 (see 76 FR 57106).

[345] Reinhart, T.E. (June 2015). Commercial Medium- and Heavy-Duty Truck Fuel Efficiency Technology Study—Report #1. (Report No. DOT HS 812 146). Washington, DC: National Highway Traffic Safety Administration.

[346] Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles; National Research Council; Transportation Research Board (2010). Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles. (''The NAS Report'') Washington, DC, The National Academies Press. Available electronically from the National Academy Press Web site at *http://www.nap.edu/catalog.php?record_id=12845*.

[347] TIAX, LLC. ''Assessment of Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles,'' Final Report to National Academy of Sciences, November 19, 2009.

duty long haul combination tractors (the NESCCAF/ICCT study),[348]

—The technology cost analysis conducted by ICF for EPA,[349] and

—Testing conducted by EPA.

As an initial step in our analysis, we identified the extent to which fuel consumption- and CO_2-reducing technologies are in use today. The technologies include those that reduce aerodynamic drag at the front, back, and underside of trailers, tires with lower rolling resistance, tire pressure technologies, and weight reduction through component substitution. For our feasibility analysis, we identified a set of technologies to represent the range of those likely to be used in the time frame of the rule. The agencies developed the CO_2 and fuel consumption standards for each stage of the program by combining the projected effectiveness of trailer technologies and the projected adoption rates for each trailer type. It should be noted that the agencies need not and did not attempt to predict the exact future pathway of the industry's response to the new performance standards for box vans. Rather, we demonstrated one example compliance pathway that could reasonably occur, taking into account cost of the standards (including costs of compliance testing and certification), and needed lead time. More details regarding our analysis can be found in Chapter 2.10 of the RIA.

(1) Technological Basis of the Standards

Trailer manufacturers can design a trailer to reduce fuel consumption and CO_2 emissions by addressing the trailer's aerodynamic drag, tire rolling resistance, and weight. Accordingly, the agencies investigated aerodynamic technologies (*e.g.,* skirts and tails), low rolling resistance tires, tire pressure systems, and materials that could be used to reduce trailer weight. A description of these technologies, including their expected performance, can be found in Chapter 2.10.2 of the RIA. For box vans, the analysis below presents one possible set of technology designs by which trailer manufacturers could reasonably achieve the standards. However, in practice, trailer manufacturers could choose different technologies, versions of technologies, and combinations of technologies that meet the business needs of their customers while complying with this program.

To minimize complexity, a single van is used to represent each box van trailer subcategory in compliance and in our feasibility analysis. Within the short box dry and refrigerated van subcategories (50-foot and shorter), the largest fraction of those trailers are 28 feet in length. Similarly, 53-foot vans make up the majority of the long box dry and refrigerated vans. Consequently, a 28-foot dry van is used to represent all lengths of short dry vans and a 53-foot dry van represents all lengths of long dry vans in this analysis and for compliance. Similar lengths represent the short and long refrigerated van subcategories. This means that manufacturers do not need to analyze the performance of devices for each trailer length in each subcategory. This approach provides a conservative estimate of CO_2 emissions and fuel consumption reductions for the longer vans within a given length subcategory,[350] but the agencies believe that the need to avoid an overly complex compliance program, reinforced by most of the industry comments, justifies this approach.

(a) Aerodynamic Technologies

For box vans under these rules, aerodynamic performance of tractor-trailers is evaluated using a vehicle's aerodynamic drag area, C_dA. However, unlike the tractor program, the performance of trailer technologies is quantified using changes in C_dA (or "delta C_dA") rather than absolute values. This delta C_dA classification methodology, which measures improvement in performance relative to a baseline, is similar to the SmartWay technology verification program with which most long box van manufacturers are already familiar. The one difference is that, although EPA's SmartWay aerodynamic verification program uses a relative improvement, the metric is a percent fuel savings, whereas the compliance program for Phase 2 uses change in drag area, delta C_dA. Chapter 2.10.2.1.1 of the RIA provides a comparison of the SmartWay and Phase 2 metrics.

The agencies proposed to use a delta C_dA measured at zero-yaw (head-on wind) in the trailer aerodynamic test procedures (80 FR 40277). However, comments from several stakeholders including ACEEE, CARB, ICCT, RMA, STEMCO, and Utility suggested that measurements that account for cross-wind provide a more appropriate measure of the benefits these technologies would experience in the real world, especially for technologies that are effective when the wind is at an angle. The agencies evaluated our own aerodynamic test data, including data collected to justify use of wind-average results in the proposed tractor program, and we recognize that the drag coefficient increases under cross-wind conditions likely seen in real-world operation. Since wind-averaging will account for this, and more appropriately capture aerodynamic benefits from many devices, including several small-scale devices, we are adopting a wind-averaged approach for aerodynamic testing in the trailer program. See Section IV.E.(3)(b)(ii) below and Chapter 2.10.2.1.2 of the RIA for a summary of yaw-angle effect as observed in our aerodynamic testing. The feasibility analysis that follows was performed using wind-averaged delta C_dA values.

(i) Aerodynamic Technologies for Non-Box Trailers

The agencies are aware that some side skirts have been adapted for the non-box trailers considered in this rule (*e.g.,* tank trailers, flatbeds, and container chassis). CARB submitted comments noting that some of these technologies have shown potential for large reductions in drag. At this time, however, we are unable to sufficiently assess the degree of CO_2 and fuel consumption improvement that could generally be achieved across this segment of the industry and the associated costs of these technologies. In the case of each of the general non-box trailer types included in the trailer program, the range of physical trailer designs, including the areas where aerodynamic devices would be installed, is great, and technologies to date tend to be designed for narrow applications. This lack of basic information about the applicability of future technologies for these trailer types also inhibits our ability to estimate costs, either of the specific future designs themselves or of the size of the market for any particular product. As a result, we expect that standards predicated on aerodynamic technologies for these trailer types could result in relatively little emission and fuel consumption improvement at relatively high costs. We will continue to monitor this segment of the trailer industry in this regard and may consider further action in the future.

The agencies proposed to adopt design-based tire standards (*i.e.*

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[348] NESCCAF, ICCT, Southwest Research Institute, and TIAX. Reducing Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO_2 Emissions. October 2009.

[349] ICF International. "Investigation of Costs for Strategies to Reduce Greenhouse Gas Emissions for Heavy-Duty On-Road Vehicles." July 2010. Docket Number EPA–HQ–OAR–2010–0162–0283.

[350] For example, aerodynamic devices on a 48 foot box van will perform somewhat better than on a 28 foot box van, so our analysis likely underestimates the benefits of these technologies. See Chapter 2.10.2.1.2.6 of the RIA and Memorandum to Docket EPA–HQ–OAR–2014–0827. "

standards not predicated on any aerodynamic technology, and for which neither GEM nor the GEM-based equation is required) for these trailers to eliminate the need for performance testing and to reduce the overall compliance burden for these manufacturers. 80 FR 40257. The data submitted and adoption rates suggested by CARB would not provide a large enough reduction in CO_2 and fuel consumption from non-box trailer aerodynamics to justify the increased burden on these manufacturers. In addition, we believe that there is not currently sufficient information to develop aerodynamic performance standards on these relatively new and untried technologies. Consequently, we are adopting design-based tire technology standards for non-box trailers, as proposed. Non-box trailer manufacturers may include aerodynamic improvements in their future trailer designs, but non-box trailer aerodynamic devices cannot be used for compliance at any point in the Phase 2 program.

(ii) Aerodynamic Technologies for Box Vans

EPA collected aerodynamic test data for several tractor-trailer configurations equipped with technologies similar to common SmartWay-verified technologies. As mentioned previously, SmartWay-verified technologies are evaluated on 53-foot dry vans. However, the CO_2- and fuel consumption-reducing potential of some aerodynamic technologies demonstrated on 53-foot dry vans can be translated to refrigerated vans and box trailers of other lengths. Some fleets have opted to add trailer skirts to their refrigerated vans and 28-foot trailers and our testing included dry vans of length 53-foot, 48-foot, 33-foot, and 28-foot.[351]

In order to evaluate performance and cost of the aerodynamic technologies, the agencies identified ''packages'' of individual or combined technologies that are being sold today on box trailers. The agencies also identified distinct performance levels (*i.e.,* bins) for these technology packages based on EPA's aerodynamic testing. All technology packages that produce similar improvements in drag would be categorized as meeting the same bin level of performance. The agencies recognize that there are other technology options that have similar performance to those that we analyzed. We chose the technologies presented here based on their current adoption rates and availability of test data.

The agencies are adopting a regulatory structure for box trailers with seven bins to evaluate aerodynamic performance. Note that these bins are slightly different than those proposed. We adjusted the aerodynamic bins to reflect additional data and the use of wind-averaged results. The most notable difference is that we expanded the width of the lower bins. The NPRM Bins III, IV and V were reduced to two bins. Bins V, VI, and VII are identical to the highest bins from the NPRM (NPRM bins VI, VII, and VIII). See Chapter 2.10.2.1.3 of the RIA for a complete description of the development of these bins.

In the final trailer program, Bin I represents a base trailer with no aerodynamic technologies added and a delta C_dA of zero. Bin II is intended to capture aerodynamic devices that achieve small reductions in CO_2 and fuel consumption. Some gap reducers may achieve Bin II on long dry vans, and most individual devices (*e.g.,* skirts or tails) will achieve this bin for short box vans. We expect a majority of single aerodynamic devices to perform in the range of Bins III through IV for long box vans. Combinations of devices are expected to meet Bin III for short vans and Bin V or Bin VI levels of performance for long vans. Bin VI represents the more optimized combinations of technologies on long vans. The agencies observed one device combination that met Bin VI in our aerodynamic testing and did not observe any combinations that meet Bin VII. This final level is designed to represent aerodynamic improvements that may become available in the future, including aerodynamic devices yet to be designed or approaches that incorporate changes to the design of trailer bodies. The agencies believe there is ample lead time to optimize additional existing Bin V combinations such that they can also meet Bin VI by MY 2027. However, none of the standards are predicated on the performance of Bin VII aerodynamic improvements. See Table IV–14 and accompanying text.

Table IV–5 illustrates the bin structure that the agencies are adopting as the basis for box vans to demonstrate compliance. The agencies believe these bins apply to all box vans (dry and refrigerated vans of various lengths). Although the underlying test data from EPA's aerodynamic testing program reflect some variation due to differences in test methods, as well as differences in trailer and aerodynamic device models, the agencies believe that each of these bins covers a wide enough range of delta C_dAs to account for the uncertainty. See RIA Chapter 2.10 for more information.

When manufacturers obtain test results, they would check the range shown in Table IV–5 for the measured C_dA value and use the corresponding input value for compliance. Note that these are wind-averaged results, as described in Chapter 2.10 of the RIA and below in Section IV.E.(3)(b)(ii). Also, the input is a threshold and not an average of the bin range. Consequently, the compliance results will be a conservative estimate of the performance of most technologies that achieve a given bin.[352]

TABLE IV–5—TECHNOLOGY BINS USED TO EVALUATE TRAILER BENEFITS AND COSTS

Bin	Delta C_dA	
	Measured value	Input value for compliance
Bin I	<0.10	0.0
Bin II	0.10–0.39	0.1
Bin III	0.40–0.69	0.4
Bin IV	0.70–0.99	0.7
Bin V	1.00–1.39	1.0
Bin VI	1.4–1.79	1.4
Bin VII	≥1.80	1.8

To develop the standards for box trailers, the agencies assessed the CO_2 emissions and fuel consumption impacts of the aerodynamic bins using an equation based on the GEM vehicle simulation tool. See Section II and Section IV.E. (1) for more information about GEM and Chapter 2.10.5 of the RIA for our development of the GEM-based equation. Within GEM, and reflected in the results of the equation, the aerodynamic performance of each box van subcategory is evaluated by subtracting the delta C_dA shown in Table IV–5 from the C_dA value representing a specific standard tractor pulling a trailer with no CO_2- or fuel consumption-reducing technologies (*i.e.,* a ''no-control'' trailer). In other words, the tractor-trailer is simulated with improvements to the baseline trailer. The agencies chose to model the no-control long box dry van using a C_dA value of 6.0 m^2 (the mean wind-averaged C_dA from EPA's wind tunnel

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[351] Although, as noted above, compliance testing (where required) uses either a 28 foot van or 53 foot van to simplify the compliance process.

[352] This is in contrast to the tractor program where manufacturers obtain absolute C_dA values in tractor aerodynamic testing. The tractor results are corrected to coastdown values before applying them to bins and obtaining a bin-average value as a compliance input. Trailers measure a delta C_dA and do not have a correction to a reference method (see Section IV.E.(3)(b)). The lower threshold approach adopted for the trailer compliance inputs limits the chance of over-predicting performance when a reference method correction is not applied.

testing). The single, short box dry vans showed lower C_dA values compared to its 53-foot counterpart in EPA's wind tunnel testing with an average of 5.6 m^2. The agencies did not test any refrigerated vans, but we assumed a refrigerated van's TRU would behave similar to a gap reducer. Our test results in Chapter 2.10.2.1.3 did not show gap reducer technologies to have a significant effect on C_dA and the agencies accordingly assigned the same default C_dA to refrigerated and dry box vans in GEM. Note that the trailer subcategories that have design standards (*i.e.,* non-box and non-aero box trailers) do not have numerical standards to meet, and do not have defaults in GEM. Table IV–6 illustrates the no-control drag areas (C_dA) associated with each trailer subcategory.

TABLE IV–6—DEFAULT AERODYNAMIC DRAG AREA (C_dA) VALUES ASSOCIATED WITH EACH (NO-CONTROL) TRAILER MODELED IN GEM

Trailer subcategory	C_dA (M^2)
Long Dry Van	6.0
Short Dry Van	5.6
Long Ref. Van	6.0
Short Ref. Van	5.6

Current ''boat tail'' devices, applied to the rear of a trailer with rear swing doors, are typically designed to collapse flat as the trailer rear doors are opened. If the tail structure can remain in the collapsed configuration when the doors are closed, the benefit of the device is lost. We requested comment on whether we should require that trailer manufacturers using such devices for compliance with these standards only use designs that automatically deploy when the vehicle is in motion. STEMCO commented that automatic deployment should not be required, since those systems are more expensive, and in their view, not necessary for the Phase 2 program. STEMCO believes that, since there is a strong economic incentive for operators to ensure that the devices are correctly deployed in order to achieve the greatest fuel cost payback, a regulatory requirement related to deployment is not needed. We generally agree, and have not included such a requirement in the final trailer program. For this analysis, we consider all boat tails to be properly deployed.

The agencies are aware that physical characteristics of some box trailers influence the technologies that can be applied. For instance, the TRUs on refrigerated vans are located at the front of the trailer, which prevents the use of current gap-reducers, either by occupying the space that a front-end fairing would use, or by blocking air flow that the TRU needs for cooling purposes. Similarly, drop deck dry vans have lowered floors between the landing gear and the trailer axles that limit the ability to use side skirts. We discuss another example, roll-up rear doors, in Section IV.C.(1)(a) above. The agencies considered the availability and limitations of aerodynamic technologies for each trailer type evaluated in our feasibility analysis of the standards.

(b) Tire Rolling Resistance

Similar to the Phase 2 tractor and vocational vehicle programs, the agencies are adopting standards based on adoption of lower rolling resistance tires. While some box vans continue to be sold with tires of higher rolling resistances, the agencies believe most box van tires currently achieve a tire C_{RR} of 6.0 kg/ton or better. Feedback from several box trailer manufacturers indicates that the standard tires offered on their new trailers are SmartWay-verified tires (*i.e.,* C_{RR} of 5.1 kg/ton or better). An informal survey of members from the Truck Trailer Manufacturers Association (TTMA) in 2014 indicates about 85 percent of box vans sold at that time had SmartWay tires.[353]

The agencies evaluated two levels of tire performance for box vans beyond the baseline trailer tire rolling resistance level (TRRL) of 6.0 kg/ton. The first performance level was set at the criteria for SmartWay-verification for trailer tires, 5.1 kg/ton, which is a 15 percent reduction in C_{RR} from the baseline. As mentioned previously, several tire models available today achieve rolling resistance values well below the present SmartWay threshold. Given the multiple year phase-in of the standards, the agencies expect that tire manufacturers will continue to respond to demand for more efficient tires and will offer increasing numbers of tire models with rolling resistance values significantly better than today's typical LRR tires. In this context, we believe it is reasonable to expect a large fraction of the trailer industry could adopt tires with rolling resistances at a second performance level that will achieve an additional reduction in rolling resistance, especially in the later stages of the program. The agencies project the C_{RR} for this second level of performance to be a value of 4.7 kg/ton (a 22 percent reduction from the baseline tire).

The vast majority of box van miles occur on-road, and current LRR tire designs are appropriate and effective for those applications. We note that current designs of LRR tires may not be appropriate for some non-box trailer types, including those that operate significantly in off-road conditions. We expect that the tire manufacturing industry will continue to expand their offerings of tire designs to additional applications. Regardless, by limiting the non-box trailer types covered by the final trailer program to those generally used in on-highway applications (tanks, flatbeds, and container chassis), the program avoids most of these potential situations.

We received comment from Michelin supporting the use of 6.0 kg/ton as the box trailer tire rolling resistance baseline, but they expressed concern that the SmartWay threshold of 5.1 kg/ton does not apply for non-box trailers, and could compromise their operation. Similarly, the Rubber Manufacturers Association indicated that a baseline of 6.0 kg/ton does not apply to non-box trailers. The agencies agree that the baseline tires for non-box trailers should have a higher rolling resistance, but we did not receive any comments that included C_{RR} data. For the analysis for the final rules, the agencies revised the baseline C_{RR} to a value of 6.5 kg/ton for non-box trailer manufacturers. The updated non-box trailer designs standards require LRR tires of 6.0 kg/ton in the first stage of the program and 5.1 kg/ton in the later years. Nowhere in the final program do we require Level 4 tires for non-box trailers.

The agencies evaluated four tire rolling resistance levels, summarized in Table IV–7, in the feasibility analysis of the following sections. It should be noted that these levels are targets for setting the stringency of the box van performance standards and rolling resistance thresholds for the non-box design standards. For compliance, box van manufacturers have the option to use tires with any rolling resistance and are not be limited to these TRRLs.

TABLE IV–7—SUMMARY OF TRAILER TIRE ROLLING RESISTANCE LEVELS EVALUATED

Tire rolling resistance level	C_{RR} (kg/ton)
Level 1 (Non-Box Baseline)	6.5
Level 2 (Box Van Baseline)	6.0
Level 3	5.1
Level 4	4.7

(c) Tire Pressure Systems

Tire pressure monitoring systems (TPMS) and automatic tire inflation systems (ATIS) are designed to address under-inflated tires. Both systems alert

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[353] Letter, Truck Trailer Manufacturers Association to EPA. Received on October 16, 2014. Docket EPA–HQ–OAR–2014–0827–0146.

drivers if a tire's pressure drops below its set point. TPMS are simpler and merely monitor tire pressure. Thus, they require user-interaction to reinflate to the appropriate pressure. Today's ATIS, on the other hand, typically take advantage of trailers' air brake systems to supply air back into the tires (continuously or on demand) until a selected pressure is achieved. In the event of a slow leak, ATIS have the added benefit of maintaining enough pressure to allow the driver to get to a safe stopping area. See Chapter 2.10.2.3 of the RIA for more on tire pressure systems.

The agencies proposed that ATIS be the only tire pressure system allowed to be used to meet the standards, since TPMS require action on the part of the operator. Our position at the time of the proposal was that TPMS could not sufficiently guarantee proper inflation. 80 FR 40262. However, some commenters stated that TPMS are effective in encouraging proper tire pressure maintenance, and should also be eligible as a compliance option. Commenters did not provide specific data about the overall effectiveness of TPMS. However, we are aware of the emergence of TPMS that use telematics to automatically report tire pressure data to a central contact. It is also our understanding that there is a growing recognition among fleet and individual operators of the potential value that these systems can provide to operators, so long as the operator and/or a central fleet contact take action to address cases of low tire pressures indicated by the systems. These factors have led the agencies to reconsider our approach to TPMS. As described in Section IV.B. above, we now believe that TPMS provides overall fuel consumption and CO_2 reductions, and the final program recognizes the option of TPMS as part of the compliance path for all covered trailers.

NHTSA and EPA recognize the role of proper tire inflation in maintaining optimum tire rolling resistance during normal trailer operation. Rather than require performance testing of tire pressure systems, the agencies recognize the benefits of these systems, and the program applies default reduction values for manufacturers that incorporate ATIS or TPMS into their trailer designs. Based on information available today, we believe that most tire pressure technologies and systems in typical use perform similarly.

We proposed to assign a 1.5 percent reduction in CO_2 and fuel consumption for all trailers that implement ATIS, based on information available at that time.[354] We did not receive any comments directly addressing the proposed reduction value. However, the agencies believed it was appropriate to align the effectiveness of tire pressure systems for tractors, trailers and vocational vehicles, and the agencies are adopting a 1.2 percent reduction for ATIS for each of these vehicle categories. As just noted, we are also adopting provisions that recognize a CO_2 and fuel consumption reduction for TPMS. The agencies believe that sufficient incentive exists for truck operators to address low tire pressure conditions if they are notified that they exist through a TPMS (for example, for reasons of personal safety as well as fuel savings). However, we recognize the dependence on operator action for TPMS, and we are adopting a reduction of 1.0 percent for these systems. We have concluded that the use of these systems can consistently ensure that tire pressure and tire rolling resistance are maintained. Sections III.D.(1)(b) and V.C.(1)(a) also discuss the overall Phase 2 program's treatment of both types of tire pressure systems for tractors and vocational vehicles, respectively.

We selected the standards for most box vans with the expectation that a high rate of adoption of ATIS will occur during all years of the phase-in of the program, and that manufacturers of non-aero vans, and non-box trailers will install either TPMS or ATIS, as well as LRR tires, to comply with the design-based tire standards.

In the performance-based compliance approach to full- and partial-aero box vans, the program incorporates a small discount in the value of TPMS in the compliance equation as compared to ATIS, to reflect the inherent user interaction required for TPMS to be effective. In the design-based compliance approach for non-aero vans and non-box trailers, manufacturers may comply by using either TPMS or ATIS, which in that case are valued equally. See Section IV.D.(2)(d) below for discussion of our estimates of the degree of adoption of tire pressure systems prior to and at various points in the phase-in of the proposed program.

(d) Weight Reduction

As proposed, the trailer program provides manufacturers the option of complying through the substitution of specified lighter-weight components that can be clearly isolated from the trailer as a whole. In the proposal, the agencies identified several conventional components with lighter-weight substitutes that are currently available (*e.g.,* substituting conventional dual tires mounted on steel wheels with wide-based single tires mounted on aluminum wheels). 80 FR 40262. Several commenters provided additional component suggestions, with information about their typical associated weight reductions. The component substitutions we have included in the final program, and the weight savings that we are associating with each component, are presented in the RIA Chapter 2.10.2.4 and 40 CFR 1037.515. The agencies have identified 12 common trailer components for which lighter weight options are currently available (see 40 CFR 1037.515).[355] [356] [357] [358] Manufacturers that adopt these technologies and choose to use them as part of their compliance strategy sum the associated weight reductions and apply those values in the GEM-based compliance equation (see Section IV.E.(2)(a)). We believe that the initial cost of these component substitutions is currently substantial enough that only a relatively small segment of the industry has adopted these technologies today.

There is no clear ''baseline'' for current trailer weight against which lower-weight designs could be compared for regulatory purposes. For this reason, the agencies do not believe it is appropriate or fair across the industry to apply overall weight reductions toward compliance using a universal baseline trailer. However, the agencies do believe it is appropriate to give a manufacturer credit for overall weight reduction achieved in their own product line. In the final program, we are clarifying that manufacturers of box trailers with significant weight reductions have the option of using our off-cycle credit process to compare overall weight reduction of future trailers using an appropriate baseline from their own production. This process allows manufacturers to do a comparison of their new trailer to a previous model to quantify the weight reduction improvements. Manufacturers wishing to go this route should contact

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[354] See Chapter 2.10.2.3 of the RIA.

[355] Scarcelli, Jamie. ''Fuel Efficiency for Trailers'' Presented at ACEEE/ICCT Workshop: Emerging Technologies for Heavy-Duty Vehicle Fuel Efficiency, Wabash National Corporation. July 22, 2014.

[356] ''Weight Reduction: A Glance at Clean Freight Strategies,'' EPA SmartWay. EPA420F09–043. Available at: *http://permanent.access.gpo.gov/gpo38937/EPA420F09-043.pdf.*

[357] Memorandum dated June 2015 regarding confidential weight reduction information obtained during SBREFA Panel. Docket EPA–HQ–OAR–2014–0827.

[358] Randall Scheps, Aluminum Association, ''The Aluminum Advantage: Exploring Commercial Vehicles Applications,'' presented in Ann Arbor, Michigan, June 18, 2009.

EPA in advance to discuss appropriate test procedures. More information about the off-cycle process can be found in Section IV.E.(5)(d) and in 40 CFR 1037.610 or 49 CFR 535.7. Note that non-box trailers and non-aero box vans have design standards that are limited to adoption of lower rolling resistance tires and tire pressure systems, and do not include weight reduction as part of their simplified compliance demonstration.

The agencies recognize that when weight reduction is applied to a trailer, some operators will replace that saved weight with additional payload. To account for this in the average vehicle represented by EPA's GEM vehicle simulation tool, it is assumed that one-third of any weight reduction will be applied to the payload. Wabash suggested that the agencies reconsider the distribution of weight between payload and trailer weight when modeling weight reduction, expressing concern that the reduction was not receiving appropriate credit in the program. Although the simulated vehicle in GEM only receives ⅔ of the weight reduction applied, the model calculates CO_2 emissions and fuel consumption on a per-ton-mile basis by dividing by the payload, which now includes the extra one-third from weight reduction. Dividing by a larger payload results in lower CO_2 and fuel consumption values.[359]

For 53-foot vans simulated in GEM (and thus, for the GEM-based equation), it takes a weight reduction of nearly 1,000 pounds before a one percent fuel savings is achieved. The impact of the same 1000 pounds is slightly greater for shorter vans, due to their lower overall weight, but the effectiveness of weight reduction is still relatively low compared to the effectiveness of many aerodynamic technologies. In addition, large material substitutions can be costly. The agencies thus believe that few trailer manufacturers will apply weight reduction solely as a means of achieving reduced fuel consumption and CO_2 emissions. Therefore, we are adopting standards that could be met without reducing weight—that is, the feasible compliance path set out by the agencies for this program does not assume weight reduction as a compliance avenue. However, as discussed here, the final program includes the option for box trailer manufacturers to apply weight reduction to some of their trailers as part of their compliance strategy.

(2) Effectiveness, Adoption Rates, and Costs of Technologies for the Trailer Standards

The agencies evaluated the technologies above as they apply to each of the trailer subcategories. The next sections describe the effectiveness, adoption rates and costs associated with these technologies. The effectiveness and adoption rate projections were used to derive these standards.

(a) No-Control Default Tractor-Trailer Vehicles in GEM (Box Van Standards Only)

The regulatory purpose of EPA's heavy-duty vehicle compliance tool, GEM, is to combine the effects of trailer technologies through simulation so that they can be expressed as g/ton-mile and gal/1000 ton-mile and thus avoid the need for direct testing of each trailer being certified. All of the standards for box vans (with the exception of non-aero box vans, which have design standards) use an equation derived from GEM to demonstrate compliance. The trailer program has separate performance standards for each box van subcategory (again, with the exception of non-aero box vans) and each of these subcategories is modeled as a tractor-trailer combination that we believe reflects the average physical characteristics and use pattern of vans in that subcategory. Long vans are pulled by sleeper cab tractors and use the long-haul drive cycle weightings. Short vans are pulled by day cabs and have the short-haul drive cycle weightings. Short vans also have a lighter payload and overall vehicle weight compared to their longer counterparts.

Table IV–8 highlights the relevant vehicle characteristics for the no-control default of each subcategory (*i.e.,* zero CO_2- or fuel consumption reducing technologies installed). Baseline trailer tires are used, and the drag area, which is a function of the aerodynamic characteristics of both the tractor and trailer, is set to the values shown previously in Table IV–6. Weight reduction and tire pressure systems are not applied in these default vehicles. Chapter 2.10 of the RIA provides a detailed description of the development of these default tractor-trailers. Note that the agencies proposed to use Class 8 tractors for all default tractor-trailer vehicles. However, we are adopting the final standards based on 4x2 Class 7 tractors for short box vans.

TABLE IV–8—CHARACTERISTICS OF THE NO-CONTROL DEFAULT TRACTOR-TRAILER VEHICLES IN GEM

	Dry van		Refrigerated van	
Trailer length	Long	Short	Long	Short
Standard Tractor:				
Class	Class 8	Class 7	Class 8	Class 7.
Cab Type	Sleeper	Day	Sleeper	Day.
Roof Height	High	High	High	High.
Axle Configuration	6 x 4	4 x 2	6 x 4	4 x 2.
Engine	2018 MY 15L, 455 HP	2018 MY 11L, 350 HP	2018 MY 15L, 455 HP	2018 MY 11L, 350 HP.
Steer Tire RR (kg/ton)	6.54	6.54	6.54	6.54.
Drive Tire RR (kg/ton)	6.92	6.92	6.92	6.92.
Drag Area, C_dA (m^2)	6.0	5.6	6.0	5.6.
Number of Trailer Axles	2	1	2	1.
Trailer Tire RR (kg/ton)	6.00	6.00	6.00	6.00.
Total Weight (kg)	31978	18306	33778	20106.
Payload (tons)	19	10	19	10.
Tire Pressure System Use	0	0	0	0.
Weight Reduction (lb)	0	0	0	0.
Drive Cycle Weightings:				
65-MPH Cruise	86%	64%	86%	64%.
55-MPH Cruise	9%	17%	9%	17%.

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[359] Memorandum to Docket EPA–HQ–OAR–2014–0827, ''Evaluation of Weight Reduction Distribution in Response to Public Comments from Wabash National Corporation,'' June 18, 2016.

TABLE IV–8—CHARACTERISTICS OF THE NO-CONTROL DEFAULT TRACTOR-TRAILER VEHICLES IN GEM—Continued

	Dry van		Refrigerated van	
Trailer length	Long	Short	Long	Short
Transient Driving	5%	19%	5%	19%.

(b) Effectiveness of Technologies

As already noted, the agencies recognize trailer improvements via four performance parameters: Aerodynamic drag reduction, tire rolling resistance reduction, the adoption of tire pressure systems, and weight-reducing strategies. Table IV–9 summarizes the performance levels the agencies evaluated for each of these parameters based on the technology characteristics outlined in Section IV.D.(1).

TABLE IV–9—PERFORMANCE PARAMETERS FOR THE TRAILER PROGRAM

Aerodynamics (Delta C_dA, m^2):	
Bin I	0.0.
Bin II	0.1.
Bin III	0.4.
Bin IV	0.7.
Bin V	1.0.
Bin VI	1.4.
Bin VII	1.8.
Tire Rolling Resistance (C_{RR}, kg/ton):	
Tire Level 1	6.5.
Tire Level 2	6.0.
Tire Level 3	5.1.
Tire Level 4	4.7.
Tire Inflation System (% reduction):	
ATIS	1.2.
TPMS	1.0.
Weight Reduction (lb):	
Weight	1/3 added to payload, remaining reduces overall vehicle weight.

These performance parameters have different effects on each trailer subcategory due to differences in the simulated trailer characteristics. Table IV–10 shows the agencies' estimates of the effectiveness of each parameter for the four box van types. Each technology was evaluated using the baseline parameter values for the other technology categories. For example, each aerodynamic bin was evaluated using the baseline tire (6.0 kg/ton) and the baseline weight reduction option (zero pounds). The table shows that aerodynamic improvements offer the largest potential for CO_2 emissions and fuel consumption reductions, making them relatively effective technologies.

TABLE IV–10—EFFECTIVENESS (PERCENT CO_2 EMISSIONS AND FUEL CONSUMPTION) OF TECHNOLOGIES FOR BOX VANS IN THE TRAILER PROGRAM

Aerodynamics	Delta C_dA (m^2)	Dry van		Refrigerated van	
		Long (%)	Short (%)	Long (%)	Short (%)
Bin I	0.0	0	0	0	0
Bin II	0.1	1	1	1	1
Bin III	0.4	3	3	3	3
Bin IV	0.7	5	5	5	5
Bin V	1.0	7	7	7	7
Bin VI	1.4	9	10	9	10
Bin VII	1.8	12	13	12	13
Tire Rolling Resistance	C_{RR} (kg/ton)	Dry van		Refrigerated van	
		Long	Short	Long	Short
Level 1	6.5				
Level 2	6.0	0	0	0	0
Level 3	5.1	−2	−1	−2	−1
Level 4	4.7	−3	−2	−3	−2
Weight Reduction	Weight (lb)	Dry van		Refrigerated van	
		Long	Short	Long	Short
Baseline	0	0	0	0	0

TABLE IV–10—EFFECTIVENESS (PERCENT CO_2 EMISSIONS AND FUEL CONSUMPTION) OF TECHNOLOGIES FOR BOX VANS IN THE TRAILER PROGRAM—Continued

Aerodynamics	Delta C_dA (m^2)	Dry van		Refrigerated van	
		Long (%)	Short (%)	Long (%)	Short (%)
Option 1	100	0	0	0	0
Option 2	500	1	1	1	1
Option 3	1000	1	2	1	2
Option 4	2000	2	4	2	4

(c) Baseline Tractor-Trailer To Evaluate Benefits and Costs

In order to evaluate the benefits and costs of the final standards for each of the ten subcategories, it is necessary to establish a reference point for comparison. As mentioned previously, the technologies described in Section IV.D.(1) exist in the market today, and their adoption is driven by available fuel savings as well as by the voluntary SmartWay Partnership and California's tractor-trailer requirements. For these rules, the agencies identified baseline tractor-trailers for each trailer subcategory based on the technology adoption rates we project would exist in MY 2018 if this trailer program was not implemented.

CARB's comments noted the informal survey of TTMA members provided in letter from TTMA to EPA in 2014 regarding current adoption rates of several technologies. CARB suggested that our proposed baseline adoption rates did not reflect the data in that letter.[360] We have reassessed available data and we believe that higher baseline rates are more appropriate, and have made corresponding changes in our analysis. First, we created a separate baseline for box vans that qualify as full-aero, box vans that qualify as partial-aero, and box vans that qualify as non-aero. Because of the challenges of installing effective aerodynamic devices, market forces are not likely to significantly drive adoption of CO_2- and fuel-consumption reducing technologies for trailers with work performing equipment (*e.g.,* lift gates), and we are projecting zero adoption of the technologies in the baselines for partial- and non-aero box vans before the start of this program. Similarly, we assume that there will be zero adoption of these technologies for non-box trailers in the baseline. We updated the baseline tire rolling resistance level for non-box trailers to reflect the lower 6.5 kg/ton value in response to RMA's comment that these trailers have different operational characteristics and should not have the same baseline tires as box vans (see Section IV.D.(1)(b) above).

TTMA's survey indicated that 35 percent of long vans and less than 2 percent of vans under 53-foot in length include aerodynamic devices, and over 80 percent have adopted lower rolling resistance tires. The agencies believe the trailers for which manufacturers have adopted these technologies are likely to be trailers that would qualify as ''full-aero'' vans, and we adjusted our baselines to reflect these values. Our baseline assumes that aerodynamics would increase to 40 percent adoption for full-aero long vans (dry and refrigerated) and 5 percent for full-aero short vans by 2018 without the Phase 2 standards. We also assume adoption of lower rolling resistance tires (Level 1) will increase to 90 percent and ATIS to 45 percent in the baseline. We held these adoption rates constant throughout the timeframe of the rules. Table IV–11 summarizes the updated baseline trailers for each trailer subcategory.

TABLE IV–11—ESTIMATED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR THE FLAT BASELINE TRAILERS FOR MY 2018 AND LATER

Technology	Long vans	Short vans	All partial-aero, non-aero vans	All non-box trailers
Aerodynamics:				
Bin I	55%	95%	100%	100%
Bin II		5%		
Bin III	40%			
Bin IV	5%			
Bin V.				
Bin VI.				
Bin VII.				
Average Delta C_dA (m^2) [a]	*0.2*	*0.0*	*0.0*	*0.0*
Tire Rolling Resistance:				
Level 1				100%
Level 2	10%	10%	100%	
Level 3	90%	90%		
Level 4.				
Average C_{RR} (kg/ton) [a]	*5.2*	*5.2*	*6.0*	*6.5*
Tire Pressure Systems:				
ATIS	45%	30%		
TPMS.				
Average Pressure System Reduction (%) [a]	*0.5%*	*0.3%*	*0.0%*	*0.0%*
Weight Reduction:				

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[360] Letter, Truck Trailer Manufacturers Association to EPA. Received on October 16, 2014. Docket EPA–HQ–OAR–2014–0827–0146.

TABLE IV–11—ESTIMATED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR THE FLAT BASELINE TRAILERS FOR MY 2018 AND LATER—Continued

Technology	Long vans	Short vans	All partial-aero, non-aero vans	All non-box trailers
Weight (lb)[b].				

Notes:
A blank cell indicates a zero value.
[a] Combines adoption rates with performance levels shown in Table IV–9.
[b] Weight reduction was not projected for the baseline trailers.

Also shown in Table IV–11 are average aerodynamic performance (delta C_dA), average tire rolling resistance (C_{RR}), and average reductions due to use of tire pressure systems and weight reduction for each reference trailer. These values indicate the performance of theoretical average tractor-trailers that the agencies project would be in use in 2018 if no federal regulations were in place for trailer CO_2 and fuel consumption. The average tractor-trailer vehicles serve as baselines for each trailer subcategory.

Because the agencies cannot be certain about future trends, we also considered a second baseline. This dynamic baseline reflects the possibility that, absent a Phase 2 regulation, there would be continuing adoption of aerodynamic technologies in the long box trailer market after 2018 that reduce fuel consumption and CO_2 emissions. This case assumes the research funded and conducted by the federal government, industry, academia and other organizations would, after 2018, result in the adoption of additional aerodynamic technologies beyond the levels required to comply with existing regulatory and voluntary programs. One example of such research is the Department of Energy SuperTruck program which has a goal of demonstrating cost-effective measures to improve the efficiency of Class 8 long-haul freight trucks by 50 percent by 2015.[361] This baseline assumes that by 2040, 75 percent of new full-aero long vans would be equipped with SmartWay-verified aerodynamic devices. The agencies project that the lower rolling resistance tires and ATIS adoption would remain constant. Table IV–12 shows the agencies' projected adoption rates of technologies in the dynamic baseline.

TABLE IV–12—PROJECTED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR THE DYNAMIC BASELINE FOR LONG DRY AND REFRIGERATED VANS

[All other trailers are the same as Table IV–11]

Technology	Long dry and refrigerated				
Model year	2018	2021	2024	2027	2040
Aerodynamics:					
Bin I	55%	50%	45%	40%	20%
Bin II.					
Bin III	40%	45%	50%	55%	75%
Bin IV	5%	5%	5%	5%	5%
Bin V.					
Bin VI.					
Bin VII.					
Average Delta C_dA (m^2)[a]	*0.2*	*0.3*	*0.3*	*0.3*	*0.4*
Tire Rolling Resistance:					
Level 1.					
Level 2	10%	10%	10%	10%	10%
Level 3	90%	90%	90%	90%	90%
Level 4.					
Average C_{RR} (kg/ton)[a]	*5.2*	*5.2*	*5.2*	*5.2*	*5.2*
Tire Pressure Systems:					
ATIS	45%	45%	45%	45%	45%
TPMS.					
Average Pressure System Reduction (%)[a]	*0.5%*	*0.5%*	*0.5%*	*0.5%*	*0.5%*
Weight Reduction (lbs):					
Weight[b].					

Notes:
A blank cell indicates a zero value.
[a] Combines adoption rates with performance levels shown in Table IV–9.
[b] Weight reduction was not projected for the baseline trailers.

The agencies applied the vehicle attributes from Table IV–8 and the average performance values from Table IV–11 in the Phase 2 GEM vehicle simulation to calculate the CO_2 emissions and fuel consumption performance of the baseline tractor-trailers. The results of these simulations are shown in Table IV–13. We used

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[361] Daimler Truck North America. SuperTruck Program Vehicle Project Review. June 19, 2014. Docket EPA–HQ–OAR–2014–0827.

these CO_2 and fuel consumption values to calculate the relative improvements that will occur over time with a regulatory program. Note that the large difference between the per ton-mile values for long and short trailers is due primarily to the large difference in assumed payload (19 tons compared to 10 tons) and the small difference between dry and refrigerated vans of the same length are due to differences in vehicle weight because of the 1800 pounds added to the simulated refrigerated vans to account for the TRU (see the vehicle characteristics of the simulated tractor-trailers Table IV–8). The alternative baseline shown in Table IV–12 mainly impacts the long-term projections of benefits beyond 2027, which are analyzed in Chapters 5–7 of the RIA.

TABLE IV–13—CO_2 EMISSIONS AND FUEL CONSUMPTION RESULTS FOR THE BASELINE TRACTOR-TRAILERS

Length	Full-aero dry van		Full-aero refrigerated van		Partial-aero dry van		Partial-aero refrigerated van	
	Long	Short	Long	Short	Long	Short	Long	Short
CO_2 Emissions (g/ton-mile)	83.2	126.5	84.9	130.3	86.1	128.5	87.9	132.4
Fuel Consumption (gal/1000 ton-miles)	8.17289	12.42633	8.33988	12.79961	8.45776	12.62279	8.63458	13.00589

(d) Projected Technology Adoption Rates for the Trailer Standards

The agencies developed their performance and design standards based on projected adoption rates of certain technologies. This section describes how these adoption rates were applied for each of the trailer subcategories.

(i) Aerodynamic and Tire Technologies for Full- and Partial-Aero Box Vans

As described in Section 0, the agencies evaluated several alternatives for the trailer program. Based on our analysis and comments received, the agencies are adopting standards consistent with the agencies' respective statutory authorities. The agencies proposed alternatives that were based on the use of averaging and the technology adoption rates for those alternatives at proposal reflected the use of averaging. As noted in Section IV.B., we received nearly unanimous, persuasive comments from the trailer industry opposing averaging and the agencies reconsidered the use of averaging in the early years of the program. The agencies designed the trailer program to have no averaging in MY 2018 through MY 2026. In those years, all box vans sold must meet the standards using any combination of available technologies. In MY 2027, when the trailer manufacturers are more comfortable with compliance and the industry is more familiar with the technologies, trailer manufacturers will have the option to use averaging to meet the standards. See Section IV.E.(5)(b) below for additional information about averaging.

Table IV–14 and Table IV–15 present sets of assumed adoption rates for aerodynamic, tire, and tire pressure technologies that a manufacturer could apply to meet the box van standards. Since averaging would not be allowed for MY 2018–MY 2026, the adoption rates consist of the combination of a single aerodynamic bin (not reflecting any averaging of aerodynamic controls), tire rolling resistance level, and tire pressure system. As mentioned previously, manufacturers can choose other combinations to meet the standards. Chapter 2.10 of the RIA shows several examples of alternative compliance pathways.

The adoption rates in Table IV–14 begin with all full-aero long box vans achieving current SmartWay-level aerodynamics (Bin III) in MY 2018 with a stepwise progression to achieving Bin V in 2024. The adoption rates for full-aero short box vans in Table IV–15 assume no adoption of aerodynamic devices in MY 2018, adoption of single aero devices in MY 2021, and combinations of devices by MY 2024. Although the shorter lengths of these trailers can restrict the design of aerodynamic technologies that fully match the SmartWay-like performance levels of long boxes, we nevertheless expect that trailer and device manufacturers will continue to innovate skirt, under-body, rear, and gap-reducing devices and combinations to achieve improved aerodynamic performance on these shorter trailers.

The adoption rates in MY 2018–MY 2026 are projected to be 100 percent for each technology, instead of an industry average seen in other vehicle sectors in the Phase 2 program. Since we are not considering averaging during those years, each set of adoption rates is one example of how an individual trailer in each subcategory could comply. Through MY 2026, the standards are based on technologies that exist today. We evaluated one technology in our aerodynamic test programs that met Bin VI levels of performance for long vans, suggesting that this bin can be met with combinations of existing aerodynamic technologies, but none of our tested technologies that met Bin IV levels of performance for short vans. We could not justify standards based on 100 percent adoption of those levels of performance as a final step in our progression of stringency. However, the industry has made great progress toward improving trailer aerodynamics in recent years and are continuing to optimize these technologies. Although we are not projecting fundamentally new technologies for trailers, we do believe aerodynamic performance will evolve in the trailer industry as a result of this rulemaking. Based on the recent rate of improvement, the agencies believe that there is ample lead time to optimize additional existing Bin V and Bin III combinations such that they can also meet Bins VI and IV by MY 2027 and it is reasonable to project that more than half of these full-aero capable trailers will have aerodynamic improvements greater than what is possible with today's technologies. Our projected aerodynamic improvements in MYs 2027 and later reflect this performance potential.

The MY 2027 full-aero box van standards are based on an averaging program.[362] We cannot predict what technologies or trailer designs may be adapted to meet this level of aerodynamic performance, but an averaging program incentivizes manufacturers to develop advanced designs with the benefit that not all trailers in their production have to meet the same level of performance. The gradual increase in assumed adoption of aerodynamic technologies throughout the phase-in to the MY 2027 standards recognizes that even though many of the technologies are available today and technologically feasible throughout the phase-in period, adoption of more advanced technologies will likely take time. The adoption rates we are

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[362] No averaging is allowed for partial-aero box van reduced standards, or the design-based standards for non-aero box vans and non-box trailers.

projecting in the interim years and the standards that we developed from these rates represent steady and reasonable improvement in aerodynamic performance.

We expect manufacturers of all box vans will adopt tires such as SmartWay-verified trailer tires (Level 3) to meet the standards in MY 2018 and will adopt tires with even lower rolling resistance tires (represented as Level 4) as they become available by MY 2021 and later years and as fleet experience with these tires develops.

In establishing standard stringency, the agencies are also assuming that all box vans will adopt ATIS throughout the program, though manufacturers have the option to install TPMS if they would prefer to make up the difference in effectiveness using other technologies. As mentioned previously, the agencies did not include weight reduction in their technology adoption projections, but certain types of weight reduction could be used as part of a compliance pathway, as discussed in Section IV.D.(1)(d) IV.D.(1)(d) above.

TABLE IV–14—PROJECTED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR FULL-AERO LONG BOX VANS

Technology	Long box dry & refrigerated vans			
Model year	2018	2021	2024	2027
Aerodynamic Technologies:				
Bin I.				
Bin II.				
Bin III	100%			
Bin IV		100%		
Bin V			100%	30%
Bin VI				70%
Bin VII.				
Average Delta C_dA (m^2)[a]	*0.5*	*0.7*	*1.0*	*1.3*
Trailer Tire Rolling Resistance:				
Level 1.				
Level 2				5%
Level 3	100%			
Level 4		100%	100%	95%
Average C_{RR} (kg/ton)[a]	*5.1*	*4.7*	*4.7*	*4.8*
Tire Pressure Systems:				
ATIS	100%	100%	100%	100%
TPMS.				
Average Pressure System Reduction (%)[a]	*1.2%*	*1.2%*	*1.2%*	*1.2%*
Weight Reduction:				
Weight (lb)[b].				

Notes:
A blank cell indicates a zero value.
[a] Combines projected adoption rates with performance levels shown in Table IV–9.
[b] This set of adoption rates did not apply any assumed weight reduction to meet these standards for these trailers.

TABLE IV–15—PROJECTED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR FULL-AERO SHORT BOX VANS

Technology	Short box dry & refrigerated vans			
Model year	2018	2021	2024	2027
Aerodynamic Technologies:				
Bin I.				
Bin II		100%		
Bin III			100%	40%
Bin IV				60%
Bin V.				
Bin VI.				
Bin VII.				
Average Delta C_dA (m^2)[b]	*0.0*	*0.1*	*0.4*	*0.6*
Trailer Tire Rolling Resistance:				
Level 1.				
Level 2				5%
Level 3	100%			
Level 4		100%	100%	95%
Average C_{RR} (kg/ton)[b]	*5.1*	*4.7*	*4.7*	*4.8*
Tire Pressure Systems:				
ATIS	100%	100%	100%	100%
TPMS.				
Average Tire Pressure Reduction (%)[c]	*1.2%*	*1.2%*	*1.2%*	*1.2%*
Weight Reduction:				
Weight (lb)[b].				

Notes:
A blank cell indicates a zero value.
[a] The majority of short box trailers are 28 feet in length. We recognize that they are often operated in tandem, which limits the technologies that can be applied (for example, boat tails).
[b] Combines projected adoption rates with performance levels shown in Table IV–9.

[c] This set of adoption rates did not apply any assumed weight reduction to meet these standards for these trailers.

The agencies proposed that the partial-aero box vans would track with the full-aero van standards until MY 2024. 80 FR 40257. Wabash commented that partial-aero box vans should be exempt starting in MY 2021 since partial-aero vans cannot use multiple devices. The agencies reconsidered the proposed partial-aero standards and recognize that it would likely be difficult to meet the proposed MY 2024 standards without the use of multiple devices and yet partial-aero trailers, by definition, are restricted from using multiple devices. For these reasons, the agencies redesigned the partial-aero standards, such that trailers with qualifying work-performing equipment can meet standards that would be achievable with the use of a single aerodynamic device throughout the program, similar to the MY 2018 standards. The partial-aero standards do, however, increase in stringency slightly in MY 2021, to reflect the broader use of improved lower rolling resistance tires.

TABLE IV–16—PROJECTED ADOPTION RATES AND AVERAGE PERFORMANCE PARAMETERS FOR PARTIAL-AERO BOX VANS

Technology	Partial-aero long box vans		Partial-aero short box vans	
Model year	2018	2021+	2018	2021+
Aerodynamic Technologies:				
Bin I.				
Bin II				100%
Bin III	100%	100%		
Bin IV.				
Bin V.				
Bin VI.				
Bin VII.				
Average Delta C_dA (m^2)[b]	*0.5*	*0.5*	*0.0*	*0.1*
Trailer Tire Rolling Resistance:				
Level 1.				
Level 2.				
Level 3	100%		100%	
Level 4		100%		100%
Average C_{RR} (kg/ton)[b]	*5.1*	*4.7*	*5.1*	*4.7*
Tire Pressure Systems:				
ATIS	100%	100%	100%	100%
TPMS.				
Average Pressure System Reduction (%)[a]	1.2%	1.2%	1.2%	1.2%
Weight Reduction:				
Weight (lb)[b].				

Notes:
A blank cell indicates a zero value.
[a] Combines projected adoption rates with performance levels shown in Table IV–9.
[b] This set of adoption rates did not apply weight reduction to meet these standards for these trailers.

The adoption rates shown in these tables are one set of many possible combinations that box trailer manufacturers could apply to achieve the same average stringency. If a manufacturer chose these adoption rates, a variety of technology options exist within the aerodynamic bins, and several models of LRR tires exist for the levels shown. Alternatively, technologies from other aero bins and tire levels could be used to comply. It should be noted that since the standards for box vans are all performance-based, box van manufacturers are not limited to specific aerodynamic and tire technologies in their compliance choices. Certain types of weight reduction, for example, may be used as part of a compliance pathway. See RIA Chapter 2.10.2.4.1 for other example compliance pathways that include weight reduction.

Similar to our analyses of the baseline cases, the agencies derived a single set of performance parameters for each subcategory by weighting the performance levels included in Table IV–9 by the corresponding adoption rates. These performance parameters represent a compliant vehicle for each trailer subcategory and are presented as average values in the Table IV–14 through Table IV–16.

(ii) Tire Technologies for Non-Aero Box Vans and Non-Box Trailers

Neither non-aero vans (*i.e.,* those with two or more work-related special components), nor non-box trailers are shown in the tables above. This is because we are adopting design-based (*i.e.,* technology-based) standards for these trailers, not performance-based standards. Manufacturers of these trailers do not need to use aerodynamic technologies, but they need to install the lower rolling resistance tires and tire pressure systems established by this program (see Section IV.C.(2)). Compared to manufacturers that needed aerodynamic technologies to comply, the approach for non-aero box trailers and non-box trailers results in a significantly lower compliance burden for manufacturers by reducing the amount of tracking and eliminating the need to calculate a compliance value (see Section IV.E.). The agencies are adopting these design standards, which can be assumed to be 100 percent adoption, in two stages. In MY 2018, the non-box trailer standards require manufacturers to use tires meeting a rolling resistance of Level 2 or better and to install tire pressure systems. In MY 2021, non-box trailers standards require tire pressure systems and LRR tires at Level 3 or better. Non-aero box vans, which we believe are largely at a baseline rolling resistance Level 2 today, require tire pressure monitoring systems with Level 3 tires in MY 2018 and Level 4 tires in MY 2021 and later.

We received comment that manufacturers were concerned about the cost and availability of ATIS for the trailer industry. Still, based on comments about TPMS and further evaluations by the agencies, we are including TPMS as an additional option for tire pressure systems in the trailer program, as discussed in Section IV.D.(1)(c) above. Non-aero vans and non-box trailers are compliant if they have appropriate lower rolling resistance tires and either TPMS or ATIS.

(e) Derivation of the Trailer Standards

The agencies applied the average performance parameters from Table IV–14 and Table IV–15 as input values to the GEM vehicle simulation to derive the HD Phase 2 fuel consumption and CO_2 emissions standards for each long and short full-aero box van subcategory. These full-aero van standards are shown in Table IV–17. Similarly, the average performance parameters from Table IV–16 were used to calculate the partial-aero van standards shown in Table IV–18. The design standards for non-box trailer and non-aero box van are summarized in Table IV–19.

Over the four stages of the trailer program, the full-aero box vans longer than 50 feet are projected to reduce their CO_2 emissions and fuel consumption by two percent, five percent, seven percent and nine percent compared to their average baseline cases in Table IV–13. Full-aero box vans 50-feet and shorter will achieve reductions of one percent, two percent, four percent and six percent compared to their average baseline cases. The partial-aero long and short box van standards will reduce CO_2 and fuel consumption by six percent and four percent, respectively, by MY 2021. The tire technologies used on non-box and non-aero box trailers are projected to provide reductions of two percent in the first stage and three percent in MY 2021 and later.

TABLE IV–17—STANDARDS FOR FULL-AERO BOX VANS

Model year	Subcategory	Dry van		Refrigerated van	
	Length	Long	Short	Long	Short
2018–2020	EPA Standard (CO_2 Grams per Ton-Mile)	81.3	125.4	83.0	129.1
	Voluntary NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.98625	12.31827	8.15324	12.68173
2021–2023	EPA Standard (CO_2 Grams per Ton-Mile)	78.9	123.7	80.6	127.5
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.75049	12.15128	7.91749	12.52456
2024–2026	EPA Standard (CO_2 Grams per Ton-Mile)	77.2	120.9	78.9	124.7
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.58350	11.87623	7.75049	12.24951
2027+	EPA Standard (CO_2 Grams per Ton-Mile)	75.7	119.4	77.4	123.2
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.43615	11.7288	7.60314	12.10216

TABLE IV–18—STANDARDS FOR PARTIAL-AERO BOX VANS

Model year	Subcategory	Dry van		Refrigerated van	
	Length	Long	Short	Long	Short
2018–2020	EPA Standard (CO_2 Grams per Ton-Mile)	81.3	125.4	83.0	129.1
	Voluntary NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.98625	12.31827	8.15324	12.68173
2021+	EPA Standard (CO_2 Grams per Ton-Mile)	80.6	123.7	82.3	127.5
	NHTSA Standard (Gallons per 1,000 Ton-Mile)	7.91749	12.15128	8.08448	12.52456

TABLE IV–19—DESIGN-BASED TIRE STANDARDS FOR NON-BOX TRAILERS AND NON-AERO BOX VANS

Model year	Tire technology	Non-box trailers	Non-aero box vans
2018–2020	Tire Rolling Resistance Level (kg/ton)	≤6.0	≤5.1
	Tire Pressure System	TPMS or ATIS	TPMS or ATIS
2021+	Tire Rolling Resistance Level (kg/ton)	≤5.1	≤4.7
	Tire Pressure System	TPMS or ATIS	TPMS or ATIS

(f) Technology Costs for the Trailer Standards

The agencies evaluated the incremental technology costs for 53-foot dry and refrigerated vans and 28-foot dry vans. (As explained above, we believe these length trailers are representative of the majority of trailers in the long and short box van subcategories, respectively.) We identified costs for each technology package and projected the costs for each year of the program. A summary of the technology costs is included in Table IV–20 through Table IV–23 for MYs 2018 through 2027, with additional details available in the RIA Chapter 2.12. Costs shown in the following tables are for the specific model year indicated and are incremental to the average baseline costs, which includes some level of adoption of these technologies as shown in Table IV–13. Therefore, the technology costs in the following tables reflect the average cost expected for each of the indicated trailer classes across the fleet. Note that these costs do not represent actual costs for the individual components because they are relative to the costs of the MY 2018 baselines which are expected due to market-driven adoption of the technologies. For more on the estimated technology costs exclusive of adoption rates, refer to Chapter 2.12 of the RIA. These costs include indirect costs via markups and reflect lower costs over time due to learning impacts. For a description of the markups and learning impacts considered in this analysis and how technology costs for other years are thereby affected, refer to Chapter 7 of the RIA.

TABLE IV–20—TRAILER TECHNOLOGY INCREMENTAL COSTS IN THE 2018 MODEL YEAR

[2013$]

	Long vans, full aero	Long vans, partial aero	Short vans, full aero	Short vans, partial aero	Long vans, no aero	Short vans, no aero	Non-box
Aerodynamics	$367	$742	$0	$0	$0	$0	$0
Tires	2	40	1	20	40	20	28
Tire inflation system	347	659	338	494	421	210	421
Total	716	1,441	339	514	461	231	448

TABLE IV–21—TRAILER TECHNOLOGY INCREMENTAL COSTS IN THE 2021 MODEL YEAR

[2013$]

	Long vans, full aero	Long vans, partial aero	Short vans, full aero	Short vans, partial aero	Long vans, no aero	Short vans, no aero	Non-box
Aerodynamics	$743	$679	$450	$475	$0	$0	$0
Tires	17	49	9	25	49	25	23
Tire inflation system	321	609	313	457	389	195	389
Total	1,081	1,337	772	957	438	219	412

TABLE IV–22—TRAILER TECHNOLOGY INCREMENTAL COSTS IN THE 2024 MODEL YEAR

[2013$]

	Long vans, full aero	Long vans, partial aero	Short vans, full aero	Short vans, partial aero	Long vans, no aero	Short vans, no aero	Non-box
Aerodynamics	$899	$645	$879	$451	$0	$0	$0
Tires	11	48	6	24	48	24	27
Tire inflation system	294	558	286	418	357	178	357
Total	1,204	1,251	1,171	894	405	202	383

TABLE IV–23—TRAILER TECHNOLOGY INCREMENTAL COSTS IN THE 2027 MODEL YEAR

[2013$]

	Long vans, full aero	Long vans, partial aero	Short vans, full aero	Short vans, partial aero	Long vans, no aero	Short vans, no aero	Non-box
Aerodynamics	$1,069	$623	$921	$436	$0	$0	$0
Tires	22	44	11	22	44	22	16
Tire inflation system	279	529	272	397	338	169	338
Total	1,370	1,196	1,204	855	382	191	354

(3) Consistency of the Trailer Standards With the Agencies' Statutory Obligations

The agencies have determined that the standards presented in the Section IV.C.(2), are the maximum feasible and appropriate under the agencies' respective authorities, considering lead time, cost, and other factors. The agencies' decisions on the stringency and timing of the trailer standards focused on available technology and the consequent emission reductions and fuel efficiency improvements associated with use of the technology, while taking into account the circumstances of the trailer manufacturing sector. Trailer manufacturers are subject to first-time emission control and fuel consumption regulation under the trailer standards. These manufacturers are in many cases small businesses, with limited resources to master the mechanics of regulatory compliance. Thus, the agencies are providing ample and reasonable time for trailer manufacturers to become familiar with the requirements and the new compliance regime.

The stringency of the standard is predicated on more widespread deployment of tire technologies that are already in commercial use and existing aerodynamic devices combinations that we believe will be further optimized in the near-term. The availability, feasibility, and level of effectiveness of these technologies are well-documented. In developing the standards, we also took into account not just the capabilities of the technologies, but also how the use of these technologies is likely to expand under the trailer program, considering factors like degree of market penetration over time and the effect of different operational patterns for different trailer types (Section IV.D.(2) above). For example, some commenters point out that trailers operating at lower speeds will achieve smaller CO_2 and fuel consumption reductions than they will at highway speeds. The agencies acknowledge this fact, and account for a fraction of trailer operation at slower speeds. All long box vans are evaluated with 5 percent of their miles at low speed operation and all short vans are evaluated with 17 percent low speed miles. While we cannot predict individual trailer use, we believe these values are a reasonable estimate of an industry average.[363] Our analysis in RIA Chapter 2.10.2.1.1 shows that skirts will provide short trailers with at least 1 percent improvement and long trailers with at least 4 percent improvement at 55 mph. We expect most trailers spend at least some of their miles at 55 mph or faster in use and will gain similar benefits during those speeds. We also show that even trailers operating under fully transient conditions (combining slower and faster operation) will experience a small improvement from use of trailer skirts.

The agencies do not believe that there is any issue of technological feasibility of the levels of the standards and the time line for implementing them in the final trailer program. The agencies considered cost and the sufficiency of lead-time, including lead-time not only to deploy technological improvements, but, as just noted, also for this industry sector to assimilate for the first time the compliance mechanisms of the trailer program.

The highest cost shown in Table IV–23 is associated with the standard for long dry vans. We project that the average cost per trailer to meet the MY 2027 standards for these trailers will be about $1,400, which is less than 10 percent of the cost of a new dry van trailer (estimated to be about $20,000). Other trailer types have lower projected technology costs, and many have higher purchase prices. As a result, we project that the per-trailer costs for all trailers covered in this regulation will be less than 10 percent of the cost of a new trailer.

The agencies regard these costs as reasonable. We project that most customers will rapidly recover the initial cost of these technologies due to the associated fuel savings, usually in two years. As discussed in Section IX.M and RIA Chapter 7.2.4, this payback is for tractors and trailers together, and includes both long and short-haul. This payback period is generally considered reasonable in the trailer industry for investments that reduce fuel consumption.[364] Although longer paybacks will occur for some trailers, we do not project that any trailers will achieve lifetime fuel savings less than the cost of the technologies. In addition, the agencies estimate the cost per metric ton of CO_2eq reduction without considering fuel savings to be $36 for tractor-trailers in 2030 which compares favorably with the levels of cost effectiveness the agencies found to be reasonable for light duty trucks.[365]

The agencies believe these technologies can be adopted at the projected rates within the lead time provided in the trailer program, as discussed above in Section IV.C.(4) above.

(4) Alternative Standards and Feasibility That the Agencies Considered

As discussed in Section X of the NPRM, the agencies evaluated five regulatory alternatives representing different levels of stringency for the Phase 2 program. See 80 FR 40273. A wide range of stakeholders commented on the proposed (Alternative 3) standards and the other alternatives that we discussed, and our final standards reflect our consideration of all of those comments.

Comments on our proposed standards (Alternative 3) and the alternatives we presented generally fell into three categories: (1) Commenters supporting Alternative 1; *i.e.,* generally advocating no mandatory standards and a continuation of today's voluntary SmartWay regime and; (2) Commenters preferring the proposed Alternative 3 standards and timeline to the standards of Alternative 4; and (3) Commenters supporting the more stringent standards and timeline of Alternative 4, Alternative 5, or of other more stringent potential programs.

Commenters including the TTMA, Utility, and Stoughton stated their belief that no mandatory standards are necessary; however, they did not provide information to show that market forces at work today will achieve the clear potential for the industry to reduce CO_2 and fuel consumption in the near- and longer-term future. The agencies have concluded that a program involving no or minimal mandatory requirements would not be appropriate or meet our statutory requirements.

As discussed previously, the agencies believe that our final trailer standards are appropriate under the Clean Air Act and are the maximum feasible standards under the EISA. In developing the proposal and the final rule, we considered standards that would be more stringent or would become effective in an earlier model year than the proposed Alternative 3 standards and timeline. Several commenters stated that a still more stringent program should be finalized, including information about current and potential future trailer aerodynamic technologies. Commenters including CARB, NACAA, NRDC, ICCT, UCS, and STEMCO supported the standards we presented for Alternative 4 in the proposal (essentially the pull ahead of the MY 2027 standards) in the proposal. In addition, some of the commenters made the additional suggestion that the agencies should anticipate that manufacturers will incorporate a modest degree of Bin VIII technologies—*i.e.,* two bins higher than any performance demonstrated in our aerodynamic testing—in the later stages of the program. EDF supported a program of even greater stringency, supporting Alternative 5 standards (advanced aerodynamic technologies on all box vans, aerodynamic technologies on some non-box trailers, and tire technologies on all non-box trailers) on the Alternative 4 timeline. The Center for Biological Diversity (CBD) did not specifically comment on the alternatives presented in the proposal, but supported a program that would result in significantly more stringent standards (based, for example, on integrated tractor and trailer technologies, such as in the SuperTruck demonstration program). Great Dane, Wabash, ATA, and the International Foodservice Distributors Association expressed concerns that a program of the stringency and timeline of Alternative 4 would have negative consequences, including requiring trailer manufacturers to adopt less-tested technology.

Where commenters provided relevant data and information, the agencies made adjustments to the final program accordingly. For example, as noted in Section IV.C.(1) and Section IV.D.(2) previously, information from the industry was helpful in the decision to limit the non-box trailer program to tanks, flatbeds, and container chassis. Also, partially in response to information we received in comments, we slightly reduced the proposed stringency for partial-aero vans to better reflect their aerodynamic limitations. Also, while not a direct change to the stringency of the standards, the program limits averaging to the final stage of the program to allow van manufacturers more time to become familiar with the compliance processes and the industry to gain confidence in the technologies. Overall, the final standards are slightly more stringent than proposed, based on

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[363] Memorandum to Docket EPA–HQ–OAR–2014–0827, ''Comparison of GEM Drive Cycle Weightings and Fleet Data Provided by Utility Trailer Manufacturing Co. in Public Comments'', July 2016.

[364] Roeth, Mike, et al. ''Barriers to Increased Adoption of Fuel Efficiency Technologies in Freight Trucking,'' July 2013. International Council for Clean Transportation. Available here: *http://www.theicct.org/sites/default/files/publications/ICCT–NACFE–CSS_Barriers_Report_Final_20130722.pdf.*

[365] See RIA Chapter 7.2.5 and Memo to Docket ''Tractor-Trailer Cost per Ton Values.'' July 2016. EPA–HQ–OAR–2014–0827.

an expectation of earlier adoption of more efficient lower rolling resistance tires for all subcategories, and a strengthened the full-aero van program that includes greater adoption of advanced aerodynamics in the final stage.

Based on this analysis and as informed by the comments, we believe that the final standards in the program, slightly revised from the proposed Alternative 3 standards, are appropriate and represent the maximum feasible standards. In contrast, we believe that the accelerated timeline of Alternative 4 may cause technologies to prematurely enter the market, leading to unnecessary costs and compliance burdens that would not be appropriate for this newly regulated industry. Standards similar to or more stringent than those we evaluated for Alternative 5 would require CO_2 and fuel consumption reductions that may well not be technologically achievable, even with fundamental changes to the industry. Nor did the commenters present any information as to how advanced aerodynamic technologies (Bins VII and VIII) could be developed and reliably brought to market at reasonable cost within the lead time of the Phase 2 program. On the basis of what we know today, the agencies are unable to show a pathway for the industry to achieve such additional improvements, at least without the potential for major disruptions to the industry due to requiring, for example, fundamental changes to trailer design and construction, or impractical levels of tractor-trailer integration.

E. Trailer Standards: Compliance and Flexibilities

As with other EPA motor vehicle programs, trailer manufacturers must annually obtain a certificate of conformity from EPA before introducing into commerce new trailers subject to the new trailer CO_2 and fuel consumption standards. See CAA section 206(a). The EPA certification provisions align with provisions that apply to the NHTSA trailer program such that this single certification program meets the requirements of both agencies.

The certification process for trailer manufacturers is very similar in its basic structure to the process for the other Phase 2 vehicle programs, although it has been simplified for trailers. This structure involves pre-certification activities, the certification application and its approval, and end-of-year reporting.

In this section, the agencies first describe the general certification process and how we developed compliance equations based on the GEM vehicle simulation tool, followed by a discussion of the specified test procedures for measuring the performance of tires and aerodynamic technologies and how manufacturers will apply test results toward compliance and certification. The section closes with discussions of several other certification and compliance provisions as well as provisions to provide manufacturers with compliance flexibility.

(1) General Certification Process

Under the process for certification, manufacturers of all covered trailers are required to apply to EPA for certification.[366] In addition, manufacturers of box vans subject to the performance-based standards are required to provide aerodynamic performance test data (see 40 CFR 1037.205) in their applications. EPA expects to provide additional guidance to the regulated industry as the program begins to be implemented, including an overview of the regulations, how to prepare for compliance, and instructions for registering with the EPA. Once a trailer manufacturer is registered with EPA, EPA's Compliance Division in the Office of Transportation and Air Quality will assign a staff certification representative to the company to help them through the compliance process. After this point, manufacturers can arrange to meet with the agencies to discuss compliance plans and obtain any preliminary approvals (*e.g.,* appropriate test methods) before applying for certification.

Trailer manufacturers submit their applications through the EPA ''Verify'' electronic database, and EPA issues certificates based on the information provided. At the end of the model year, trailer manufacturers submit an end-of-year report to the agencies to complete their annual obligations.

(a) Definition of Model Year

As mentioned previously, consistent with Clean Air Act specifications, EPA's vehicle certification is an annual process. EPA CO_2 emissions standards start to apply for trailers built on or after January 1, 2018, with later standards being introduced by model year. Under the Clean Air Act, the term ''model year'' refers to a manufacturer's annual production period. Manufacturers may use the calendar year as the model year, or may choose a different period of production that includes January 1 of that year. Thus, manufacturers have the option to choose any year-long period of production that begins on or before January 1 of the named model year, but no sooner than January 2 of the previous calendar year. For example, at certification, a manufacturer could specify the 2021 model year production period to be July 1, 2020 through June 30, 2021.

(b) Preliminary Considerations for Compliance

Before submitting an application for a certificate, a manufacturer chooses the technologies they plan to offer their customers, and identifies any trailers in their production line that qualify for exclusion from the program.[367] Non-box trailers, which are subject to design standards, the manufacturer will need to select which tires and tire pressure systems to include and confirm that their tires meet the LRR performance standards. For box vans subject to performance standards, manufacturers also obtain performance information for these technologies at this time, either from supplier data or their own testing. Manufacturers that choose to perform aerodynamic or tire testing themselves may also need to obtain approval of test methods and perform preliminary testing. Trailer manufacturers relying on data from a third-party aerodynamic device manufacturer would need to verify that these data are approved.

During this time, the manufacturers also decide the strategy they intend to use for compliance by identifying ''families'' for the trailers they produce. A family is a grouping of similar products that are all subject to the same standard and covered by a single certificate. All products in each trailer subcategory are generally certified as the same family. That is, long box dry vans, short box dry vans, long refrigerated vans, short refrigerated vans, non-box trailers, partial-aero vans (long and short box, dry and refrigerated vans), and non-aero box vans, are each certified as separate trailer families. Manufacturers may combine dissimilar trailers into a single vehicle family to reduce the compliance burden as described in 40 CFR 1037.230(d)(3) and 49 CFR 535.5(e). In general, manufacturers can combine trailers that have less stringent standards with more stringent standards as long as the combined set of trailers

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[366] As with the other Phase 2 vehicle programs, manufacturers submit their applications to EPA, which then shares them with NHTSA. Obtaining an approved certificate of conformity from EPA is the first step in complying with the NHTSA program.

[367] Trailers that meet the qualifications for exclusion do not require a certificate of conformity and manufacturers do not have to submit an application to EPA for these trailers.

meet the more stringent standards. Refrigerated and dry vans of the same length can be combined to meet the dry van standards. Short vans can combine with long vans, meeting the corresponding long van standard. Additionally, non-box trailers can be combined with the non-aero box vans if the manufacturer would like to meet the more stringent non-aero box van design standards with higher-performing tires.

When no averaging is available (*i.e.,* MY 2018 through MY 2026 for full-aero box vans, and all years for remaining trailers), all products within a family need to meet or exceed the standards for that trailer subcategory (except for any trailers included in the manufacturer's allowance for non-complying vehicles (See Section IV.E.(5)(a) below)). This is not to say that, for example, every long box dry van model needs to have identical technologies like skirts, tires, and tire inflation systems, but that every model in that family need to meet the standard for that family.

In MY 2027 and later, full-aero box van manufacturers will still generally have one family per subcategory. However, if a full-aero box van manufacturer subject to performance standards wishes to utilize the averaging provisions, it would need to divide the trailer models in each of the van subcategories/families into subfamilies.[368] Each subfamily can be a grouping of box vans that have similar performance levels, even if they use different technologies. We refer to the performance levels for each subfamily as ''Family Emission Limits'' (FELs). A long box dry van manufacturer could choose, for example, to create two subfamilies in its long box dry van family. Trailers in one of these subfamilies could be allowed to under-comply with the standard (*e.g.,* not apply a tire pressure system) as long as the performance of the other subfamily over-complies with the standard (*e.g.,* installs additional aerodynamic technologies), such that the average of all of the subfamilies' FELs met or exceeded the standard for that family on a production-weighted basis. Section IV.E.(5)(b) below further discusses how the averaging program would function for any such trailer subfamilies.

(c) Submitting a Certification Application and Request for a Certificate to EPA

Once the preliminary steps are completed, the manufacturer can prepare and submit applications to EPA for certificate of conformity for each of its trailer families. The contents of the application are specified in 40 CFR 1037.205, though not all items listed in the regulation are applicable to each trailer manufacturer.

For the early years of the program (*i.e.,* MY 2018 through MY 2020), the application must specify whether the trailer manufacturer is opting into the NHTSA voluntary program to ensure the information is transferred between the agencies. Throughout the program, the application must include a description of the emission and fuel consumption reduction technologies that a manufacturer intends to offer. These technologies could include aerodynamic features, LRR tire models, tire pressure systems, or components that qualify for weight reduction. Basic information about labeling, warranty, and recommended maintenance should also be included the application (see Section IV.E.(4) for more information on these additional compliance provisions).

The manufacturer also provides a summary of the plans to comply with the standard. This information includes a description of the trailer family and subfamilies (if applicable) covered by the certificate, the technologies that are used for compliance, and projected sales of its products. For trailers subject to performance-based standards (and not those subject to the design-based standards), in the earlier stages of the program when averaging is not available (or for manufacturers of full-aero vans that do not participate in averaging after MY 2026), additional provisions apply. These manufacturers will include information on the configuration with the worst performance level in terms of CO_2 and fuel consumption offered in the trailer family. Any of these manufacturers that choose to average within their full-aero van families after MY 2026 will include performance information for the projected highest production trailer configuration, as well as the lowest and the highest performing configurations within those families. For all covered trailers, once the certification application is accepted, a certificate is issued and manufacturers can begin selling their trailers.

(d) End-of-Year Obligations

After the end of each year, all manufacturers, including those with design-based standards, need to submit a report to the agencies presenting production-related data for that year (see 40 CFR 1037.250 and 49 CFR 535.8). In addition, the year's final compliance data (as calculated using the compliance equation) for box van manufacturers subject to performance-based standards will include both CO_2 emissions and fuel consumption information and actual production volumes in order to demonstrate that the trailers met the standards for that year.

In MY 2027 and later, full-aero box van manufacturers that opt to participate in the averaging program will submit a second report that describes their subfamily FELs and a final calculation of their production-weighted average CO_2 and fuel consumption. See 40 CFR 1037.730, 40 CFR 1037.745, and 49 CFR 535.7. All certifying manufacturers need to maintain records of all the data and information that is required to be supplied to EPA and NHTSA for eight years.

(2) Evaluating Trailer Performance for Compliance

The agencies believe that this final compliance program for trailer manufacturers is straightforward, technically robust, transparent, and minimizes administrative burdens on the industry. As described earlier in this section and in Chapter 4 of the RIA, GEM is a customized vehicle simulation model that EPA developed for the Phase 1 program to relate measured aerodynamic and tire performance values, as well as other parameters, to CO_2 and fuel consumption without performing full-vehicle testing. As with the Phase 1 and Phase 2 tractor and vocational vehicle programs, the trailer program uses GEM in evaluating emissions and fuel consumption in developing the trailer standards. However, unlike the tractor and vocational vehicle programs, trailer manufacturers will not use GEM directly to demonstrate compliance with the trailer standards. Instead, we have developed an equation based on GEM that calculates CO_2 and fuel consumption from performance inputs without running the model.

(a) Development of the GEM-Based Trailer Compliance Equation

For compliance with the performance-based standards in the trailer program (*i.e.* the standards for full- and partial-aero long and short box vans), the trailer characteristics that a manufacturer supplies to the equation are aerodynamic improvements (*i.e.,* the change in the aerodynamic drag area,

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[368] The program essentially requires that manufacturers equip 100 percent of their non-box and special purpose box trailers with tire pressure systems and tires meeting the specified rolling resistance levels. Partial-aero box vans meet a reduced performance standard. As a result, averaging provisions do not apply to these trailer subcategories.

delta C_dA, from the appropriate bin in m^2), tire rolling resistance (*i.e.,* coefficient of rolling resistance, C_{RR}, in kg/metric ton), the presence of a tire pressure system, and any weight reduction applied in pounds. The use of the equation quantifies the overall performance of the trailer in terms of CO_2 emissions on a grams per ton-mile basis, which can be converted to fuel consumption on a gallons per 1000 ton-mile basis.

Chapter 2.10.5 of the RIA provides a full a description of the development and evaluation of the equation for trailer compliance where the standards are performance-based. Equation IV–1 is a single linear regression curve that can be used for all box vans in these rules to calculate CO_2 emissions, e_{CO2}. Unique constant values, C_1 through C_4, are applied for each of the van types as shown in Table IV–24. Constant C_5 is equal to 0.988 for any trailer that installs an ATIS (accounting for the 1.2 percent reduction given for use of ATI), 0.990 for any trailer that installs a TPMS, or 1.0 for trailers without tire pressure systems. We found that this equation accurately reproduces the results of GEM for each of the box van subcategories, and the program requires these trailer manufacturers use Equation IV–1 to calculate CO_2 for compliance. Manufacturers insert their tire rolling resistance level (TRRL), wind-averaged change in drag area (ΔC_dA), weight reduction value (WR) (if applicable), and the appropriate C_5 value if a tire pressure system is installed into the equation and submit the result to EPA. The program provides for manufacturers to use a conversion of 10.180 grams of CO_2 per gallon of diesel to calculate the corresponding fuel consumption values for compliance with NHTSA's regulations. See 40 CFR 1037.515 and 49 CFR 535.6.

$$e_{CO2} = [C_1 + C_2 \cdot (TRRL) + C_3 \cdot (\Delta C_d A) + C_4 \cdot (WR)] \cdot C_5 \qquad \text{(IV-1)}$$

TABLE IV–24—CONSTANTS FOR GEM-BASED TRAILER COMPLIANCE EQUATION

Trailer subcategory	C_1	C_2	C_3	C_4	C_5 (tire pressure)		
					None	TPMS	ATIS
Long Dry Van	76.1	1.67	−5.82	−0.00103	1.000	0.990	0.988
Long Refrigerated Van	77.4	1.75	−5.78	−0.00103			
Short Dry Van	117.8	1.78	−9.48	−0.00258			
Short Refrigerated Van	121.1	1.88	−9.36	−0.00264			

These long and short van constants are based on GEM-simulated tractors pulling 53-foot and solo 28-foot trailers, respectively. As a result, aerodynamic testing to obtain a trailer's performance parameters for Equation IV–1 must be performed using consistent trailer sizes (*i.e.,* aerodynamic performance for all lengths of short vans would be tested as a solo 28-foot van, and performance for all lengths of long vans would be tested as a 53-foot van). More information about aerodynamic testing is provided in Section IV.E.(3)(b) below.

The constants for long vans apply for all dry or refrigerated vans longer than 50-feet and the constants for short vans apply for all dry or refrigerated vans 50-feet and shorter. The vans with work-performing devices that may be designated as partial-aero vans would use the same equation constants as their full-aero counterparts for compliance. The partial-aero designation simply allows a van to input different values (*i.e.,* lower delta C_dA) and meet a different standard. Note that compliance with the design-based standards (non-box trailers and non-aero vans) does not require use of the GEM-based equation. Manufacturers supply the TRRL values for their trailer tires and attest that they installed one of the tire pressure systems (TPMS or ATIS) to EPA for compliance.

(b) Use of the Compliance Equation for Box Van Compliance

Box van manufacturers subject to the performance-based standards meet the standards using the GEM-based compliance equation to combine the effects of technologies and quantify the overall performance of the vehicle to demonstrate compliance. Trailer manufacturers obtain delta C_dA and tire rolling resistance values from testing (either from their own testing or from testing performed by another entity as described in Section IV.E.(3)(b)) and attest that they installed a qualifying tire pressure system and/or adopted weight reduction strategies. Manufacturers adopting aerodynamic improvements will compare their measured delta C_dA value to the values shown in Table 2 of 40 CFR 1037.515 (and Table IV–5 previously) and use the appropriate aerodynamic bin value as the aerodynamic input into the equation. The TRRL can be directly applied from measurements. Weight reduction is obtained by summing applicable values in our list of light weight components (Table 3 of 40 CFR 1037.515) or from measurements using the off-cycle provisions. Manufacturers indicate use of TPMS or ATIS with a specified percent reduction in CO_2 and fuel consumption.

Qualifying components for weight reduction can be found in 40 CFR 1037.515(d). Manufacturers that substitute one or more of these components on their box vans sum the weight reductions assigned to each component and enter that total into the equation. As noted in Section IV.D.(1)(d), the equation accounts for weight reduction by assigning one-third of that reduced weight to increase the payload and the remaining weight reduction to reduce the overall weight of the assumed vehicle.

Manufacturers of box vans subject to the performance standards apply the compliance equation separately to each configuration to ensure that all of the trailer configurations they offer need to meet the standard for the given model year. The certification application submitted to EPA includes equation results from the worst performing trailer configuration for each subcategory and the manufacturer attests that no regulated trailer will be sold in a lower performing configuration. If the manufacturer offers a new technology package during the model year, the performance can be evaluated using the equation. If the performance of the new package is lower than the value submitted in the application, the manufacturer would submit a ''running change'' to EPA to reflect the change. Box van manufacturers will submit a single end-of-year report that will include their production volumes and confirmation that all of their trailers applied the technology packages outlined in their application.

Any full-aero box van manufacturers that wish to take advantage of the agencies' averaging provision in MY 2027 and later will make greater use of the compliance equation. Before submitting a certificate application, these manufacturers would decide which technologies to make available for their customers and use the equation to determine the range of performance of the packages they planned to offer. The manufacturers would supply these results from the equation in their certificate application and those manufacturers that wish to perform averaging would continue to calculate emissions (and fuel consumption) with the equation throughout the model year and keep records of the results for each trailer package produced. As described in Section IV.E.(1)(d) above, at the end of the year, these manufacturers would submit two reports. One report would include their production volumes for each configuration. The second report would summarize the families and subfamilies, and CO_2 emissions and fuel consumption results from the equation for all of the trailer configurations they build in that model year, including a production-weighted average to show compliance.

For non-box trailers and non-aero box vans, compliance is design-based, not performance-based, and the compliance equation is not needed. As described earlier, the standards for these trailers require the use of tires with rolling resistance levels at or below a threshold, and tire pressure systems (either TPMS or ATIS). Instead of aerodynamic testing data in their certification applications, manufacturers of these trailers submit their tire rolling resistance levels and a description of their tire pressure system(s) to EPA.

(3) Trailer Certification Test Protocols

The Clean Air Act specifies that compliance with emission standards for motor vehicles be demonstrated by the manufacturer using emission test data (see CAA section 206(a) and (b)). As discussed earlier, for the design-based standards (non-box trailers and non-aero vans), the trailer program considers the use of specified LRR tires and tire pressure systems an appropriate surrogate for emission testing, and there are no testing requirements associated with these standards beyond the testing required to show the tires qualify as LRR tires. We expect that tire testing will be performed by the tire manufacturers.

All full- and partial-aero vans covered by the program are subject to performance standards, and compliance is based on measured emission performance. For these trailers, the program uses the GEM-based compliance equation discussed in Section IV.E.(2)(a) above as the official ''test procedure'' for quantifying CO_2 and fuel consumption performance for trailer compliance and certification (as opposed to use of GEM, which serves this function in the tractor and vocational vehicle programs). Manufacturers input performance information from the applicable trailer technologies into the equation in order to calculate their impact on overall trailer performance. Manufacturers needing aerodynamic and tire rolling resistance performance data obtain it either through their own testing or through a device or tire manufacturer that performed the testing. The program specifies pre-determined values for tire pressure systems and many weight reduction components for manufacturers to apply.

The following subsections describe the approved performance tests for tire rolling resistance and aerodynamic drag in this trailer program. See 40 CFR part 1037, subpart F, for a full description of the performance tests, in particular section 40 CFR 1037.515.

(a) Trailer Tire Performance Testing

Under Phase 1, tractor and vocational chassis manufacturers are required to input the tire rolling resistance level (TRRL) into GEM, and the agencies adopted the provisions in ISO 28580:2009(E)[369] to determine the rolling resistance of tires. The tire rolling resistance level (TRRL) is a declared value that is based on a measured value. As described in 40 CFR 1037.520(c), this measured value, expressed as C_{RR}, is required to be the result of measurements of three different tires of a given design, giving a total of at least three data points. Manufacturers specify a C_{RR} value for GEM that is less than or equal to the average of these three results. Tire rolling resistance may be determined by either the vehicle or tire manufacturer. In the latter case, the tire manufacturer provides a signed statement confirming that it conducted testing in accordance with this part.

The Phase 1 tire testing provisions for rolling resistance apply to all of the regulated trailers in the Phase 2 program. In the Phase 2 program, full- and partial-aero box van manufacturers, subject to the trailer performance-based standards, apply their declared TRRL in the compliance equation. Non-box trailer and non-aero box vans, subject to the design-based standards, simply report the TRRL as part of their certification application. Based on the current practice for Phase 1, we expect the trailer manufacturers to obtain these data from tire manufacturers, but trailer manufacturers have the option to perform tire testing themselves.

The agencies requested comment on adopting a program for tire manufacturers similar to the provision described in Section IV.E.(3)(b)(v) for aerodynamic device manufacturers, through which tire manufacturers would seek preliminary approval of the performance of their trailer tires. 80 FR 40278. CARB supported this option and further requested that EPA create a public database of the tire rolling resistance data submitted to the agency in such preliminary approvals. RMA's comments opposed making tire data available to the public without first developing a rating system for medium and heavy truck tires. The agencies have chosen not to pursue provisions for pre-approved trailer tire rolling resistance data or a public database of this information in this rulemaking, recognizing the overall unresolved issues relating to standard HD truck and trailer testing within the tire industry (as discussed in the Tractor section of this Preamble, Section III.E(1)(e)). Instead, trailer tire manufacturers provide tire rolling resistance values directly to the trailer manufacturers and that information is shared with EPA and NHTSA for certification.

(b) Trailer Aerodynamic Performance Testing

As discussed earlier, manufacturers of trailers subject to performance standards (*i.e.,* most box vans), need to provide EPA with aerodynamic performance data at the time of certification. The purpose of our trailer aerodynamic test procedures is to establish an estimate of the aerodynamic drag experienced by a tractor-trailer vehicle in real-world operation. We based these procedures on the current tractor aerodynamic procedures, including coastdown, wind tunnel, and computational fluid dynamics (CFD) modeling. More specifically, the tests are conducted according to the same test procedures for tractors and trailers, but different provisions apply for the test articles and the data analysis. In the tractor program, the resulting C_dA value represents the absolute aerodynamic drag of a tested tractor assumed to be pulling a specified standard trailer. In the trailer program,

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[369] *See http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44770.*

the tests measure the difference in C_dA value between the tested trailer as pulled by a standard tractor and a reference trailer pulled by the same standard tractor. In other words, the trailer test procedure is intended to measure the aerodynamic improvements rather than the absolute aerodynamic performance. The agencies chose to base the standards on measurements of aerodynamic improvements in part to reflect the market reality that many trailer manufacturers rely on manufacturers of bolt-on aerodynamic devices for the improvements rather than redesigning their trailer or developing their own components.

To minimize the testing burden, the program specifies that all aerodynamic devices for long box vans (*i.e.,* those greater than 50-feet in length) be evaluated based on 53-foot box vans, and that devices for all trailers 50-feet and shorter be evaluated based on 28-foot box vans. In other words, a manufacturer can use test data from a single trailer to certify all trailers in the same subcategory. As noted previously in Section IV.D.(1) and demonstrated in Chapter 2.10.2.1.2.6 of the RIA, the performance of aerodynamic devices on these two trailer lengths is expected to provide a conservative estimate of the performance on the longer trailers within the same length category. We believe that this compliance approach effectively represents the performance of such devices on the majority of box vans, yet limits the number of such vans that a manufacturer needs to track and evaluate.

The program provides for manufacturers to have flexibility in the devices (or packages of devices) they install on box vans with lengths that differ from 53-feet or 28-feet. In such situations, a manufacturer could use devices that they believe would be more appropriate for the length of the trailer they are producing, consistent with good engineering judgement. For example, they could test skirts on a 28-foot trailer and use longer skirts on 40-foot trailers that they make. No additional testing would be required in order to validate the appropriateness of using the alternate devices on these trailers.

The agencies have structured the final regulations to make wind tunnel testing the primary method for measuring trailer aerodynamic performance. While coastdown testing measures performance of full-scale vehicles, which is generally the agencies' preference for performance testing, wind tunnel testing achieves similar results in terms of delta C_dA, with the added benefit of measuring wind-averaged values in the same test. In addition, wind tunnel testing is inexpensive relative to other aero test methods and does not require as much time to complete. Thus, it has generally been the preferred method for the trailer industry. Nevertheless, the program provides for manufacturers to use coastdown or CFD methods as described below and fully in 40 CFR 1037.526(b) and 1037.150(x).

The agencies considered making coastdown testing the primary test method for trailers, as it is for the tractor program. However, the delta C_dA approach for the trailer aerodynamic program would require multiple tests to evaluate most configurations. Coastdown testing is a full-scale test method that requires the vehicle, which includes the trailer and an appropriately aerodynamic tractor, be driven on a road or track that meets specified conditions. An important challenge with coastdown testing is that wind and weather restrictions can limit the days in which testing can be performed. Additionally, coastdown testing has higher natural variability due to environmental variability in an uncontrolled system. We have placed an additional restriction on the allowable difference in yaw angles for delta C_dA measurements to reduce this variability (see 40 CFR 1037.526(a)(2)). However, the combination of our test constraints (*e.g.,* restrictions on the wind, temperature, and road conditions), can make it challenging to measure a drag difference from two valid coastdown tests. These factors would make accurate coastdown testing for the trailer program even more time-consuming and expensive relative to the tractor program. Accordingly, we decided that wind tunnel testing is more appropriate for this newly regulated industry.

Coastdown testing has two significant advantages over wind tunnel testing. First, as a full-scale method, it can be directly applied to actual products. Second, full-scale methods may be the only way to reliably test small-scale devices that cannot be appropriately scaled or recreated in wind tunnel or CFD. Although these advantages justify allowing coastdown testing as an alternate method, they do not justify the additional costs that would occur if it were specified as the primary test method for trailers.

In making this determination, the agencies were cognizant of the limited financial ability of trailer manufacturers (and device manufacturers) to absorb testing costs. Unlike the tractor industry, most of the manufacturers in the trailer industry are small- to medium-sized companies. Even the largest trailer manufacturers are much smaller than the companies that manufacture tractors. Had we established coastdown as the primary method, trailer manufacturers would have needed to not only perform extensive coastdown testing to show equivalency with their preferred methods, but would have also needed to maintain the ability to perform coastdowns on a regular basis like tractor manufacturers are required to under Phase 1 and Phase 2, including owning or maintaining access to an appropriate test tractor or tractors. While this is a manageable burden for the large tractor manufacturers, it would have been a substantial burden for trailer manufacturers, especially the smaller ones. TTMA commented that any of the larger manufacturers in its membership that may do testing would prefer wind tunnel or CFD testing to ''contain costs.'' In conjunction with the NODA, EPA laid out principles related to aerodynamic testing that we intended to follow when applying our compliance oversight to trailers.[370] In particular, we indicated that we intended to rely more on our own confirmatory testing, recognizing that both trailer manufacturers and device manufacturers have less financial ability to perform Selective Enforcement Audit (SEA) testing than do tractor manufacturers (see Section IV.E.(4)(f) for more information on SEAs). Under the final regulations, the agencies can perform wind tunnel testing, but would also retain the right to perform coastdown testing, provided we adjusted any coastdown results to account for yaw differences. If we conducted confirmatory testing using coastdowns, we would also need to perform enough runs to minimize variability between the test conditions. Should we measure worse aerodynamic performance (after fully adjusting for methodological differences and accounting for test-to-test variability), we would require the manufacturer to use our test results as the official test results. It is important to emphasize that, because confirmatory testing generally occurs before we have issued a certificate of conformity and before the manufacturer has begun production, there are no penalties or other compliance actions that would result from EPA confirmatory testing. Thus, we do not expect manufacturers using wind tunnels to have any need to

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[370] ''Additional Discussion of Selective Enforcement Audit and Confirmatory Testing for Aerodynamic Parameters for Combination Tractors and for Trailers,'' February 19, 2015. Docket EPA–HQ–OAR–2014–0827–1625.

separately verify their results using coastdown procedures.

Details of the test procedures can be found in 40 CFR 1037.526 and a discussion of EPA's aerodynamic testing program as it relates to the trailer program is provided in the RIA Chapter 3.2. The following subsections outline the testing requirements for the long term trailer program, as well as simpler testing provisions that apply in the nearer term.

(i) A to B Testing for Trailer Aerodynamic Performance

The agencies expect a majority of the aerodynamic improvements for trailers will be accomplished by adding bolt-on technologies. As just explained above, a key difference between the tractor program and the trailer program is that while the tractor test procedures provide a direct measurement of an absolute C_dA value for each tractor model, aerodynamic improvements for trailers are evaluated by measuring a change in C_dA (delta C_dA) relative to a baseline without aerodynamic improvements. Specifically, trailer tests are performed as ''A to B'' tests, comparing the aerodynamic performance of a tractor-trailer without a trailer aerodynamic device (or package of devices) to one with the device (or package) installed. As noted below, this approach can be applied if changes are made to the aerodynamic design of a trailer as well. See RIA Chapter 2.10.2.1.2 for more justification for this A to B approach.

In essence, an A to B test is a pair of tests: one test of a baseline tractor-trailer in a ''no-control'' configuration with zero trailer aerodynamic improvements (A), and one test that includes the aerodynamic improvements to be tested (B). However, because an A test relates to a B test only with respect to the test method and the basic tractor-trailer vehicle, one A test could be used for many different B test configurations. This type of testing results in a delta C_dA value instead of an absolute C_dA value. For the trailer program, the vehicle configuration in the A test includes a standard tractor that meets specified characteristics (40 CFR 1037.501(h)), and a baseline trailer with no aerodynamic improvements. The entity conducting the testing (*e.g.,* the trailer manufacturer, a contractor, or an aerodynamic device manufacturer, as discussed below) performs the test for this configuration according to the procedures in 40 CFR 1037.526 and repeats the test for the B configuration, which includes the trailer aerodynamic package/device(s) being tested. The delta C_dA value for that trailer with that aerodynamic improvement is the difference between the C_dA values obtained in the A and B tests.

The agencies note that it was relatively straightforward in Phase 1 to establish a standard trailer with enough specificity to ensure consistent testing of tractors, since there are relatively small differences in aerodynamic performance of base-model dry box vans. However, as discussed in Chapter 2.10 of the RIA, small differences in tractor design can have a significant impact on overall tractor-trailer aerodynamic performance. An advantage of an A to B test approach for trailers is that many of the effects due to differences in tractor design are minimized, which allows different models of tractors to be used as standard tractors in testing without compromising the evaluation of the trailer aerodynamic technology. Thus, the relative approach does not require the agencies to precisely specify a standard tractor, nor does it require trailer manufacturers to purchase, modify or retain a specific tractor model in order to evaluate their trailers.

In the event that a trailer manufacturer makes major changes to the aerodynamic design of its trailer in lieu of installing add-on devices, it could use the same baseline trailer for the A configuration as could be used for bolt-on features. In both cases, the baseline trailer would be a manufacturer's standard box van. Thus, the manufacturer of a redesigned trailer would get full credit for any aerodynamic improvements it made.

As discussed in Chapter 2.10 of the RIA, measured drag coefficients and drag areas can vary slightly depending on the test method used. In general, absolute wind-averaged C_dA values measured using wind tunnels and CFD tend to be higher than values measured using the near-zero yaw coastdown method. The Phase 1 and Phase 2 tractor program use coastdown testing as the reference test method, and the agencies require tractor manufacturers to perform at least one test using that method to establish a correction factor to apply to each of the alternative test methods. The proposed trailer regulations referred to coastdown as our reference method, although we noted that the size of the bins and the use of delta C_dA (as opposed to absolute values) minimized the significance of variability between test methods. 80 FR 40280. CARB recommended that we require a reference method in our aerodynamic testing, but provided no data to support their recommendation.

As noted already, the agencies have established the wind tunnel method as the primary method. Like the tractor program, the allowance to use alternate aerodynamic test procedures provides for adjustments to make the measurements equivalent to the primary method. This is done to ensure that the manufacturer is neither advantaged nor disadvantaged by using the alternate method, relative to results they would have obtained using the primary method. However, because determining equivalency between methods can be burdensome, the agencies are adopting in 40 CFR 1037.150(x) an interim allowance to use certain specific approximations based on data currently available to us. Manufacturers would not be required to justify using these approximations or to seek prior approval for them. Nevertheless, in the unlikely event that we determine that these approximations overstate actual aerodynamic performance for a particular trailer or device, we would not allow the manufacturer to use the approximated values for certification and they would be required to use other more reasonable adjustments.

Our test results shown in Chapter 2.10 of the RIA, show that wind tunnel and CFD produce wind-averaged delta C_dA values within the same bin for the devices tested. Thus, this interim provision allows CFD results to be used without adjustment. Coastdown delta C_dA results, which are not wind-averaged, may be in the same bin, but we note that the tails showed more yaw dependence and coastdown tests under-predicted the performance of tails relative to wind-averaged methods. We anticipate some additional current and future devices may be sensitive to yaw angle, and our interim provision accounts for this. Manufacturers that choose to use coastdown testing can use their results without adjustment, or, if they suspect their device is affected by yaw angle, they can use other testing or analytical methods to demonstrate a means of adjusting their near-zero yaw results to a wind-averaged equivalent 4.5-degree value. The bin values in Section IV.E.(3)(b)(iv), which were updated based on additional aerodynamic test data collected between the NPRM and final rules, are based on our wind tunnel testing results, though our results suggest that most CFD and coastdown results will fit into the same bins. See RIA Chapter 2.10.2.1.3.

(ii) Standard Tractor for Aerodynamic Testing in the Trailer Program

The agencies are adopting a set of characteristics that qualify a tractor to be use in trailer aerodynamic compliance testing. EPA's trailer testing program investigated the impact of tractor aerodynamics on the performance of trailer aerodynamic technologies, as mentioned in Chapter 2.10.2.1.2.2 of the RIA. We found the A to B test strategy reduces the degree of precision with which the standard tractor needs to be specified. Instead of identifying a specific make and model of a tractor to be used over the entire duration of the program, the agencies identified an appropriate aerodynamic performance threshold that maintains a relatively consistent level of performance between trailers. Tractors used in trailer aerodynamic tests must meet Phase 2 aerodynamic Bin III or better tractor requirements. We believe the majority of tractors in the U.S. trucking fleet will be Bin III or better in the timeframe of this rulemaking, and trailer manufacturers have the option to choose higher-performing tractors in later years as tractor technology improves. See Section III.D.2.c.i. The standard tractor for long-box vans is a Class 8 high-roof sleeper cab. The standard tractor for short box vans is a Class 7 or 8 high roof day cab with a single drive axle (*i.e.,* 4x2 axle configuration). Trailer or device manufacturers are free to choose any standard tractor that meets these criteria in their aerodynamic performance testing. See 40 CFR 1037.501.

The compliance equation used to determine compliance with the trailer standards is based on GEM, so our discussion of the feasibility of our standards (Section IV.D.(2)) includes a description of the tractor-trailer vehicle used in GEM. The agencies proposed to require use of a 6x4 Class 8 sleeper cab for long box van aerodynamic testing, and a 6x4 Class 8 day cab for short box van testing. 80 FR 40279. We believe Class 8 tractors are more widely available, which will make it easier for the trailer industry to obtain a qualified tractor if they choose to perform trailer testing. In order to align with the test procedures, we also proposed to consistently model a Class 8 tractor across all trailer subcategories in GEM. CARB supported the use of Class 8 tractors in their comments. However, EPA encountered difficulty in meeting the test procedure-specified tractor-trailer gap width when using a dual drive axle day cab in one of our short box van wind tunnel tests due to the location of the landing gear relative to the kingpin. As a result, we are changing the standard tractor specifications for aerodynamic testing to require the use of a 4x2 tractor for short trailers. While we expect most manufacturers will use tractor-trailer models in wind tunnel or CFD testing, we recognize that there are fewer 4x2 tractors available for full-scale testing, and we are adopting provisions that testers can use either a Class 8 or Class 7 day cab tractor to address availability concerns. We believe the external aerodynamic characteristics of Class 7 and Class 8 day cabs are very similar and the engine performance differences between the two tractor classes would not impact the aerodynamic performance in terms of delta C_dA. Note that a Class 7 4x2 day cab tractor is used for all short van default tractor-trailer vehicles within GEM and represented in the GEM-based equation (see Table IV–8).

Daimler requested that we choose a *single* tractor for all trailer testing to ensure consistency over time. As stated above, the agencies agree that the tractor does have the potential to influence the aerodynamic performance of trailers. As discussed above, however, we believe that influence is reduced with use of a delta C_dA. Additionally, we believe it would be a significant burden on the trailer industry to require manufacturers and suppliers to acquire a specific tractor make and model over the timeframe of the rules. Thus, the final trailer program does not require the use of a specific tractor make for the Phase 2 trailer program.

(iii) Accounting for Wind Impacts When Measuring Aerodynamic Performance

The agencies proposed to determine the delta C_dA for trailer aerodynamic performance using the zero-yaw (or head-on wind) values from any of the approved test procedures. However, based on comments received, we are revising the final program to be based on wind-averaged results, similar to the tractor program. The agencies recognize the value of wind-averaging to better reflect the performance expected in real-world operation, but at the time of proposal, we believed the use of a zero-yaw delta C_dA would reduce the number of tests compared to generating a wind-averaged value from a sweep of yaw angles. Additionally, it is relatively straightforward to generate wind-averaged C_dA values from wind tunnel and CFD, but there is a significant increase in test burden to obtain wind-averaged results from coastdown tests. Our intent was to ensure parity between test procedures, such that manufacturers would have the several options to test aerodynamic performance.

The agencies received comment on this issue, in the context of the proposed tractor standards, suggesting that the C_dA measured at a yaw angle of 4.5 degrees is very similar to the wind-averaged C_dA calculated at 7 degrees/65 MPH. The agencies evaluated our own test data using an average of +4.5 degrees and −4.5 degrees to minimize the effect of potential facility asymmetry, and found that the results were within two percent of the corresponding wind-averaged values (See Section III.E.2.a and Chapter 3.2 of the RIA). Adoption of this surrogate angle approach reduces the cost of generating a wind-averaged value from wind tunnel and CFD procedures.[371] Consequently, the tractor program uses an average C_dA measured at +4.5 and −4.5 degree yaw angles as a surrogate wind-averaged value (see RIA Chapter 3.2 for more information). However, it does not address the increased burden for conducting coastdown tests.

The agencies received comment from TTMA that ‘‘repetitive’’ coastdown testing would rarely be used by its trailer manufacturer members. Instead, manufacturers that do choose to perform their own testing will likely rely on CFD and wind tunnel tests. Because we are establishing the wind tunnel method as the primary method, and because we expect it to also be the most commonly used method, we no longer have test burden concerns about requiring wind-averaging. Therefore, the agencies believe we can adopt aerodynamic test procedures for trailers that require wind-averaged delta C_dA values, as represented by an average of results from +4.5 and −4.5 degree yaw angles, for compliance. We believe that coastdown testing will be chosen by a small number of manufacturers and the burden of performing this optional test on the overall industry will be relatively small. EPA may rely on coastdown testing in its own confirmatory testing, and the agency will accept the additional burden of correcting to a wind-averaged value.

(iv) Bins for Aerodynamic Performance

As mentioned in Section IV.D., the trailer program uses aerodynamic bins to account for testing variability and to provide consistency in the performance values used for compliance. We developed these bins in terms of delta C_dA ranges, and we designed them to be broad enough to cover the range of uncertainty seen in our aerodynamic testing program in terms of test-to-test variability as well as variability due to

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[371] CFD test contracts are often priced for individual yaw angles. Wind tunnel test contracts are often priced for an entire yaw sweep. Limiting our measurement requirement to one or two yaw angles is expected to reduce the cost of generating a wind-averaged value from CFD, but will only reduce the cost from wind tunnel tests if the manufacturer choses to do individual yaw angles in lieu of the customary sweep.

differences in test method, tractor models, trailer models and device models. The bins are somewhat different than in the proposal, as discussed in Section IV.D.(1)(a)(ii) above RIA Chapter 2.10.2.1.3.

TABLE IV–25—AERODYNAMIC BINS USED TO DETERMINE INPUTS FOR TRAILER CERTIFICATION

Delta C_dA measured in testing	Bin	Delta C_dA input for compliance
<0.1	Bin I	0.0
0.10–0.39	Bin II	0.1
0.40–0.69	Bin III	0.4
0.70–0.99	Bin IV	0.7
1.00–1.39	Bin V	1.0
1.40–1.79	Bin VI	1.4
≥1.8	Bin VII	1.8

A manufacturer that wishes to perform testing first identifies a standard tractor according to 40 CFR 1037.501(h) and a representative baseline trailer with no aerodynamic features (or models of these vehicles), then performs the A to B tests with and without aerodynamic improvements to obtain a delta C_dA value. The manufacturer uses Table IV–25 to determine the appropriate bin based on their measured delta C_dA. Each bin has a corresponding delta C_dA threshold value that is the value manufacturers insert into the compliance equation.

(v) Aerodynamic Device Testing Compliance Path

The agencies recognize that much of the trailer manufacturing industry may have little experience with aerodynamic performance testing. For this reason, the program includes a compliance option that we believe minimizes the testing burden for trailer manufacturers, and at the same time meets the requirements of the Clean Air Act and of EISA by providing reasonable assurance that the anticipated CO_2 and fuel consumption benefits of the program will be realized in real-world operation. This approach provides an opportunity for trailer manufacturers to choose technologies with pre-approved test data for installation on their new trailers without performing their own aerodynamic testing. We note that this testing option is consistent with recommendations of the Small Business Advocacy Review (SBAR) Panel, which is summarized in Section XIV.D and Chapter 12 of the RIA.

The trailer program provides for trailer aerodynamic device manufacturers to seek preliminary approval of the performance of their devices (or combinations of devices) based on the same performance tests described previously. Trailer manufacturers could then choose to use these devices and apply the approved performance levels in the certification application for their trailer families. A device manufacturer would need to perform the required A to B testing using a tractor-trailer that meets the requirements specified in 40 CFR 1037.211 and 1037.526 and submit the performance results, in terms of delta C_dA, directly to EPA.[372] EPA would require much of the same information from the device manufacturers as it would normally require during certification, including the technology name, a description of its proper installation procedure, and its corresponding delta C_dA derived from the approved test procedures. See 40 CFR 1037.211.

Once a device manufacturer has obtained this preliminary approval, it could supply the same information to any trailer manufacturers that wish to install its devices. When the trailer manufacturer certifies, the agencies would merely verify that the values in the trailer manufacturer's certification application are those already approved for the device manufacturer. To ease the transition for MYs 2018 through 2020, we proposed and are adopting a flexibility to allow pre-approval of certain data accepted by the EPA SmartWay aerodynamic verification program. Section IV.E.(5)(c) below describes how a device manufacturer can use certain test data generated for SmartWay verification as a part of its pre-approval in the early years of the program.

The program also allows trailer manufacturers to use multiple devices with individually pre-approved test data on a single trailer configuration, provided each device does not impair the effectiveness of the other(s), consistent with good engineering judgment.[373] 40 CFR 1037.211 outlines a process for combining the effects of multiple devices to determine an appropriate delta C_dA value for compliance. More specifically, manufacturers would fully count the technology with largest delta C_dA value, discount the second by 10 percent, and discount each of the remaining additional technologies by 20 percent. This discounting acknowledges the complex interactions that can occur among individual aerodynamic devices and provides a conservative value for the impact of the combined devices (see the analysis of device combinations in RIA Chapter 2.10). For example, a manufacturer applying three separately tested devices with delta C_dA values of 0.40, 0.30, and 0.10 would calculate the combined delta C_dA as:

$$\text{Delta } C_dA = 0.40 + 0.90*0.30 + 0.80*0.10 = 0.75 \text{ m}^2$$

The agencies believe that discounting the delta C_dA values of individually-tested devices used as a combination provides a modest incentive for trailer or device manufacturers to test and get EPA pre-approval of the combination as an aerodynamic system for compliance. To avoid this discounting, device manufacturers can test a trailer incorporating a combination of devices and receive EPA pre-approval for data from that combination. Trailer manufacturers could then use the test results from that specific combination for certification.

Note that the aerodynamic bins of Table IV–25 do not apply to aerodynamic data that device manufacturers submit to EPA for pre-approval. The pre-approved data will have greater precision than the bin-averaged values shown in Table IV–25. Therefore, trailer manufacturers calculating a delta C_dA value based on combinations of pre-approved data use the exact numbers submitted by the device manufacturers to calculate the discounted delta C_dA, and thus select an appropriate bin value for compliance based on that result. The process to obtain approval is outlined in 40 CFR 1037.211.

The agencies note that many of the largest van manufacturers are already performing aerodynamic test procedures to some extent, and the agencies expect other van manufacturers will increasingly be capable of and interested in performing these tests as the program progresses. The device testing approach is intended to allow trailer manufacturers to focus on and become familiar with the certification process in the early years of the program and, if they wish, begin to perform testing in the later years, when it may be more appropriate for their individual companies. This approach does not preclude trailer manufacturers from performing their own testing at any time, even if the technologies they wish to install are already pre-approved. For

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[372] Note that in the event a device manufacturer submits false or inaccurate data to EPA, it could incur liability for causing a regulated entity to commit a prohibited act. See 40 CFR 1068.101(c). This same potential liability exists with respect to information provided by a device manufacturer directly to a trailer manufacturer.

[373] A trailer manufacturer needs to use good engineering judgement (as defined in 40 CFR 1068.5) in combining devices for compliance in order to avoid combinations that are not intended to work together (*e.g.,* both a side skirt and an under-body device).

example, a manufacturer that believed a specific trailer actually performed in a more synergistic manner with a given device than the device's pre-approved delta C_dA value suggested could perform its own testing and submit the results to EPA for certification.

STEMCO, an aerodynamic device manufacturer, commented in support of the proposed pre-approval option, but also supported the agencies publishing information about the testing performed by device manufacturers for their devices to be pre-approved. The agencies are not committing to publish the pre-approved aerodynamic data at this time. We do note that once data are submitted to EPA and the device is introduced into commerce, the data are available to the public at their request and the information gathered may be published by outside stakeholders.

(4) Additional Certification and Compliance Provisions

(a) Trailer Useful Life

Section 202(a)(1) of the CAA specifies that EPA is to propose emission standards that are applicable for the ''useful life'' of the vehicle. NHTSA is adopting EPA's proposed useful life requirements for trailers, to ensure that manufacturers consider in their design process the need for fuel efficiency standards to apply for the same duration as the EPA standards. Based on our own research and discussions with trailer manufacturers, EPA and NHTSA are adopting a regulatory useful life value for trailers of 10 years, as proposed. This useful life value represents the average duration of the initial use of trailers, before they are moved into less rigorous duty (*e.g.,* limited use or storage). We note that the useful life value is 10 years or a mileage threshold for other heavy-duty vehicles. However, unlike for the other vehicles, the program does not include a parallel mileage value for trailers. This would require odometers on trailers, and we do not believe that mandating odometers would be appropriate for this purpose.

With this useful life provision, trailer manufacturers are responsible for designing and building their trailers so that they will be able to meet the CO_2 emissions and fuel consumption standards for 10 years after the trailer is produced, provided that they are properly maintained. For technologies at issue here, we believe that this requirement is essentially the same as customers' existing durability expectations. The useful life requirements do not include liability for damage to or removal of devices by users. Instead, trailer manufacturers must ensure at the time of sale that devices are properly installed and able to maintain functionality throughout the useful life. We believe that manufacturers will be able to demonstrate at certification that their trailers, including all bolt-on technologies used as emissions controls, will comply with the CO_2 and fuel consumption standards for the useful life of the trailers without separate durability testing. The aerodynamic technologies that we expect manufacturers to use to comply with the trailer standards, including side skirts and boat tails, are designed to continue to provide their full potential benefit indefinitely as long as no serious damage occurs.

Regarding a useful life value for trailer tires, we recognize that the original lower rolling resistance tires will wear over time and will be replaced several times during the useful life of a trailer, either with new or retreaded tires. As with the Phase 1 tractor program, to help ensure that trailer owners have sufficient knowledge of which replacement tires to purchase in order to retain the as-certified emission and fuel consumption performance of their trailer for its useful life, the trailer program requires that trailer manufacturers supply adequate information in the owners manual to allow the trailer owner to purchase replacement tires meeting or exceeding the rolling resistance performance of the original equipment tires. (Note that the ''owners manual'' need not be a physical document, but could be made available on line). We believe that the favorable fuel consumption benefit of continued use of LRR tires generally results in proper replacements throughout the 10-year useful life. Finally, the program requires that tire pressure systems remain effective for at least the 10-year useful life, although some servicing may be necessary by the customer. See also the related discussions below in Section IV.E.(4)(c) (Emission-Related Warranty) and Section IV.E.(4)(d) (Maintenance).

(b) Emission Control Labels

Historically, EPA-certified vehicles are required to have a permanent emission control label affixed to the vehicle. The label facilitates identification of the vehicle as a certified vehicle. For the trailer program, EPA requires that the labels include the same basic information as we require for tractor labels in Phase 1. For trailers, this information includes the manufacturer, a trailer identifier such as the Vehicle Identification Number, the trailer family and regulatory subcategory, the date of manufacture, and compliance statements. Although the Phase 2 label for tractors does not include emission control system identifiers (as previously required for tractors in the Phase 1 program in 40 CFR 1037.135(c)(6)), the trailer program requires that these identifiers be included in the trailer labels. See 40 CFR 1037.135 for a list of general requirements for emissions labels, which includes a reference to Appendix III for appropriate abbreviations for trailer technologies.

(c) Emission-Related Warranty

Section 207 (a) of the CAA requires manufacturers to warrant their products to be free from defects that could otherwise cause non-compliance with emission standards. For purposes of the trailer program, EPA requires trailer manufacturers to warrant all components that form the basis of the certification to the CO_2 emission standards. The emission-related warranty covers all aerodynamic devices, lower rolling resistance tires, tire pressure systems, and other components that may be included in the certification application. Note that the emission-related warranty is completely separate from any other warranties a manufacturer might offer.

The trailer manufacturer needs to warrant that these emission-related components and systems are designed to remain functional for the warranty period. We note that this emission-related warranty, and the trailer manufacturer's financial responsibility for repairs, does not apply to components that are damaged in collisions or through abuse; nor does it cover components that experience wear with normal use. This warranty is meant to apply to defects in the product or improper installation by the manufacturer. Based on the historical practice of requiring emissions warranties to apply for half of the useful life, we are adopting a warranty period for trailers of five years for everything except tires. For trailer tires, we apply a warranty period of one year.

Utility and Great Dane noted in their comments that the warranty of current ATIS that they are aware of is limited to three years. However, we view this as a business decision by the ATIS manufacturers, rather than as a reflection of the actual durability of the systems. With proper maintenance, we are aware of no reason that these systems would be unable to meet the durability requirements of the trailer program or to be designed to last the full useful life of the trailer if properly maintained. See the Maintenance discussion at IV.E.(4)(d) below. We believe a five year emission-related warranty is justified, but we note that trailer manufacturers can specify that their warranty depends on the proper maintenance of components. Manufacturers can offer a more generous warranty if they choose; however, the emission-related warranty may not be shorter than any other warranty they offer without charge for the trailer. NHTSA is not adopting any warranty requirements relating to its trailer fuel consumption program.

At the time of certification, manufacturers need to supply a copy of the warranty statement that they supply to the end customer. This document outlines what is covered under the GHG emissions related warranty as well as the duration of coverage. Customers also need to have clear access to the terms of the warranty, the repair network, and the process for obtaining warranty service.

(d) Maintenance

In general, EPA requires that vehicle manufacturers specify schedules for any maintenance needed to keep their product in compliance with emission standards throughout the useful life of the vehicle (CAA section 207(a)). For trailers, such maintenance could include adjustments to fairings or service to tire pressure systems. EPA believes that any such maintenance is likely to be performed by operators to maintain the fuel savings of the components. If manufacturers believe that the durability of their trailer's performance is contingent on proper maintenance of these systems, they must include a corresponding maintenance schedule in their certification applications.

Since lower rolling resistance tires are key emission control components under this program, and they will likely require replacement at multiple points within the life of a vehicle, it is important to clarify how tires fit into the emission-related maintenance requirements. Although the agencies encourage the exclusive use of LRR tires throughout the life of trailers vehicles, we do not hold trailer manufacturers responsible for the actions of end users. We do not see this as problematic because, as noted above, we believe that trailer end users have a genuine financial motivation for ensuring their vehicles are as fuel efficient as possible, which includes purchasing LRR replacement tires and that they will continue to use them once they are accustomed to their use. Therefore, as mentioned in Section IV.E.(4) above, to help ensure that trailer owners have sufficient knowledge of which replacement tires to purchase in order to retain the as-certified emission and fuel consumption performance of their trailer, the program requires that trailer manufacturers supply adequate information in the owners manual to allow the trailer owner to purchase tires meeting or exceeding the rolling resistance performance of the original equipment tires. (As discussed above, note that the ''owners manual'' need not be a physical document, but could be made available on line). Manufacturers submit these instructions to EPA as part of the application for certification.

(e) Post-Useful Life Modifications

The Clean Air Act generally prohibits any person from removing or rendering inoperative any emission control device installed for compliance, such as those needed to comply with the requirements of 40 CFR part 1037. However, in 40 CFR 1037.655 EPA clarifies that certain vehicle modifications are allowed after a vehicle reaches the end of its regulatory useful life. This section applies to trailers, since it applies to all vehicles subject to 40 CFR part 1037.

The provisions of 40 CFR 1037.655 clarify that owners may modify a vehicle for the purpose of reducing emissions, provided they have a reasonable technical basis for knowing that such modification will not increase emissions of any other pollutant, but emphasizes that EPA presumes such modifications to be more appropriate for second owners. In the case of trailers, an owner would need to have information that would lead an engineer or other person familiar with trailer design and function to reasonably believe that the modifications will not increase emissions of any regulated pollutant. In the absence of such information, modifications during or after the trailer's useful life would constitute tampering with an emission control system. Thus, this provision does not provide a blanket allowance for modifications after the useful life.

This section does not specifically apply with respect to modifications that occur within the useful life period, other than to note that many such modifications to the vehicle during the useful life are presumed to violate CAA section 203(a)(3)(A). EPA notes, however, that this is merely a presumption, and would not prohibit modifications during the useful life where the owner clearly has a reasonable technical basis for knowing the modifications will not cause the vehicle to exceed any applicable standard.

(f) Confirmatory Testing and Selective Enforcement Audits (SEA) for GEM Inputs

In Phase 2, vehicle performance for box vans (except non-aero box vans) is measured using a GEM-based equation, which accepts input parameters related to aerodynamics, tire rolling resistance, and trailer weight. Trailer manufacturers are responsible for obtaining performance measures for these parameters through valid testing according to the specified test procedures. The Clean Air Act authorizes EPA to perform its own testing to confirm the manufacturer's data. This testing, which is called confirmatory testing, is conducted prior to issuing a certificate. The Act also authorizes EPA to require manufacturers to conduct Selective Enforcement Audits (SEA), which would involve testing performed on production vehicles before they enter into commerce.

The agencies are finalizing a list of lightweight trailer components that can be installed by trailer manufacturers and used in certification. Additionally, we are assigning a set percent reduction value to qualifying tire pressure systems (*i.e.,* ATIS and TPMS) that manufacturers can apply if they install these systems. Thus, because these are agency-default values rather than the manufacturers' measured or declared values, we will not hold trailer manufacturers responsible for the accuracy of these values. Additionally, we expect most trailer manufacturers will obtain LRR tire information directly from the tire manufacturers and many trailer manufacturers will install aerodynamic devices with data that was pre-approved by EPA. Information provided by a third party (such as a tire or device manufacturer) to a regulated entity for compliance is treated as though it was submitted directly to EPA. EPA has the authority to verify such data and hold the third party responsible for any falsified data, since submission of such data could incur liability for causing a regulated entity to commit a prohibited act. See 40 CFR 1068.101(c).

Of all of the performance measures for trailers, we believe aerodynamic testing has the greatest potential for variability and these results are likely to receive the most scrutiny. In the NPRM, we proposed to generally apply the same SEA and confirmatory testing structures to tractors and trailer with respect to aerodynamics. However, we also proposed to retain the authority to require *component* manufacturers to perform SEAs where certification relies on their test data. See, *e.g.* section 1037.301(d)(4) of the proposed regulations.

We are revising the SEA and confirmatory testing structures for trailers based on further consideration and comments received from the trailer manufacturing industry (TTMA). In general, the final regulations reflect the following principles:

- Due to the smaller number of possible trailer configurations (compared to tractor configurations), it would be more possible for EPA to rely on confirmatory testing for trailer aerodynamics.
- Since test-to-test variability for individual coastdown runs can be high, confirmatory test determinations should be based on average values from multiple runs.
- Trailer manufacturers and trailer component manufacturers have less financial ability to perform SEAs than do tractor manufacturers. Nevertheless, EPA should retain the authority to require trailer and trailer component manufacturers to perform SEAs, especially where EPA has reason to believe the trailers are non-compliant.
- Given the limited ability to eliminate uncertainty, compliance determinations should consider the statistical confidence that a true value lies outside a bin.

EPA will generally try to duplicate a manufacturer's test setup in any confirmatory testing (which would include the standard tractor) unless we have reason to believe an inappropriate setup was used. While our test results presented in Chapter 2.10 of the RIA show that the trailer program's delta C_dA approach reduces the tractor's impact on trailer results, to the extent practical, EPA will use the same standard tractors that manufacturers used in their testing.

We believe that, although the final compliance structure for trailers is simpler than for tractors, it will still provide a strong incentive for manufacturers to act in good faith. In particular, the regulations emphasize the final value of EPA's auditing records and inspecting production components, rather than requiring manufacturers to perform expensive testing. Thus, EPA expects to require manufacturers to perform SEA testing only when we have reasonable evidence leading us to believe a manufacturer have not provided accurate test data. See Section III.E.(2)(a)(ix) for a discussion of how EPA would conduct an aerodynamic SEA.

(g) Importation of New Trailers

Manufacturers have raised concerns about enforcement of emission standards for new trailers that are imported into the United States. This poses unique challenges at the point of entry, because new trailers may be carrying cargo and are therefore nearly indistinguishable from trailers that have already been imported or otherwise placed into service. We are not adopting any new or different compliance provisions in this rulemaking to address this; however, we intend to work cooperatively with Customs and Border Protection and other agencies to ensure that first-time state registration of new trailers includes verification that the trailer manufacturers have certified them to meet U.S. emission and fuel consumption standards. We expect this to be similar to the current system for ensuring that new, imported trailers meet NHTSA safety standards.

A related concern applies for foreign-based trailers traveling in the United States for importing or exporting cargo. Such trailers are not subject to emission and fuel consumption standards unless they are considered imported into the United States. U.S. cabotage law prohibits foreign truck drivers from carrying product from one point to another within the United States. Effective enforcement of this cabotage law will help prevent manufacturers of noncompliant foreign-produced trailers from gaining a competitive advantage over manufacturers of compliant domestic trailers.

(5) Flexibilities

The trailer program that the agencies are adopting incorporates a number of provisions that have the effect of providing flexibility and easing the compliance burden on trailer manufacturers while maintaining the expected CO_2 and fuel consumption benefits of the program. Among these is the basic approach we used in setting the trailer standards, including the staged phase-in of the standards, which gradually increase the CO_2 and fuel consumption reductions that manufacturers need to achieve over time as they also increase their experience with the program. As described in Section IV.E.(3)(b)(v), another of these is the process for device manufacturers to submit test data directly to EPA for review by the agencies in advance of formal certification, allowing a trailer manufacturer to reduce the amount of testing needed to demonstrate compliance or avoid it altogether.

In addition to these provisions inherent to the trailer program, this section describes additional options the agencies are adopting that we believe will be valuable to many trailer manufacturers.

(a) Limited Allowance of Non-Complying Trailers

As described in Section IV.B. above the agencies are not finalizing the proposed provisions that would have allowed manufacturers to comply with the trailer standards using averaging before MY 2027. As a result, in the absence of mitigating provisions, manufacturers would need to comply with the applicable standards for all of their trailers. The agencies received comment, primarily from trailer manufacturers, that, without the flexibility of averaging, trailer manufacturers should be allowed to ''carve-out'' a set percentage of their sales that would not be required to meet the standards. Stoughton Trailers suggested a 20 percent carve-out.

The agencies considered this concept and this final program provides each manufacturer with a limited ''allowance'' of trailers that do not need to meet the standards. In determining an appropriate value for this allowance, the agencies sought to balance the need for some degree of flexibility in the absence of averaging while minimizing changes in the competitive relationships among larger and smaller trailer manufacturers. An allowance of 20 percent, as suggested by Stoughton, is problematic, since the annual production for individual trailer manufacturers varies so widely. An allowance of 20 percent for a very large manufacturer could very well represent the same volume of trailers as an entire year's sales for a small manufacturer. This in turn could result in a situation where a large number of non-complying trailers would be on the market, potentially attracting customers away from smaller manufacturers that needed to market complying trailers.

Because of this, the agencies estimated a representative volume of trailers based on the 2015 Trailer Production Figures published by Trailer-BodyBuilders.com.[374] The smallest box van manufacturer in the list produced 1800 dry freight vans in 2015. Twenty percent of that production is 360 trailers. The agencies are adopting an interim provision providing box van manufacturers an allowance of 20 percent of their production (up to a maximum of 350 units) that are not

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[374] 2015 Trailer Production Figures Table. Schenk, Paul. March 4, 2016. Accessed January 4, 2016. Available at: *http://trailer-bodybuilders.com/trailer-output/2015-trailer-production-figures-table.*

required to meet the standards for model years 2018 through 2026 when we do not include averaging. All lengths of box vans, including both dry and refrigerated, produced by a given manufacturer count toward the allowance.

While averaging does not apply for partial- and non-aero box trailers at any point in the program, the agencies believe manufacturers can also benefit from the ability to exempt some trailers from these subcategories in the early years as they transition into the full program. For MY 2018 through 2026, manufacturers can include partial- and non-aero box trailers in their 350 box van allowance. In MY 2027, we believe all partial- and non-aero box vans can meet the reduced standards for their given subcategories.

Non-box trailers have design-based tire standards and averaging thus does not apply for this subcategory. Similar to the partial- and non-aero box vans, we also believe non-box manufacturers can benefit from a transitional exemption allowance. The agencies are adopting a separate allowance for non-box trailers, because their production volumes differ and many non-box trailer manufacturers do not build box vans. Using the same trailer production figures, we found that the smallest non-box trailer manufacturer in the list produced 1325 trailers in 2015 and twenty percent of that production is 265 trailers. From MY 2018 through 2026, non-box trailer manufacturers can exempt 20 percent or 250 trailers from the applicable tire standards. By MY 2027, we believe all non-box trailers can incorporate the tire technologies required by the design standards.

The agencies estimate that the box van and non-box trailer allowances translate on average to less than two percent of production across the trailer industry, and the agencies believe that this minor degree of loss of emission and fuel consumption reduction benefits is more than offset by the flexibility which, as pointed out earlier, may be needed by this newly regulated industry segment. These allowances are specified in 40 CFR 1037.150 and 49 CFR 535.3.

(b) Averaging Provisions for the Late Years of the Trailer Program

The agencies proposed to allow trailer manufacturers to use averaging throughout the phase-in of the program as one option for complying with the trailer standards. As noted, we received nearly unanimous comments, in response to the pre-proposal SBREFA panel and to the NPRM, from trailer manufacturers opposing averaging. Specifically, the commenters cited their concern that the unique aspects of the trailer market tend to mean that the value of averaging as a tool is less than it has been for manufacturers in other industries, and the potential for negative consequences to some manufacturers is substantial. The trailer manufacturing industry is very competitive, and manufacturers must be highly responsive to their customers' diverse demands. Compared to other industry sectors, they can have little control over what kinds of trailer models their customers demand and thus limited ability to manage the mix and volume of different products. Additionally, one of the larger, more diverse manufacturers could potentially supply a customer with trailers that had few if any aerodynamic features, while offsetting this part of their business with over-complying trailers that they were able to sell to another customer; many smaller companies with limited product offerings might not be able to compete for those customers.

As a result of the many comments opposing averaging from trailer manufacturers—the very stakeholders meant to benefit from an averaging program—the agencies have reconsidered how averaging is incorporated into the program. The final program does not allow averaging as a compliance option in the early years of the program, in MY 2018 through MY 2026. In those years, all box vans sold (beyond a manufacturer's allowance of non-complying trailers) must meet the standards using any combination of available technologies.

However, the agencies have concluded that by late in the program, the value of an averaging option to many trailer manufacturers may well outweigh the concerns they have expressed. In addition, the final stage of the phase-in of the standards for MY 2027 represents the most stringent standards in the program, and additional flexibility may be welcome by trailer manufacturers. Therefore, the final program will provide a limited optional averaging program for MY 2027 and later full-aero box vans. By that time, we believe that the trailer manufacturers will be experienced and comfortable with the program, and the industry will be more familiar with the technologies.

The MY 2027 and later averaging provisions are identical in most respects to those we proposed for the other Phase 2 vehicle programs. One notable difference involves use of credits. As in the proposed trailer program, the averaging provisions for trailers focus on each individual model year's production. A manufacturer choosing to use the averaging provisions could not ''bank'' compliance credits for a future model year or ''trade'' (sell) credits to another manufacturer, since these provisions would disproportionately benefit the few large trailer manufacturers. Under these averaging provisions, a full-aero box van manufacturer that produces some MY 2027 or later box vans that perform better than required by the applicable standard could produce a number of vans in the same family that do not meet the standards, provided that the average compliance levels of the trailers it produces in any given model year is at or below the applicable standards for that family.

As in the proposed program, averaging is only available for full-aero box vans. The program is already designed to offer reduced standards for box vans designated as partial-aero, and the additional flexibility of averaging is not available. Also, averaging is inherently incompatible with design standards for non-aero box vans and non-box trailers, since those manufacturers cannot choose among compliance paths.

The agencies are adopting averaging sets for full-aero box vans based on trailer length. Trailers in a family are certified to a single standard, but individual trailers within the family may be grouped to certify to a family emissions limit (FEL) that is higher or lower than the standard, provided the production-weighted average of all FELs in a family can be averaged to the standard or better. By allowing averaging sets to include both refrigerated and dry vans similar length categories, a manufacturer that over-complies, on average, in one family, can use the credits generated toward compliance in the other family. For example, if a manufacturer has two subfamilies in each of its long dry and long refrigerated van families, and the over-compliance of one dry van subfamily exceeds the under-compliance of the other dry van subfamily, the additional over-compliance beyond the dry van family's standard become credits that can be used to offset any under-compliance in the refrigerated van family.

In order to avoid backsliding with the use of averaging, the agencies are adopting a provision to require a minimum level of technology adoption in MY 2027 and later. No FEL can exceed the MY 2018 standard for the given trailer subcategory. For example, a manufacturer could not over-comply on some trailers and expect to produce a fraction of their trailers with zero technologies installed; every trailer must, at minimum, include enough technologies to meet the corresponding MY 2018 standard. See 40 CFR 1037.107(a)(5) and 49 CFR 535.5(e).

As mentioned previously, manufacturers with a trailer family that performed better than the standard at the end of the year would not be allowed to bank credits for a future model year. However, the agencies understand that it is possible for a manufacturer to misjudge production and come up short at the end of the model year. In such a case, the program provides for a manufacturer to generate a credit deficit, if necessary, as a temporary recourse for unexpected challenges in a given model year.[375] The agencies would closely monitor the certification applications for the following model year, to ensure the manufacturer can make progress in reducing the deficit. Any such credit deficits would need to be resolved within the following three model years, and the manufacturer would need to generate credits from over-compliance in subsequent years to address deficits from prior model years. See 40 CFR 1037.745.

The agencies believe that limiting the availability of averaging provisions to the final stage of the program will ease a number of the competitive concerns that trailer manufacturers have raised, since the trailer program will be familiar and the value of averaging may be greater as the most stringent standards phase in. Small business manufacturers raised concerns in our pre-proposal small business outreach that averaging would disproportionately benefit larger manufacturers with larger production volumes and greater product diversity. We are limiting our averaging program to single model year averaging (*i.e.,* no banking or trading) to help address this concern. Similarly, we are adopting a maximum FEL based on the MY 2018 standard to ensure that larger manufacturers will not be able to produce large volumes of trailers with little or no technologies at the expense of manufacturers that cannot accumulate sufficient over-compliance within their annual production. To the extent that concerns about the MY 2027 and later averaging provisions remain as that model year approaches, the agencies look forward to working with manufacturers as they consider using averaging.

(c) Aerodynamic Device Testing Using SmartWay-Verified Data

The agencies expect some trailer manufacturers and aerodynamic device manufacturers to continue to submit test data to the SmartWay program for verification. Since many manufacturers have some experience with EPA's SmartWay program, the agencies have designed the trailer program and aerodynamic testing to recognize the significant synergy with the SmartWay Technology Program. Section IV.E.(3)(b)(v) describes the compliance path available to trailer manufacturers to use pre-approved performance data for aerodynamic devices. As an additional interim option, any device manufacturer that attains SmartWay verification for a device prior to January 1, 2018 is eligible to submit its previous SmartWay-verified data to EPA's Compliance Division for pre-approval, provided their test results come from one of SmartWay's 2014 test protocols that measure a delta C_dA. The protocols for coastdown, wind tunnel, and computational fluid dynamics analyses result in a C_dA value. Note that SmartWay's 2014 protocols allow SAE J1321 Type 2 track testing, which generates fuel consumption results, not C_dA values. Two commenters (a device manufacturer and an NGO) requested that we allow SAE J1321 track test results, but did not suggest a means of converting from the fuel consumption results to an appropriate delta C_dA value for use in compliance. As a result, the agencies will not accept J1321 data for pre-approval.

Beginning on January 1, 2018, EPA will require that device and trailer manufacturers that seek approval of new aerodynamic technologies for trailer certification use one of the approved test methods for Phase 2 (*i.e.,* coastdown, wind tunnel or CFD) and the test procedures found in 40 CFR 1037.526. Aerodynamic technologies that were pre-approved using performance data from SmartWay's 2014 Protocols will maintain their approved status through December 31, 2020. Beginning January 1, 2021, all pre-approval of device performance will need to be based on testing using the Phase 2 test procedures.

(d) Off-Cycle Technologies

The Phase 1 and Phase 2 programs include provisions for manufacturers to request the use of off-cycle technologies that are not recognized in GEM and were not in common use before MY 2010. During the development of the trailer proposal, the agencies were not aware of any technologies that could improve CO_2 and fuel consumption performance that would not be captured in the trailer test protocols, and we did not propose a process to evaluate off-cycle trailer technologies. We continue to believe that effective trailer aerodynamic technologies that would not be captured by the test protocols are unlikely to emerge. However, Wabash provided comments requesting a process for evaluating future trailer weight reduction options. They suggested that these options could include lightweight components that are not listed in our regulations as approved material substitution components, or overall trailer weight reduction strategies that are not limited to individual components.

In light of these comments and further consideration of the issue, the agencies believe that the off-cycle technology process is an appropriate way for certain box van manufacturers—that is, those using the compliance equation and not subject to the design standards—to receive credit for future lightweighting or other technologies that are not recognized in the compliance equation. For this reason, we have incorporated box vans into the existing off-cycle provisions. In the case of lightweighting, a measured difference in trailer weight could substitute for the weight component of the compliance equation. For other such technologies (should any exist), the general off-cycle provisions apply. See 40 CFR 1037.515(e).

(e) Small Business Regulatory Flexibility Provisions

As a part of our small business obligations under the Regulatory Flexibility Act, EPA and NHTSA have considered additional flexibility provisions aimed at this segment of the trailer manufacturing industry. EPA convened a Small Business Advocacy Review (SBAR) Panel as required by the Small Business Regulatory Enforcement Fairness Act (SBREFA), and much of the information gained and recommendations provided by this process form the basis of the proposed flexibilities.[376] As in previous rulemakings, our justification for including provisions specific to small businesses is that these entities generally have a greater degree of difficulty in complying with the

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[375] Section IV.E.(1)(b) describes the process of identifying trailer families and sub-families based on basic trailer characteristics. 40 CFR 1037.710 describes the provisions for establishing subfamilies within a trailer family and the Family Emission Limits that are averaged among the subfamilies.

[376] Additional information regarding the findings and recommendations of the Panel are available in Section XIV, Chapter 12 of the RIA, and in the Panel's final report titled ''Final Report of the Small Business Advocacy Review Panel on EPA's Planned Proposed Rule: Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: Phase 2'' (See Docket EPA–HQ–OAR–2014–0827).

standards compared to other entities. Thus, as discussed below, we are adopting several regulatory flexibility provisions for small trailer manufacturers that we believe will reduce the burden on them while achieving the goals of the program.

The agencies identified 178 trailer and tank manufacturers for our analysis and we believe 147 qualify as small business (*i.e.,* less than 1000 employees).[377] The agencies designed many of the program elements and flexibility provisions available to all trailer manufacturers with the large fraction of small business trailer manufacturers in mind. For the small van manufacturers, we believe the option to choose pre-approved aerodynamic data will significantly reduce the compliance burden and eliminate the requirement for all manufacturers to perform testing. We are also limiting the final non-box trailer program to tanks, flatbeds, and container chassis. All other non-box trailers are exempt from the Phase 2 trailer program, with no regulatory requirements. This exemption reduces the number of small businesses in the trailer program from 147 to 74 companies at the time of the development of this rulemaking. With no regulatory requirements, these companies have zero burden under the trailer program. We are also adopting the proposed design standards for the remaining non-box trailers, such that they can certify by installing tire technologies only, with no testing requirements. The agencies are also adopting provisions that would increase the number of eligible tire pressure systems that can be installed for compliance. In addition to ATIS, TPMS is a recognized technology in the final rulemaking. Furthermore, the non-box trailers, which have design-based tire standards, comply if they have either a TPMS or an ATIS, and appropriate lower rolling resistance tires. The inclusion of the less expensive TPMS as a tire pressure system option will improve the availability of technologies and reduce the technology cost for many small businesses.

As noted above, the small trailer manufacturers raised concerns that their businesses could be harmed by provisions allowing averaging, banking, and trading of emissions and fuel consumption performance, since they will not be able to generate the same volume of credits as large manufacturers. The agencies are not adopting banking and trading provisions in any part of the program, and are limiting the option to average to manufacturers of full-aero dry and refrigerated box trailers and delaying the averaging until MY 2027. Similarly, we are adopting a maximum FEL based on the MY 2018 standard to ensure that larger manufacturers will not be able to produce large volumes of trailers with little or no technologies at the expense of manufacturers that cannot accumulate sufficient over-compliance within their annual production. We expect that the familiarity of the industry, including small business manufacturers, with the trailer program by this stage of the program, and the requirement that all trailers meet at least the MY 2018 level of control, will reduce the concerns of small manufacturer compared to an earlier or broader averaging program.

For all small business trailer manufacturers, the agencies are adopting a one-year delay in the beginning of implementation of the program, until MY 2019. We believe that this allows small businesses additional needed lead time to make the necessary staffing adjustments and process changes, and possibly add new infrastructure to meet the requirements of the program. TTMA commented that all trailer manufacturers are ‘‘small businesses’’ relative to other heavy-duty industries and that the one-year delay would divert sales to small businesses for that model year. Wabash argued that providing a flexibility is not required by the RFA and not authorized by the Clean Air Act. The agencies believe that small businesses do not have the same resources available to become familiar with the regulations, make process and staffing changings, or evaluate and market new technologies as their larger counterparts. We believe a one-year delay provides additional time for small businesses to address these issues, without a large CO_2 and fuel consumption impact or substantial negative competitive effects. The cumulative annual production of all of the small business box trailer manufacturers is estimated to be less than 15 percent of the industry's total production, which is significantly less than the annual production of the four largest manufacturers.[378] We expect any diverted sales for this one year will be a small fraction of the large manufacturers' production and we are finalizing the one-year delay for all small business trailer manufacturers.

Chapter 12 of the RIA presents the agencies' Final Regulatory Flexibility Analysis. In this chapter, we discuss the recommendations of the Panel, what we proposed, and what we finalized for the small businesses regulated in Phase 2. We also estimate the economic effect of the rulemaking on these businesses based on their annual revenue. Considering the flexibilities adopted in this rulemaking, our estimate of compliance burden indicates that only 15 of the 147 small trailer manufacturers (about 10 percent) will have an economic impact greater than one percent of their annual revenue. Therefore, we believe the trailer provisions in this rulemaking do not have a significant impact on small businesses.

V. Class 2b–8 Vocational Vehicles

A. Summary of Phase 1 Vocational Vehicle Standards

Class 2b–8 vocational vehicles include a wide variety of vehicle types, and serve a wide range of functions. Some examples include service for urban delivery, refuse hauling, utility service, dump, concrete mixing, transit service, shuttle service, school bus, emergency, motor homes, and tow trucks. In the HD Phase 1 Program, the agencies defined Class 2b–8 vocational vehicles as all heavy-duty vehicles that are not included in the Heavy-duty Pickup Truck and Van or the Class 7 and 8 Tractor categories. In effect, the rules classify heavy-duty vehicles that are not a combination tractor or a pickup truck or van as vocational vehicles. Class 2b–8 vocational vehicles and their engines emit approximately 17 percent of the GHG emissions and burn approximately 17 percent of the fuel consumed by today's heavy-duty truck sector.[379]

Most vocational vehicles are produced in a two-stage build process, though some are built from the ‘‘ground up’’ by a single entity. In the two-stage process, the first stage sometimes is completed by a chassis manufacturer that also builds its own proprietary components such as engines or transmissions. This is known as a vertically integrated manufacturer. The first stage can also be completed by a chassis manufacturer who procures all

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[377] In the period between the SBAR Panel and Initial Regulatory Flexibility Analysis and issuing of the final rule, the Small Business Administration (SBA) finalized new size standards for small business classification. For trailers, the threshold to qualify as small changed from 500 employees to 1000 employees. We have updated our analysis to reflect the new size standards.

[378] See Figure 1–3 of Chapter 1 in the RIA comparing the 2015 trailer output from the top 28 trailer manufacturers.

[379] Memorandum to the Docket ‘‘Runspecs, Model Inputs, MOVES Code and Database for HD GHG Phase 2 FRM Emissions Modeling.’’. July 2016. *See also* EPA's MOVES Web page at *https://www3.epa.gov/otaq/models/moves/index.htm.*

vehicle standards or one of the custom chassis standards.

C. Feasibility of the Vocational Vehicle Standards

This section describes the agencies' technological feasibility and cost analysis. Further detail on all of these technologies can be found in the RIA Chapter 2.4 and Chapter 2.9. The variation in the design and use of vocational vehicles has led the agencies to project different technology solutions for each regulatory subcategory. Manufacturers may also find additional means to reduce emissions and lower fuel consumption than the technologies identified by the agencies, and of course may adopt any compliance path they deem most advantageous. This section includes discussion of the feasibility of the final standards for non-custom vocational vehicles using the full Phase 2 certification path, as well as the final optional standards for custom chassis standards.

NHTSA and EPA collected information on the cost and effectiveness of fuel consumption and CO_2 emission reducing technologies from several sources. The primary sources of information were the Southwest Research Institute evaluation of heavy-duty vehicle fuel efficiency and costs for NHTSA,[407] the 2010 National Academy of Sciences report of Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,[408] TIAX's assessment of technologies to support the NAS panel report,[409] the technology cost analysis conducted by ICF for EPA,[410] and the 2009 report from Argonne National Laboratory on Evaluation of Fuel Consumption Potential of Medium and Heavy Duty Vehicles through Modeling and Simulation.[411]

(1) What technologies are the Agencies considering to reduce the CO_2 emissions and fuel consumption of vocational vehicles?

In assessing the feasibility of the final Phase 2 vocational vehicle standards, the agencies evaluated a suite of technologies, including workday idle reduction, improved tire rolling resistance, tire pressure monitoring or inflation systems, improved transmissions including hybrids, improved axles, improved accessories, and weight reduction, as well as their impact on reducing fuel consumption and GHG emissions. The agencies also evaluated aerodynamic technologies and full electric vehicles.

As discussed above, vocational vehicles may be powered by either SI or CI engines. The technologies and feasibility of the engine standards are discussed in Section II. At the vehicle level, the agencies have considered the same suite of technologies and have applied the same reasoning for including or rejecting these vehicle-level technologies as part of the basis for the final standards, regardless of whether the vehicle is powered by a CI or SI engine, since the vehicle level technologies are not a function of engine type. Generally, the analysis below does not distinguish between vehicles with different types of engines. The resulting vehicle standards do reflect the differences arising from the performance of CI (primarily diesel) or SI (primarily gasoline) engines over the GEM cycles. Note that vehicles powered by engines using fuels other than diesel or gasoline are subject to either the SI or CI vehicle standards, as specified in 40 CFR 1037.101.

(a) Vehicle Technologies Considered in Standard-Setting

The agencies note that the effectiveness values estimated for the technologies have been obtained using a variety of methods, including average literature values, engineering calculation, and GEM simulation. They do not reflect the potentially-limitless combination of possible values that could result from adding the technology to different vehicles. For example, while the agencies have estimated an effectiveness of one percent for e-accessories, each vehicle could experience a unique effectiveness depending on the actual accessory load for that vehicle. On-balance the agencies believe this is the most practicable approach for determining effectiveness for the technologies in the Phase 2 vocational vehicle program. This section is organized to first present the agencies' analyses of technology feasibility and effectiveness in Section V.C.(1), and below in Section V.C.(2) we present our projected technology adoption rates and estimated costs. Where other details are not given, the feasibility sections set forth our rationale for the projected adoption rates. Average vehicle technology package costs by regulatory subcategory are presented below in Section V.C.(2)(e). Individual technology costs are summarized in the RIA Chapter 2.9.3, and full details behind all these costs are presented in RIA Chapter 2.11, including the markups and learning effects applied for each of the technologies.

(i) Transmissions

Transmission improvements present a significant opportunity for reducing fuel consumption and CO_2 emissions from vocational vehicles. Transmission efficiency is important for all vocational vehicles as their duty cycles involve significant amounts of driving under transient operation. Even Regional vocational vehicles have 20 percent of their composite score based on the transient test cycle. The three categories of transmission improvements the agencies proposed to consider as part of a compliance path used to determine standard stringency were driveline optimization, architectural improvements, and hybrid powertrain systems. As a result of comments and enhanced capabilities of GEM, we are adopting standards based on performance of a revised set of transmission technologies. For each technology, we have adjusted our projected penetration rates where we found that comments provided a persuasive reason to do so, and the effectiveness values are all updated according to the current GEM over the new drive cycle weightings.

The technology we described at proposal as driveline integration, 80 FR 40296, is now defined as use of an advanced shift strategy. At proposal the agencies included shift strategy, aggressive torque converter lockup, and a high efficiency gearbox among the technologies defined as driveline integration that would only be recognized by use of powertrain testing. We also proposed a 70 percent adoption rate in MY 2027 on the basis that this approach to improving fuel efficiency is highly cost-effective and technically feasible in a wide range of applications, and that the additional lead time would enable manufacturers to overcome barriers related to the non-integrated nature of businesses serving this sector. We received persuasive comments from manufacturers emphasizing the diversity of their product lines and the extent of testing that would be needed to apply this technology to 70 percent of their sales, and as a result we have reduced our projected adoption rates for this technology. The agencies continue to believe that an effective way to derive

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[407] Reinhart, T. (February 2016). *Commercial Medium- and Heavy-Duty (MD/HD) Truck Fuel Efficiency Technology Study—Report #2.* Washington, DC: National Highway Traffic Safety Administration. EPA–HQ–OAR–2014–0827–1623.; and Schubert, R., Chan, M., Law, K. 2015, *Commercial Medium- and Heavy-Duty (MD/HD) Truck Fuel Efficiency Cost Study.* Washington, DC: National Highway Traffic Safety Administration.

[408] See NAS Report, Note 229 above.

[409] See TIAX 2009, Note 230 above.

[410] See ICF 2010, Note 232 above.

[411] Argonne National Laboratory, ''Evaluation of Fuel Consumption Potential of Medium and Heavy Duty Vehicles through Modeling and Simulation.'' October 2009.

include sufficient real-world heavy-duty vehicle data on which to base the menu credit value recommended by the commenter. Thus, in several cases, the analysis provided by commenters was based on light-duty vehicle data or on simulations with little detail provided, which analysis is not directly applicable to heavy duty pickups and vans for purposes of technology performance quantification. Second, in several cases, the technologies recommended for off-cycle credits for pickups and vans provide significant on-cycle benefit. Such technologies are considered to be adequately captured by the test procedures (within the meaning of section 86.1819–14(d)(13)) [532] and are not considered to be eligible for off-cycle credits. Examples of adequately captured technologies that commenters recommended for off-cycle credits include cylinder deactivation and cooled EGR. Moreover, these are technologies the agencies expect to be in the mix of technologies used to meet the standards (and are projected to be used in the respective analyses of compliance paths on which the stringency of the final standards are predicated). EPA has already indicated that off-cycle credits are not available for technologies that form part of the technology basis for the greenhouse gas standards because these technologies' benefits would already be reflected in the standard's stringencies (and costs). 77 FR 62835 (Oct. 12, 2012). Indeed, it is because of these technologies' robust performance in two-cycle space that the agencies have projected their use as part of the compliance path on which standard stringency is predicated. Likewise, many of these technologies are inherent to vehicle design and so are similarly ineligible. *Id.* at 62732, 62836. Finally, a few other recommended technologies are considered safety-related technologies not eligible for credits because they could reasonably be expected to fall under vehicle safety standards in the future and so would be adopted in any case. Granting off-cycle credits for these technologies consequently would amount to an unwarranted windfall. Adaptive cruise control and forward collision warning systems are examples of these technologies. Chapter 7 of the Response to Comments for this final rule provides a detailed response to these comments

(4) Demonstrating Compliance for Heavy-Duty Pickup Trucks and Vans

The Phase 1 rule established a comprehensive compliance program for HD pickups and vans that NHTSA and EPA are generally retaining for Phase 2. The compliance provisions cover details regarding the implementation of the fleet average standards including vehicle certification, demonstrating compliance at the end of the model year, in-use standards and testing, carryover of certification test data, and reporting requirements. Please see Section V.B.(1) of the Phase 1 rule Preamble (76 FR 57256–57263) for a detailed discussion of these provisions.

The Phase 1 rule contains special provisions regarding loose engines and optional chassis certification of certain vocational vehicles over 14,000 lbs. GVWR. As proposed, the agencies are extending the optional chassis certification provisions to Phase 2 and are providing a temporary loose engine provision for Phase 2 as described in Section V.D.3.e, under Compliance Flexibility Provisions. See the vocational vehicle Section V.D. and XIII.A.2 for a detailed discussion of the rule for optional chassis certification and Section II.D. for the discussion of loose engines.

VII. Aggregate GHG, Fuel Consumption, and Climate Impacts

Given that the purpose of setting these Phase 2 standards is to reduce fuel consumption and greenhouse gas (GHG) emissions from heavy-duty vehicles, it is necessary for the agencies to analyze the extent to which these standards will accomplish that purpose. This section describes the agencies' methodologies for projecting the reductions in greenhouse gas (GHG) emissions and fuel consumption and the methodologies the agencies used to quantify the impacts associated with these standards. In addition, EPA's analyses of the projected change in atmospheric carbon dioxide (CO_2) concentration and consequent climate change impacts are discussed. Because of NHTSA's obligations under EPCA/EISA and NEPA, NHTSA further analyzes the projected environmental impacts related to fuel consumption, GHG emissions, and climate change, for each regulatory alternative. Detailed documentation of this analysis is provided in Chapters 3, 4 and 5 of NHTSA's FEIS accompanying today's notice.

A. What methodologies did the Agencies use to project GHG emissions and fuel consumption impacts?

Different tools exist for estimating potential fuel consumption and GHG emissions impacts associated with fuel efficiency and GHG emission standards. One such tool is EPA's official mobile source emissions inventory model named Motor Vehicle Emissions Simulator (MOVES).[533] The agencies used a revised version of MOVES2014a to quantify the impacts of these standards for vocational vehicles and combination tractor-trailers on GHG emissions and fuel consumption.

Since the notice of proposed rulemaking, EPA has made certain updates to MOVES in response to the public comments on the proposal: (1) The projections of vehicle sales, populations, and activity in the version used for the final rulemaking were updated to incorporate the latest projections from the U.S. Department of Energy's Annual Energy Outlook 2015 report; [534] (2) the extended idle and APU emission rates in MOVES were updated based on the analyses of latest test programs that reflect the current prevalence of clean idle certified engines; and (3) the baseline adoption rates of idle reduction technology were reassessed and projected to be lower than what was assumed in the proposal, as described in Section III.D.1.a of the Preamble. In addition, changes to APU emissions rates for $PM_{2.5}$ were implemented in MOVES reflecting the fact that EPA is adopting requirements to control $PM_{2.5}$ emissions from APUs installed in new tractors, as discussed in Section III.C.3 of the Preamble. Finally, methodological improvements were made in classifying vehicle types and in forecasting vehicle populations and activity. The aforementioned updates above, along with other changes, are documented in the memorandum to the docket.[535]

MOVES was run with user input databases, described in more detail below, that reflected the projected technological improvements resulting from the final rules, such as the improvements in engine and vehicle efficiency, aerodynamic drag, and tire rolling resistance. The changes made to

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[532] This provision states that an off-cycle credit must be for a technology that is ''not adequately captured on the Federal Test procedure (FTP) and/or the highway Fuel Economy Test (HFET).'' EPA has indicated that this requires manufacturers to demonstrate ''an incremental off-cycle benefit that is significantly greater than the 2-cycle benefit.'' 77 FR 62836 (Oct. 12, 2012).

[533] MOVES homepage: *https://www3.epa.gov/otaq/models/moves/index.htm* (last accessed May 27, 2016).

[534] Annual Energy Outlook 2015. *http://www.eia.gov/forecasts/archive/aeo15/* (last accessed May 27, 2016).

[535] U.S. EPA. Updates to MOVES for Emissions Analysis of Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2 FRM. Docket No. EPA–HQ–OAR–2016. July 2016.

the default MOVES database are described below in Section VII.B.(3). All the input data, MOVES run spec files, and the scripts used for the analysis, as well as the version of MOVES used to generate the emissions inventories, can be found in the docket.[536]

Another such tool is DOT's CAFE model, which estimates how manufacturers could potentially apply technology improvements in response to new standards, and then calculates, among other things, resultant changes in national fuel consumption and GHG emissions. As described in Section VI, two versions of this model were used for analysis of potential new standards for HD pickups and vans. Both versions use the work-based attribute metric of ''work factor'' established in the Phase 1 rule for heavy-duty pickups and vans instead of the light-duty ''footprint'' attribute metric. The CAFE model takes user-specified inputs on, among other things, vehicles that are projected to be produced in a given model year, technologies available to improve fuel efficiency on those vehicles, potential regulatory standards that will drive improvements in fuel efficiency, and economic assumptions. The CAFE model takes every vehicle in each manufacturer's fleet and decides what technologies to add to those vehicles in order to allow each manufacturer to comply with the standards in the most cost-effective way. Based on those results, the CAFE model then calculates total fuel consumption and GHG emissions impacts based on those inputs, along with economic costs and benefits. The DOT's CAFE model is further described in detail in Section VI of the Preamble and Chapter 10 of the RIA.

For these rules, the agencies used two analytical methods for the heavy-duty pickup and van segment employing both DOT's CAFE model and EPA's MOVES model. The agencies used EPA's MOVES model to estimate fuel consumption and emissions impacts for tractor-trailers (including the engine that powers the tractor) and vocational vehicles (including the engine that powers the vehicle).

For heavy-duty pickups and vans, the agencies performed separate analyses, which we refer to as ''Method A'' and ''Method B.'' In Method A, a modified version of the CAFE model was used to project a pathway the industry could use to comply with each regulatory alternative and the estimated effects on fuel consumption, emissions, benefits and costs. In Method B, the MOVES model was used to estimate fuel consumption and emissions from these vehicles. NHTSA considered Method A as its central analysis. EPA considered the results of Method B as its central analysis. The agencies concluded that these methods led the agencies to the same conclusions and the same selection of the final standards. See Chapter 5 of the RIA for additional discussions of these two methods.

For both methods, the agencies analyzed the impact of the final rules, relative to two different reference cases—''flat'' (Alternative 1a) and ''dynamic'' (Alternative 1b). The flat baseline projects very little improvement in new vehicles in the absence of new Phase 2 standards. In contrast, the dynamic baseline projects more improvements in vehicle fuel efficiency in the absence of new Phase 2 standards. The agencies considered both reference cases (for additional details, see Chapter 11 of the RIA). The results for all of the regulatory alternatives relative to both reference cases, derived via the same methodologies discussed in this section, are presented in Section X of the Preamble.

For brevity, a subset of these analyses are presented in this section, and the reader is referred to both Chapter 11 of the RIA and NHTSA's FEIS Chapters 3, 4 and 5 for complete sets of these analyses. In this section, Method A is presented for the final standards (*i.e.*, Alternative 3—the agencies' preferred alternative), relative to both the dynamic baseline (Alternative 1b) and the flat baseline (Alternative 1a). Method B is presented for the final standards, relative only to the flat baseline.

Because reducing fuel consumption also affects emissions that occur as a result of fuel production and distribution (including renewable fuels), the agencies also calculated those ''upstream'' changes using the ''downstream'' fuel consumption reductions predicted by the CAFE model (in ''Method A'') and the MOVES model (in ''Method B''). As described in Section VI, Method A uses the CAFE model to estimate vehicular fuel consumption and emissions impacts only for HD pickups and vans and to calculate upstream impacts. For vocational vehicles and combination tractor-trailers, both Method A and Method B use the same upstream tools originally created for the Renewable Fuel Standard 2 (RFS2) rulemaking analysis,[537] used in the LD GHG rulemakings,[538] HD GHG Phase 1,[539] and updated for the current analysis. The estimate of emissions associated with production and distribution of gasoline and diesel from crude oil is based on emission factors in the ''Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation'' model (GREET) developed by DOE's Argonne National Lab. In some cases, the GREET values were modified or updated by the agencies to be consistent with the National Emission Inventory (NEI) and emission factors from MOVES. Method B uses the same tool described above to estimate the upstream impacts for HD pickups and vans. For additional details, see Chapter 5 of the RIA. The upstream tool used for the Method B can be found in the docket.[540] As noted in Section VI above, these analyses corroborate each other's results.

The agencies analyzed the anticipated emissions impacts of the final rules on carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs) for a number of calendar years (for purposes of the discussion in these final rules, only 2025, 2040 and 2050 will be shown) by comparing to both reference cases.[541] Additional runs were performed for just three of the greenhouse gases (CO_2, CH_4, and N_2O) and for fuel consumption for every calendar year from 2016 to 2050, inclusive, which fed the economy-wide modeling, monetized greenhouse gas benefits estimation, and climate impacts analyses, discussed in sections below.[542]

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[536] Memorandum to the Docket ''Runspecs, Model Inputs, MOVES Code and Database for HD GHG Phase 2 FRM Emissions Modeling'' Docket No. EPA–HQ–OAR–2016. July 2016.

[537] U.S. EPA. Draft Regulatory Impact Analysis: Changes to Renewable Fuel Standard Program. Chapters 2 and 3. May 26, 2009. Docket ID: EPA–HQ–OAR–2009–0472–0119.

[538] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards (77 FR 62623, October 15, 2012).

[539] Greenhouse Gas Emission Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (76 FR 57106, September 15, 2011).

[540] Memorandum to the Docket ''Upstream Emissions Modeling Files for HDGHG Phase 2 FRM'' Docket No. EPA–HQ–OAR–2016. July 2016.

[541] The emissions impacts of the final rules on non-GHGs, including air toxics, were also estimated using MOVES. See Section VIII of the Preamble for more information.

[542] The CAFE model estimates, among other things, manufacturers' potential multiyear planning decisions within the context of an estimated year-by-year product cadence (*i.e.*, schedule for redesigning and freshening vehicles). The model was allowed to deploy technology in earlier model years in the analysis in order to account for the potential that manufacturers might take anticipatory actions in model years preceding those covered by today's rules.

B. Analysis of Fuel Consumption and GHG Emissions Impacts Resulting From Final Standards

The following sections describe the model inputs and assumptions for both the flat and dynamic reference cases and the control case representing the agencies' final fuel efficiency and GHG standards. The details of all the MOVES runs and input data tables, as well as the MOVES code and database, can be found in the docket.[543] See Section VI.C for the discussion of the model inputs and assumptions for the analysis of the HD pickups and vans using DOT's CAFE Model.

(1) Model Inputs and Assumptions for the Flat Reference Case

The flat reference case (identified as Alternative 1a in Section X), includes the impact of Phase 1, but assumes that fuel efficiency and GHG emission standards are not improved beyond the required 2018 model year levels. Alternative 1a functions as one of the baselines against which the impacts of the final standards can be evaluated. The MOVES2014a default road load parameters and energy rates were used for the vocational vehicles and HD pickups and vans for this alternative because we assumed no market-driven improvements in fuel efficiency. The tractor-trailer road load parameters were changed from the MOVES2014a default values to account for projected improvements in the efficiency of the box trailers pulled by combination tractors due to increased penetration of aerodynamic technologies and low rolling resistance tires attributed to both EPA's SmartWay Transport Partnership and California Air Resources Board's Tractor-Trailer Greenhouse Gas regulation, as described in Section IV of the Preamble. We maintained the same road load inputs for tractor-trailers for 2018 and beyond. The flat reference case assumed the growth in vehicle populations and miles traveled based on the relative annual VMT growth from AEO2015 Final Release for model years 2014 and later.[544]

(2) Model Inputs and Assumptions for the Dynamic Reference Case

The dynamic reference case (identified as Alternative 1b in Section X) also includes the impact of Phase 1 and generally assumes that fuel efficiency and GHG emission standards are not improved beyond the required 2018 model year levels. However, for this case, the agencies assume market forces will lead to additional fuel efficiency improvements for HD pickups and vans and tractor-trailers. These additional assumed improvements are described in Section X of the Preamble. No additional fuel efficiency improvements due to market forces were assumed for vocational vehicles. For HD pickups and vans, the agencies applied the CAFE model using the input assumption that manufacturers having achieved compliance with Phase 1 standards will continue to apply technologies for which increased purchase costs will be "paid back" through corresponding fuel savings within the first six months of vehicle operation. The agencies conducted the MOVES analysis of this case in the same manner as for the flat reference case.

(3) Model Inputs and Assumptions for "Control" Case

(a) Vocational Vehicles and Tractor-Trailers

The "control" case represents the agencies' final fuel efficiency and GHG standards. The agencies developed additional user input data for MOVES runs to estimate the control case inventories. The inputs to MOVES for the control case account for improvements of engine and vehicle efficiency in vocational vehicles and combination tractor-trailers. The agencies used the percent reduction in aerodynamic drag and tire rolling resistance coefficients and absolute changes in average total running weight (gross combined weight) expected from the final rules to develop the road load inputs for the control case, based on the GEM analysis. The agencies developed energy inputs for the control case runs using the percent reduction in CO_2 emissions expected from the powertrain and other vehicle technologies not accounted for in the aerodynamic drag and tire rolling resistance in the final rules.

Table VII–1 and Table VII–2 describe the improvements in engine and vehicle efficiency from the final rules for each affected model year for vocational vehicles and combination tractor-trailers that were input into MOVES for estimating the control case emissions inventories. Additional details regarding the MOVES inputs are included in Chapter 5 of the RIA.

TABLE VII–1—ESTIMATED REDUCTIONS IN ENERGY RATES FOR THE FINAL STANDARDS

Vehicle type	Fuel	Model years	Reduction from flat baseline (%)
Long-haul Tractor-Trailers and HHD Vocational	Diesel	2018–2020	1.0
		2021–2023	7.9
		2024–2026	12.4
		2027+	16.3
Short-haul Tractor-Trailers and HHD Vocational	Diesel	2018–2020	0.6
		2021–2023	7.4
		2024–2026	11.9
		2027+	15.0
Single-Frame Vocational[545]	Diesel	2021–2023	7.8
		2024–2026	12.3
		2027+	16.0

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[543] Memorandum to the Docket "Runspecs, Model Inputs, MOVES Code and Database for HD GHG Phase 2 FRM Emissions Modeling" Docket No. EPA–HQ–OAR–2016. July 2016.

[544] Annual Energy Outlook 2015. *http://www.eia.gov/forecasts/archive/aeo15/* (last accessed May 27, 2016).

[545] Vocational vehicles modeled in MOVES include heavy heavy-duty, medium heavy-duty, and light heavy-duty vehicles. However, for light heavy-duty vocational vehicles, class 2b and 3 vehicles are not included in the inventories for the vocational sector. Instead, all vocational vehicles with GVWR of less than 14,000 lbs. were modeled using the energy rate reductions described below for HD pickup trucks and vans. In practice, many manufacturers of these vehicles choose to average the lightest vocational vehicles into chassis-certified families (*i.e.,* heavy-duty pickups and vans).

TABLE VII–1—ESTIMATED REDUCTIONS IN ENERGY RATES FOR THE FINAL STANDARDS—Continued

Vehicle type	Fuel	Model years	Reduction from flat baseline (%)
Urban Bus	Gasoline	2021–2023	6.9
		2024–2026	9.8
		2027+	13.3
	Diesel and CNG	2021–2023	7.0
		2024–2026	11.8
		2027+	14.4

TABLE VII–2—ESTIMATED REDUCTIONS IN ROAD LOAD FACTORS FOR THE FINAL STANDARDS

Vehicle type	Model years	Reduction in tire rolling resistance coefficient (%)	Reduction in aerodynamic drag coefficient (%)	Weight reduction (lb)[a]
Combination Long-haul Tractor-Trailers	2018–2020	6.1	5.6	−140
	2021–2023	13.3	12.5	−199
	2024–2026	16.3	19.3	−294
	2027+	18.0	28.2	−360
Combination Short-haul Tractor-Trailers.[546]	2018–2020	5.2	0.9	−23
	2021–2023	11.9	4.0	−43
	2024–2026	14.1	6.2	−43
	2027+	15.9	8.8	−43
Intercity Buses	2021–2023	18.2	0	0
	2024–2026	20.8	0	0
	2027+	24.7	0	0
Transit Buses	2021–2023	0	0	0
	2024–2026	0	0	0
	2027+	12.1	0	0
School Buses	2021–2023	10.1	0	0
	2024–2026	14.9	0	0
	2027+	19.7	0	0
Refuse Trucks	2021–2023	0	0	0
	2024–2026	0	0	0
	2027+	12.1	0	0
Single Unit Short-haul Trucks	2021–2023	6.4	0	4.4
	2024–2026	6.4	0	10.4
	2027+	10.2	0	16.5
Single Unit Long-haul Trucks	2021–2023	8.4	0	7.9
	2024–2026	13.3	0	23.6
	2027+	13.3	0	39.4
Motor Homes	2021–2023	20.8	0	0
	2024–2026	20.8	0	0
	2027+	24.7	0	0

Note:

[a] Negative weight reductions reflect an expected weight increase as a byproduct of other vehicle and engine improvements as described in Chapter 5 of the RIA.

In addition, the CO_2 standard for tractors, reflecting the use of idle reduction technologies such as diesel-powered auxiliary power units (APUs) and battery-powered APUs, as discussed in Section III.D of the Preamble, was included in the modeling for the long-haul combination tractor-trailers, as shown below in Table VII–3.

TABLE VII–3—ASSUMED APU USE DURING EXTENDED IDLING FOR COMBINATION LONG-HAUL TRACTOR-TRAILERS[a]

Vehicle type	Model year	Diesel APU Penetration (%)	Battery APU Penetration (%)
Combination Long-Haul Trucks	2010–2020	9	0
	2021–2023	30	10
	2024–2026	40	10
	2027+	40	15

Note:

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[546] Vocational tractors are included in the short-haul tractor segment.

[a] Other idle reduction technologies (such as automatic engine shutdown, fuel operated heaters, and stop-start systems) were modeled as part of the energy rates.

To account for the potential increase in vehicle use expected to result from improvements in fuel efficiency for vocational vehicles and combination tractor-trailers due to the final rules (also known as the ''rebound effect'' and described in more detail in Section IX.E of the Preamble), the control case assumed an increase in VMT from the reference levels by 0.30 percent for the vocational vehicles and 0.75 percent for the combination tractor-trailers.[547]

(b) Heavy-Duty Pickups and Vans

As explained above and as also discussed in the RIA, the agencies used both DOT's CAFE model and EPA's MOVES model, for Method A and B, respectively, to project fuel consumption and GHG emissions impacts resulting from these standards for HD pickups and vans, including downstream vehicular emissions as well as emissions from upstream processes related to fuel production, distribution, and delivery.

(i) Method A for HD Pickups and Vans

For Method A, the agencies used the CAFE model which applies fuel properties (density and carbon content) to estimated fuel consumption in order to calculate vehicular CO_2 emissions, applies per-mile emission factors from MOVES to estimated VMT (for each regulatory alternative, adjusted to account for the rebound effect) in order to calculate vehicular CH_4 and N_2O emissions (as well, as discussed below, of non-GHG pollutants), and applies per-gallon upstream emission factors from GREET in order to calculate upstream GHG (and non-GHG) emissions.

As discussed above in Section VI, the standards for HD pickups and vans increase in stringency by 2.5 percent annually during model years 2021–2027. The standards define targets specific to each vehicle model, but no individual vehicle is required to meet its target; instead, the production-weighted averages of the vehicle-specific targets define average fuel consumption and CO_2 emission rates that a given manufacturer's overall fleet of produced vehicles is required to achieve as a whole. The standards are specified separately for gasoline and diesel vehicles, and vary with work factor. Both the NPRM and today's analysis assume that some application of mass reduction could enable increased work factor in cases where manufacturers increase a vehicle's rated payload and/or towing capacity without a change to GVWR and GCWR, but there are other ways manufacturers may change work factor which the analysis does not capture. Average required levels will depend on the future mix of vehicles and the work factors of the vehicles produced for sale in the U.S. Since these can only be estimated at this time, average required and achieved fuel consumption and CO_2 emission rates are subject to uncertainty. Between the NPRM and the issuance of today's final rules, the agencies updated the market forecast (and other inputs) used to analyze HD pickup and van standards, and doing so leads to different estimates of required and achieved fuel consumption and CO_2 emission rates (as well as different estimates of impacts, costs, and benefits).

The following four tables present stringency increases and estimated required and achieved fuel consumption and CO_2 emission rates for the two No Action Alternatives (Alternative 1a and 1b) and the standards defining the final program. Stringency increases are shown relative to standards applicable in model year 2018 (and through model year 2020). As mathematical functions, the standards themselves are not subject to uncertainty. By 2027, they are 16.2 percent more stringent (*i.e.,* lower) than those applicable during 2018–2020. NHTSA estimates that, by model 2027, these standards could reduce average required fuel consumption and CO_2 emission rates to about 4.88 gallons/100 miles and about 4 grams/mile, respectively. NHTSA further estimates that average achieved fuel consumption and CO_2 emission rates could correspondingly be reduced to about the same levels. If, as represented by Alternative 1b, manufacturers will, even absent today's standards, voluntarily make improvements that pay back within six months, these model year 2027 levels are about 12 percent lower than the agencies estimate could be achieved under the Phase 1 standards defining the No Action Alternative. If, as represented by Alternative 1a, manufacturers will, absent today's standards, only apply technology as required to achieve compliance, these model year 2027 levels are about 13 percent lower than the agencies estimate could be achieved under the Phase 1 standards. As indicated below, the agencies estimate that these improvements in fuel consumption and CO_2 emission rates will build from model year to model year, beginning as soon as model year 2017 (insofar as manufacturers may make anticipatory improvements if warranted given planned product cadence).

The NPRM analysis suggested that both the achieved and required fuel consumption and CO_2 reductions would be larger than the current analysis suggests. The NPRM suggested that achieved reductions would be 13.5 and 15 percent, for the dynamic and flat baselines, respectively. The erosion of the standards and fuel consumption reductions can be attributed to the increased work factor of the 2015 fleet relative to the 2014 fleet. Section 6 discusses in more detail the changes in the distribution of work factor for key market players from the MY 2014 to the MY 2015 fleet.

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[547] Memorandum to the Docket ''VMT Rebound Inputs to MOVES for HDGHG2 Phase 2 FRM'' Docket No. EPA–HQ–OAR–2016. July 2016.

TABLE VII–4—STRINGENCY OF HD PICKUP AND VAN STANDARDS, ESTIMATED AVERAGE REQUIRED AND ACHIEVED FUEL CONSUMPTION RATES FOR METHOD A, RELATIVE TO ALTERNATIVE 1b[a]

Model year	Stringency (vs. 2018)	Ave. required fuel cons. (gal./100 mi.)			Ave. achieved fuel cons. (gal./100 mi.)		
		No action	Final	Reduction (%)	No action	Final	Reduction (%)
2016	MYs 2016–2020 Subject to Phase 1 Standards.	6.32	6.32	0.0	6.14	6.14	0.0
2017		6.16	6.16	0.0	6.02	5.89	2.2
2018		5.83	5.83	0.0	5.97	5.78	3.2
2019		5.81	5.81	0.0	5.77	5.47	5.3
2020		5.80	5.80	0.0	5.75	5.46	5.1
2021	2.5	5.79	5.65	2.4	5.68	5.28	7.2
2022	4.9	5.80	5.52	4.8	5.64	5.22	7.5
2023	7.3	5.80	5.38	7.2	5.64	5.21	7.6
2024	9.6	5.80	5.25	9.5	5.65	5.22	7.6
2025	11.9	5.81	5.12	11.8	5.65	5.14	9.1
2026	14.1	5.81	5.01	13.7	5.65	5.02	11.1
2027	16.2	5.80	4.88	15.8	5.57	4.92	11.7
2028 *	16.2	5.81	4.91	15.5	5.57	4.89	12.2
2029 *	16.2	5.81	4.91	15.6	5.57	4.88	12.4
2030 *	16.2	5.81	4.91	15.6	5.57	4.88	12.4

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

* Absent further action, standards assumed to continue unchanged after model year 2027.

TABLE VII–5—STRINGENCY OF HD PICKUP AND VAN STANDARDS, ESTIMATED AVERAGE REQUIRED AND ACHIEVED CO_2 EMISSION RATES FOR METHOD A, RELATIVE TO ALTERNATIVE 1b[a]

Model year	Stringency (vs. 2018) (%)	Ave. required CO_2 Rate (g./mi.)			Ave. achieved CO_2 Rate (g./mi.)		
		No Action	Final	Reduction (%)	No Action	Final	Reduction (%)
2016	MYs 2016–2020 Subject to Phase 1 Standards.	597	597	0.0	578	578	0.0
2017		582	582	0.0	567	554	2.2
2018		550	550	0.0	562	544	3.2
2019		548	548	0.0	543	514	5.3
2020		547	547	0.0	541	513	5.1
2021	2.5	545	532	2.4	534	496	7.1
2022	4.9	546	519	4.9	530	491	7.4
2023	7.3	545	506	7.2	529	490	7.5
2024	9.6	547	494	9.5	531	491	7.5
2025	11.9	547	483	11.7	530	483	9.0
2026	14.1	547	472	13.7	530	472	11.0
2027	16.2	546	460	15.8	523	462	11.5
2028*	16.2	547	462	15.5	523	460	12.0
2029*	16.2	547	462	15.5	524	460	12.2
2030*	16.2	547	462	15.5	524	460	12.2

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

* Absent further action, standards assumed to continue unchanged after model year 2027.

TABLE VII–6—STRINGENCY OF HD PICKUP AND VAN STANDARDS, ESTIMATED AVERAGE REQUIRED AND ACHIEVED FUEL CONSUMPTION RATES FOR METHOD A, RELATIVE TO ALTERNATIVE 1a[a]

Model year	Stringency (vs. 2018) (%)	Ave. required fuel cons. (gal./100 mi.)			Ave. achieved fuel cons. (gal./100 mi.)		
		No Action	Final	Reduction (%)	No Action	Final	Reduction (%)
2016	MYs 2016–2020 Subject to Phase 1 Standards.	6.32	6.32	0.0	6.14	6.14	0.0
2017		6.16	6.16	0.0	6.00	5.85	2.4
2018		5.83	5.83	0.0	5.94	5.75	3.2
2019		5.81	5.81	0.0	5.74	5.43	5.4
2020		5.80	5.80	0.0	5.73	5.43	5.2
2021	2.5	5.79	5.65	2.4	5.70	5.27	7.5
2022	4.9	5.80	5.52	4.8	5.69	5.23	8.2
2023	7.3	5.80	5.38	7.2	5.69	5.22	8.3
2024	9.6	5.80	5.25	9.5	5.70	5.22	8.3

TABLE VII–6—STRINGENCY OF HD PICKUP AND VAN STANDARDS, ESTIMATED AVERAGE REQUIRED AND ACHIEVED FUEL CONSUMPTION RATES FOR METHOD A, RELATIVE TO ALTERNATIVE 1a[a]—Continued

Model year	Stringency (vs. 2018) (%)	Ave. required fuel cons. (gal./100 mi.)			Ave. achieved fuel cons. (gal./100 mi.)		
		No Action	Final	Reduction (%)	No Action	Final	Reduction (%)
2025	11.9	5.81	5.13	11.8	5.70	5.13	10.0
2026	14.1	5.81	5.02	13.6	5.70	5.03	11.9
2027	16.2	5.80	4.89	15.8	5.64	4.92	12.8
2028*	16.2	5.81	4.91	15.4	5.64	4.89	13.3
2029*	16.2	5.81	4.91	15.5	5.64	4.89	13.4
2030*	16.2	5.81	4.91	15.5	5.64	4.89	13.4

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

* Absent further action, standards assumed to continue unchanged after model year 2027.

** Increased work factor for some vehicles produces a slight increase in average required fuel consumption.

TABLE VII–7—STRINGENCY OF HD PICKUP AND VAN STANDARDS, ESTIMATED AVERAGE REQUIRED AND ACHIEVED CO_2 EMISSION RATES FOR METHOD A, RELATIVE TO ALTERNATIVE 1a [a]

Model year	Stringency (vs. 2018) (%)	Ave. required CO_2 Rate (g./mi.)			Ave. achieved CO_2 Rate (g./mi.)		
		No Action	Final	Reduction (%)	No Action	Final	Reduction (%)
2016	MYs 2016–2020 Subject to Phase 1 Standards.	597	597	0.0	578	578	0.0
2017		582	582	0.0	564	551	2.3
2018		550	550	0.0	559	541	3.2
2019		548	548	0.0	540	511	5.4
2020		547	547	0.0	538	510	5.2
2021	2.5	545	532	2.4	535	495	7.4
2022	4.9	546	519	4.8	534	491	8.0
2023	7.3	545	506	7.2	533	490	8.2
2024	9.6	547	494	9.5	535	491	8.2
2025	11.9	547	483	11.7	535	483	9.8
2026	14.1	547	472	13.6	535	473	11.7
F 2027	16.2	546	460	15.8	529	462	12.6
2028*	16.2	547	462	15.5	530	460	13.1
2029*	16.2	547	462	15.5	530	460	13.2
2030*	16.2	547	462	15.5	530	460	13.2

Notes:

a For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

* Absent further action, standards assumed to continue unchanged after model year 2027.

** Increased work factor for some vehicles produces a slight increase in the average required CO_2 emission rate.

While the above tables show the agencies' estimates of average fuel consumption and CO_2 emission rates manufacturers of pickups and vans might achieve under today's standards, total U.S. fuel consumption and GHG emissions from HD pickups and vans will also depend on how many of these vehicles are produced, and how they are operated over their useful lives. Relevant to estimating these outcomes, the CAFE model applies vintage-specific estimates of vehicle survival and mileage accumulation, and adjusts the latter to account for the rebound effect. This impact of the rebound effect is specific to each model year (and, underlying, to each vehicle model in each model year), varying with changes in achieved fuel consumption rates.

(ii) Method B for HD Pickups and Vans

For Method B, the MOVES model was used to estimate fuel consumption and GHG emissions for HD pickups and vans. MOVES evaluated these standards for HD pickup trucks and vans in terms of grams of CO_2 per mile or gallons of fuel per 100 miles. Since nearly all HD pickup trucks and vans are certified on a chassis dynamometer, the CO_2 reductions for these vehicles were not represented as engine and road load reduction components, but rather as total vehicle CO_2 reductions. The control case for HD pickups and vans assumed an increase in VMT from the reference levels of 1.08 percent.[548]

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[548] Memorandum to the Docket "VMT Rebound Inputs to MOVES for HDGHG2 Phase 2 FRM" Docket No. EPA–HQ–OAR–2016. July 2016.

TABLE VII–8—ESTIMATED TOTAL VEHICLE CO_2 REDUCTIONS FOR THE FINAL STANDARDS AND IN-USE EMISSIONS FOR HD PICKUP TRUCKS AND VANS IN METHOD B[a]

Vehicle type	Fuel	Model year	CO_2 reduction from flat baseline (%)
HD pickup trucks and vans	Gasoline and Diesel	2021	2.50
		2022	4.94
		2023	7.31
		2024	9.63
		2025	11.89
		2026	14.09
		2027+	16.24

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

C. What are the projected reductions in fuel consumption and GHG emissions?

NHTSA and EPA expect significant reductions in GHG emissions and fuel consumption from the final rules—fuel consumption reductions from more efficient vehicles, emission reductions from both downstream (tailpipe) and upstream (fuel production and distribution) sources, and reduction in HFC emissions from the air conditioning leakage standards (see Section V.B.(2)(c)). The following subsections summarize two different analyses of the annual GHG emissions and fuel consumption reductions expected from these final rules, as well as the reductions in GHG emissions and fuel consumption expected over the lifetime of each heavy-duty vehicle category. Section VII.C.(1) shows the impacts of the final rules on fuel consumption and GHG emissions, using the MOVES model for tractor-trailers and vocational vehicles and the DOT's CAFE model for HD pickups and vans (Method A), relative to two different reference cases—flat and dynamic. Section VII.C.2 shows the impacts of the final standards, relative to the flat reference case only, using the MOVES model for all heavy-duty vehicle categories. NHTSA also analyzes these impacts resulting from the final rules and reasonable alternatives in Chapters 3, 4 and 5 of its FEIS.

(1) Impacts of the Final Rules Using Analysis Method A

(a) Calendar Year Analysis

(i) Downstream (Tailpipe) Emissions Projections

As described in Section VII.A, for the analysis using Method A, the agencies used MOVES to estimate downstream GHG inventories from the final rules for vocational vehicles and tractor-trailers. For HD pickups and vans, DOT's CAFE model was used.

The following two tables summarize the agencies' estimates of HD pickup and van fuel consumption and GHG emissions under the current standards defining the No-Action and final program, respectively, using Method A. Table VII–9 shows results assuming manufacturers will voluntarily make improvements that pay back within six months (*i.e.,* Alternative 1b). Table VII–10 shows results assuming manufacturers will only make improvements as needed to achieve compliance with standards (*i.e.,* Alternative 1a). While underlying calculations are all performed for each calendar year during each vehicle's useful life, presentation of outcomes on a model year basis aligns more clearly with consideration of cost impacts in each model year, and with consideration of standards specified on a model year basis. In addition, Method A analyzes manufacturers' potential responses to HD pickup and van standards on a model year basis through 2030, and any longer-term costs presented in today's notice represent extrapolation of these results absent any underlying analysis of longer-term technology prospects and manufacturers' longer-term product offerings.

TABLE VII–9—ESTIMATED FUEL CONSUMPTION AND GHG EMISSIONS OVER USEFUL LIFE OF HD PICKUPS AND VANS PRODUCED IN EACH MODEL YEAR FOR METHOD A, RELATIVE TO ALTERNATIVE 1b[a]

Model year	Fuel consumption (b. gal.) over fleet's useful life			GHG emissions (MMT CO_2eq) over fleet's useful life		
	No action	Final	Reduction (%)	No action	Final	Reduction (%)
2016	10.4	10.4	0.0	127	127	0.0
2017	10.4	10.2	2.0	127	124	2.0
2018	10.5	10.2	2.9	127	124	2.9
2019	10.1	9.60	4.8	123	117	4.8
2020	10.1	9.60	4.6	123	117	4.6
2021	9.82	9.17	6.6	120	112	6.5
2022	9.67	9.01	6.9	118	110	6.8
2023	9.64	8.97	7.0	117	109	6.9
2024	9.67	9.00	7.0	118	110	6.9
2025	9.79	8.98	8.3	119	109	8.2
2026	9.91	8.90	10.2	121	109	10.1
2027	9.89	8.84	10.7	120	108	10.5
2028	10.0	8.89	11.1	122	108	10.9

Table VII–9—Estimated Fuel Consumption and GHG Emissions Over Useful Life of HD Pickups and Vans Produced in Each Model Year for Method A, Relative to Alternative 1b [a]—Continued

Model year	Fuel consumption (b. gal.) over fleet's useful life			GHG emissions (MMT CO_2eq) over fleet's useful life		
	No action	Final	Reduction (%)	No action	Final	Reduction (%)
2029	10.1	8.97	11.2	123	109	11.1
2030	10.1	8.94	11.2	123	109	11.1

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

Table VII–10—Estimated Fuel Consumption and GHG Emissions Over Useful Life of HD Pickups and Vans Produced in Each Model Year for Method A, Relative to Alternative 1a [a]

Model year	Fuel consumption (b. gal.) over fleet's useful life			GHG emissions (MMT CO_2eq) over fleet's useful		
	No action	Final	Reduction (%)	No action	Final	Reduction (%)
2016	10.43	10.43	0.0	122	122	0.0
2017	10.37	10.15	2.2	122	119	2.2
2018	10.41	10.10	3.0	122	118	3.1
2019	10.04	9.55	4.9	118	112	5.1
2020	10.03	9.56	4.7	118	112	4.9
2021	9.84	9.16	6.9	115	107	7.1
2022	9.74	9.01	7.5	114	105	7.7
2023	9.71	8.97	7.6	114	105	7.8
2024	9.75	9.00	7.6	114	105	7.8
2025	9.88	8.97	9.1	116	105	9.3
2026	10.00	8.92	10.8	117	104	11.1
2027	10.01	8.84	11.7	117	103	11.9
2028	10.12	8.89	12.1	119	104	12.4
2029	10.22	8.98	12.1	120	105	12.4
2030	10.18	8.95	12.2	119	105	12.4

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

To more clearly communicate these trends visually, the following two charts present the above results graphically for Method A, relative to Alternative 1b. As shown, fuel consumption and GHG emissions follow parallel though not precisely identical paths. Though not presented, the charts for Alternative 1a will appear sufficiently similar that differences between Alternative 1a and Alternative 1b remain best communicated by comparing values in the above tables.

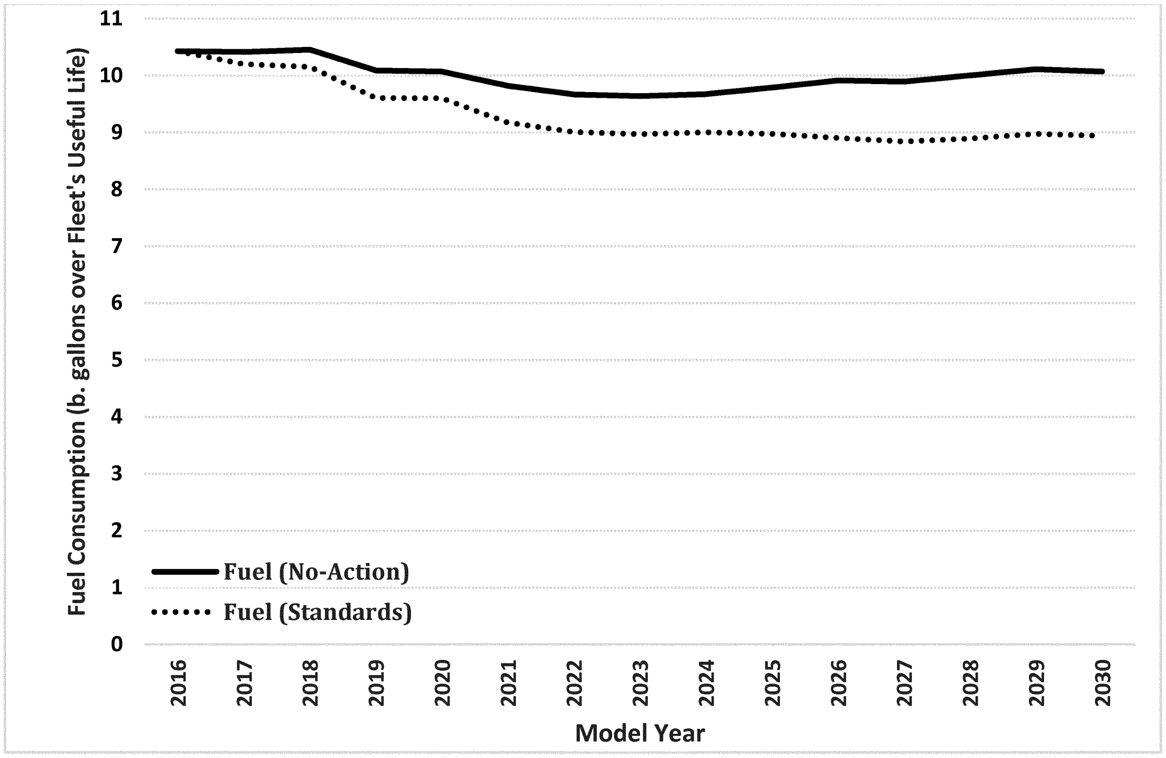

Figure VII-1 Fuel Consumption (b. gal.) over Useful Life of HD Pickups and Vans Produced in Each Model Year for Method A

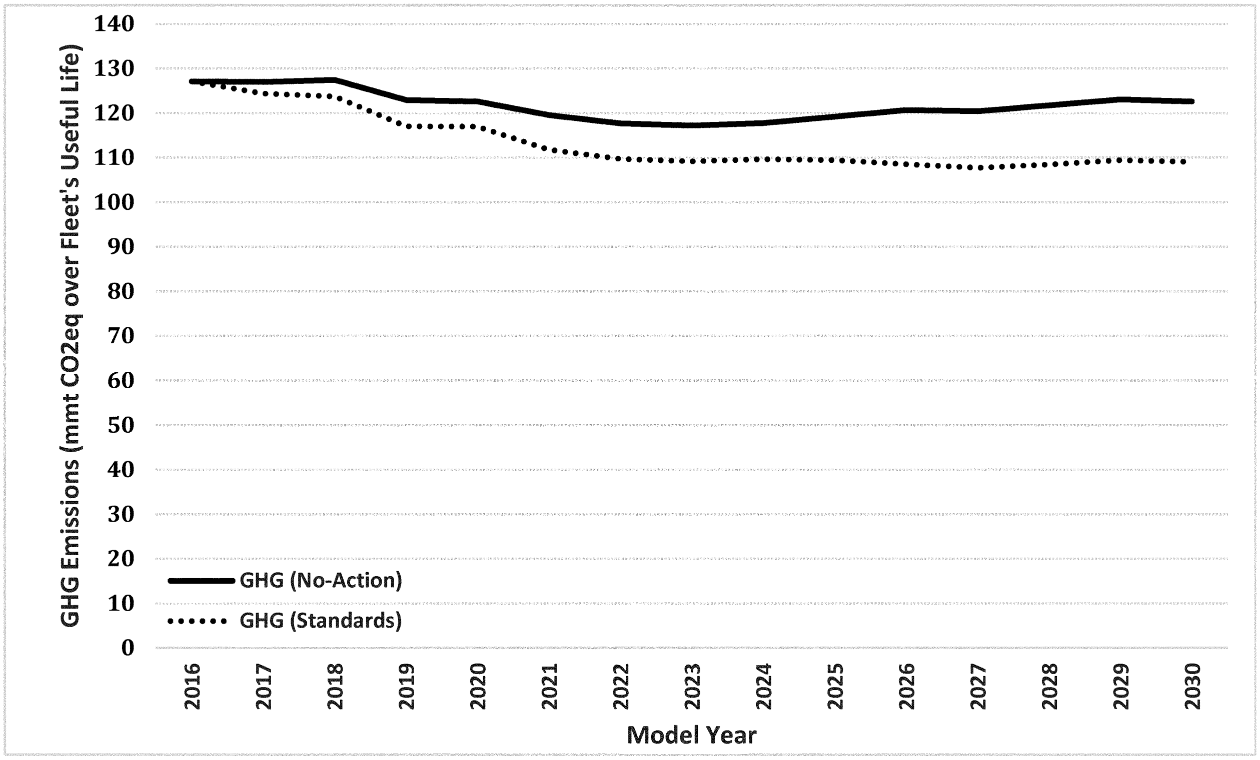

Figure VII-2 GHG Emissions (MMT CO_2eq) over Useful Life of HD Pickups and Vans Produced in Each Model Year for Method A

Table VII–11—Annual Downstream GHG Emissions Impacts in Calendar Years 2025, 2040 and 2050—Final Program vs. Alt 1b Using Analysis Method A[a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total downstream	
				MMT CO_2eq	% Change
2025	−26.5	−0.004	0.002	−26.6	−4.9
2040	−103.3	−0.02	0.006	−103.3	−17.0
2050	−123.8	−0.03	0.007	−123.8	−18.0

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

Table VII–12—Annual Fuel Savings in Calendar Years 2025, 2040 and 2050—Final Program vs. Alt 1b Using Analysis Method A[a]

CY	Diesel		Gasoline	
	Billion gallons	% Savings	Billion gallons	% Savings
2025	2.3	4.9	0.4	5.0
2040	9.2	17.8	1.0	12.2
2050	11.1	19.3	1.2	12.8

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

Table VII–13—Annual Downstream GHG Emissions Impacts in Calendar Years 2025, 2040 and 2050—Final Program vs. Alt 1a Using Analysis Method A[a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total downstream	
				MMT CO_2eq	% Change
2025	−28.9	−0.005	0.003	−28.9	−5.3
2040	−114.1	−0.02	0.006	−114.1	−18.0
2050	−136.9	−0.03	0.007	−136.9	−20.0

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

Table VII–14—Annual Fuel Savings in Calendar Years 2025, 2040 and 2050—Final Program vs. Alt 1a Using Analysis Method A[a]

CY	Diesel		Gasoline	
	Billion gallons	% Savings	Billion gallons	% Savings
2025	2.4	5.2	0.5	5.6
2040	10.2	19.0	1.2	13.0
2050	12.3	21.0	1.3	14.0

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(ii) Upstream (Fuel Production and Distribution) Emissions Projections

Table VII–15—Annual Upstream GHG Emissions Impacts in Calendar Years 2025, 2040 and 2050—Final Program vs. Alt 1b Using Analysis Method A[a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total upstream	
				MMT CO_2eq	% Change
2025	−8.1	−0.9	−0.08	−9.0	−4.9
2040	−31.8	−3.4	−0.2	−35.5	−17.0
2050	−38.1	−4.2	−0.2	−42.5	−19.0

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE VII–16—ANNUAL UPSTREAM GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD A [a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total upstream	
				MMT CO_2eq	% Change
2025	−8.7	−0.9	−0.09	−9.8	−5.3
2040	−35.2	−3.9	−0.2	−39.3	−19.0
2050	−42.2	−4.6	−0.3	−47.2	−20.0

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(iii) HFC Emissions Projections

The projected HFC emission reductions due to the HD Phase 2 air conditioning leakage standards for vocational vehicles are 86,735 metric tons of CO_2eq in 2025, 256,061 metric tons of CO_2eq in 2040, and 314,930 metric tons CO_2eq in 2050. See Chapter 5 of the RIA for additional details on calculations of HFC emissions.

(iv) Total (Downstream + Upstream + HFC) Emissions Projections

TABLE VII–17—ANNUAL TOTAL GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1b USING ANALYSIS METHOD A [a]

	CY2025		CY2040		CY2050	
	MMT CO_2eq	% Change	MMT CO_2eq	% Change	MMT CO_2eq	% Change
Downstream	−26.6	−4.9	−103.3	−17.0	−123.8	−18.0
Upstream	−9.0	−4.9	−35.5	−17.0	−42.5	−19.0
HFC[b]	−0.1	−15.0	−0.3	−13.0	−0.3	−13.0
Total	−35.7	−4.9	−139.1	−17.0	−166.6	−19.0

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.
[b] HFC represents HFC emission reductions and percent change from the vocational vehicle category only.

TABLE VII–18 ANNUAL TOTAL GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD A [a]

	CY2025		CY2040		CY2050	
	MMT CO_2eq	% Change	MMT CO_2eq	% Change	MMT CO_2eq	% Change
Downstream	−28.9	−5.3	−114.1	−18.0	−136.9	−20.0
Upstream	−9.8	−5.3	−39.3	−19.0	−47.2	−20.0
HFC	−0.1	−15.0	−0.3	−13.0	−0.3	−13.0
Total	−38.8	−5.3	−153.7	−19.0	−184.4	−20.0

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(b) Model Year Lifetime Analysis

TABLE VII–19—LIFETIME GHG REDUCTIONS AND FUEL SAVINGS USING ANALYSIS METHOD A—SUMMARY FOR MODEL YEARS 2018–2029 [a]

No–action alternative (baseline)	Final program (alternative 3)	
	1b (dynamic)	1a (flat)
Fuel Savings (Billion Gallons)	71.1	77.7
Total GHG Reductions (MMT CO_2eq)	958	1,049
Downstream (MMT CO_2eq)	715	781
Upstream (MMT CO_2eq)	243	268

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(2) Impacts of the Final Rules Using Analysis Method B

(a) Calendar Year Analysis

(i) Downstream (Tailpipe) Emissions Projections

As described in Section VII.A., Method B used MOVES to estimate downstream GHG inventories from the final rules, relative to Alternative 1a, for all heavy-duty vehicle categories (including the engines associated with tractor-trailer combinations and vocational vehicles). The agencies expect reductions in CO_2 emissions from all heavy-duty vehicle categories due to engine and vehicle improvements. We expect N_2O emissions to increase very slightly because of a rebound in vehicle miles traveled (VMT). However, since N_2O is produced as a byproduct of fuel combustion, the increase in N_2O emissions is expected to be more than offset by the improvements in fuel efficiency from the final rules.[549] We expect methane emissions to decrease primarily due to reduced refueling from improved fuel efficiency and the differences in hydrocarbon emission characteristics between on-road diesel engines and APUs. The amount of methane emitted as a fraction of total hydrocarbons is expected to be less for APUs than for on-road diesel engines during extended idling. Overall, the downstream GHG emissions will be reduced significantly and are described in the following subsections.

Fuel consumption is calculated from the MOVES output of total energy consumption converted using the fuel heating values assumed in the Renewable Fuels Standard rulemaking[550] and in MOVES.[551]

Table VII–20 shows the impacts on downstream GHG emissions and fuel savings in 2025, 2040 and 2050, relative to Alternative 1a, for the final program.

Table VII–21 shows the estimated fuel savings from the final program in 2025, 2040, and 2050, relative to Alternative 1a. The results from the comparable analyses relative to Alternative 1b are presented in Section VII.C.(1).

TABLE VII–20—ANNUAL DOWNSTREAM GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B[a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total downstream	
				MMT CO_2eq	% Change
2025	−27.8	−0.01	0.002	−27.8	−4.6
2040	−124.3	−0.02	0.003	−124.3	−18.4
2050	−148.4	−0.03	0.004	−148.4	−0.0

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE VII–21—ANNUAL FUEL SAVINGS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B[a]

CY	Diesel		Gasoline	
	Billion gallons	% Savings	Billion gallons	% Savings
2025	2.5	5.0	0.3	2.8
2040	10.8	19.4	1.7	13.3
2050	13.0	21.0	1.9	14.4

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(ii) Upstream (Fuel Production and Distribution) Emissions Projections

The upstream GHG emission reductions associated with the production and distribution of gasoline and diesel from crude oil include the domestic emission reductions only. Additionally, since this rulemaking is not expected to impact biofuel volumes mandated by the annual Renewable Fuel Standards (RFS) regulations[552], the impacts on upstream emissions from changes in biofuel feedstock (*i.e.,* agricultural sources such as fertilizer, fugitive dust, and livestock) are not shown. In other words, we attribute decreased fuel consumption from this program to petroleum-based fuels only, while assuming no net effect on volumes of renewable fuels. We used this approach because annual renewable fuel volumes are mandated independently from this rulemaking under RFS. As a consequence, it is not possible to conclude whether the decreasing petroleum consumption projected here would increase the fraction of the U.S. fuel supply that is made up by renewable fuels (if RFS volumes remained constant), or whether future renewable fuel volume mandates would decrease in proportion to the decreased petroleum consumption projected here.

As background, EPA sets annual renewable fuel volume mandates through a separate RFS notice-and-comment rulemaking process, and the

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[549] MOVES is not capable of modeling the changes in exhaust N_2O emissions from the improvements in fuel efficiency. Due to this limitation, a conservative approach was taken to only model the VMT rebound in estimating the emissions impact on N_2O from the final rules, resulting in a slight increase in downstream N_2O inventory.

[550] Renewable Fuels Standards assumptions of 115,000 BTU/gallon gasoline (E0) and 76,330 BTU/gallon ethanol (E100) were weighted 90 percent and 10 percent, respectively, for E10 and 85 percent and 15 percent, respectively, for E15 and converted to kJ at 1.055 kJ/BTU. The conversion factors are 117,245 kJ/gallon for gasoline blended with ten percent ethanol (E10) and 115,205 kJ/gallon for gasoline blended with fifteen percent ethanol (E15).

[551] The conversion factor for diesel is 138,451 kJ/gallon. See MOVES2004 Energy and Emission Inputs. EPA420–P–05–003, March 2005. *http://www3.epa.gov/otaq/models/ngm/420p05003.pdf* (last accessed Mar 15, 2016).

[552] U.S. EPA. 2014 Standards for the Renewable Fuel Standard Program. 40 CFR part 80. EPA–HQ–OAR–2013–0479; FRL–9900–90–OAR, RIN 2060–AR76.

final volumes are based on EIA projections, EPA's own market assessment, and information obtained from the RFS notice and comment process. Also, RFS standards are nested within each other, which means that a fuel with a higher GHG reduction threshold can be used to meet the standards for a lower GHG reduction threshold. This creates additional uncertainty in projecting this rule's net effect on future annual RFS standards.

In conclusion, the impacts of this rulemaking on annual renewable fuel volume mandates are difficult to project at the present time. However, since it is not centrally relevant to the analysis for this rulemaking, we have not included any impacts on renewable fuel volumes in this analysis. The upstream GHG emission reductions of the final program can be found in Table VII–22.

TABLE VII–22—ANNUAL UPSTREAM GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B [a]

CY	CO_2 (MMT)	CH_4 (MMT CO_2eq)	N_2O (MMT CO_2eq)	Total upstream	
				MMT CO_2eq	% CHANGE
2025	−8.6	−0.9	−0.04	−9.5	−4.7
2040	−38.0	−4.0	−0.2	−42.2	−18.7
2050	−45.5	−4.8	−0.2	−50.5	−20.3

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(iii) HFC Emissions Projections

The projected HFC emission reductions due to the HD Phase 2 air conditioning leakage standards for vocational vehicles are 86,735 metric tons of CO_2eq in 2025, 256,061 metric tons of CO_2eq in 2040, and 314,930 metric tons CO_2eq in 2050. See Chapter 5 of the RIA for additional details on calculations of HFC emissions.

(iv) Total (Downstream + Upstream + HFC) Emissions Projections

Table VII–23 combines the impacts of the final program from downstream (Table VII–20), upstream (Table VII–22), and HFC to summarize the total GHG reductions in calendar years 2025, 2040 and 2050, relative to Alternative 1a.

TABLE VII–23—ANNUAL TOTAL GHG EMISSIONS IMPACTS IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B [a]

	CY2025		CY2040		CY2050	
	MMT CO_2eq	% Change	MMT CO_2eq	% Change	MMT CO_2eq	% Change
Downstream	−27.8	−4.6	−124.3	−18.4	−148.4	−20.0
Upstream	−9.5	−4.7	−42.2	−18.7	−50.5	−20.3
HFC [b]	−0.1	−15.0	−0.3	−13.0	−0.3	−13.0
Total	−37.4	−4.7	−166.8	−18.5	−199.2	−20.1

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] HFC represents HFC emission reductions and percent change from the vocational vehicle category only.

(b) Model Year Lifetime Analysis

In addition to the annual GHG emissions and fuel consumption reductions expected from the final rules, we estimated the combined (downstream and upstream) GHG and fuel consumption impacts for the lifetime of the impacted vehicles sold in the regulatory timeframe. Table VII–24 shows the fleet-wide GHG reductions and fuel savings from the final program, relative to Alternative 1a, through the lifetime of heavy-duty vehicles.[553] For the lifetime GHG reductions and fuel savings by vehicle categories, see Chapter 5 of the RIA.

TABLE VII–24—LIFETIME GHG REDUCTIONS AND FUEL SAVINGS USING ANALYSIS METHOD B—SUMMARY FOR MODEL YEARS 2018–2029 [a]

Model years	Final program (Alternative 3)
No-action alternative (baseline)	1a (Flat)
Fuel Savings (Billion Gallons)	82.2
Total GHG Reductions (MMT CO_2eq)	1,097.6
Downstream (MMT CO_2eq)	819.2
Upstream (MMT CO_2eq)	278.4

Note:

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[553] A lifetime of 30 years is assumed in MOVES.

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

D. Climate Impacts and Indicators

(1) Climate Change Impacts From GHG Emissions

The impact of GHG emissions on the climate has been reviewed in the 2009 Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act, the 2012–2016 light-duty vehicle rulemaking, the 2014–2018 heavy-duty vehicle GHG and fuel efficiency rulemaking, the 2017–2025 light-duty vehicle rulemaking, and the standards for new electricity utility generating units. See 74 FR 66496; 75 FR 25491; 76 FR 57294; 77 FR 62894; 79 FR 1456–1459; 80 FR 64662. This section briefly discusses again some of the climate impact of EPA's actions in context of transportation emissions. NHTSA has analyzed the climate impacts of its specific actions (*i.e.,* excluding EPA's HFC regulatory provisions) as well as reasonable alternatives in its DEIS that accompanies this final rules. DOT has considered the potential climate impacts documented in the DEIS as part of the rulemaking process.

Once emitted, GHGs that are the subject of this regulation can remain in the atmosphere for decades to millennia, meaning that (1) their concentrations become well-mixed throughout the global atmosphere regardless of emission origin, and (2) their effects on climate are long lasting. GHG emissions come mainly from the combustion of fossil fuels (coal, oil, and gas), with additional contributions from the clearing of forests, agricultural activities, cement production, and some industrial activities. Transportation activities, in aggregate, were the second largest contributor to total U.S. GHG emissions in 2010 (27 percent of total emissions).[554]

The EPA Administrator relied on thorough and peer-reviewed assessments of climate change science prepared by the Intergovernmental Panel on Climate Change (‘‘IPCC’’), the United States Global Change Research Program (‘‘USGCRP’’), and the National Research Council of the National Academies (‘‘NRC’’) [555] as the primary scientific and technical basis for the Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act (74 FR 66496, December 15, 2009). These assessments comprehensively address the scientific issues the EPA Administrator had to examine, providing her data and information on a wide range of issues pertinent to the Endangerment Finding. These assessments have been rigorously reviewed by the expert community, and also by United States government agencies and scientists, including by EPA itself.

Based on these assessments, the EPA Administrator determined that the emissions from new motor vehicles and engines contribute to elevated concentrations of greenhouse gases; that these greenhouse gases cause warming; that the recent warming has been attributed to the increase in greenhouse gases; and that warming of the climate endangers the public health and welfare of current and future generations. See *Coalition for Responsible Regulation* v. *EPA,* 684 F. 3d 102, 121 (D.C. Cir. 2012) (upholding all of EPA's findings and stating ‘‘EPA had before it substantial record evidence that anthropogenic emissions of greenhouse gases ‘very likely' caused warming of the climate over the last several decades. EPA further had evidence of current and future effects of this warming on public health and welfare. Relying again upon substantial scientific evidence, EPA determined that anthropogenically induced climate change threatens both public health and public welfare. It found that extreme weather events, changes in air quality, increases in food- and water-borne pathogens, and increases in temperatures are likely to have adverse health effects. The record also supports EPA's conclusion that climate change endangers human welfare by creating risk to food production and agriculture, forestry, energy, infrastructure, ecosystems, and wildlife. Substantial evidence further supported EPA's conclusion that the warming resulting from the greenhouse gas emissions could be expected to create risks to water resources and in general to coastal areas as a result of expected increase in sea level.'')

A number of major peer-reviewed scientific assessments have been released since the administrative record concerning the Endangerment Finding closed following EPA's 2010 Reconsideration Denial.[556] These assessments include the ‘‘Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation'' [557], the 2013–14 Fifth Assessment Report (AR5),[558] the 2014 National Climate Assessment report,[559] the ‘‘Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean,'' [560] ‘‘Report on Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia,'' [561] ‘‘National Security Implications for U.S. Naval Forces'' (National Security Implications),[562] ‘‘Understanding Earth's Deep Past: Lessons for Our Climate Future,'' [563] ‘‘Sea Level Rise for

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[554] U.S. EPA (2012) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010. EPA 430–R–12–001. Available at *http://epa.gov/climatechange/emissions/downloads12/US-GHG-Inventory-2012-Main-Text.pdf.*

[555] For a complete list of core references from IPCC, USGCRP/CCSP, NRC and others relied upon for development of the TSD for EPA's Endangerment and Cause or Contribute Findings see Section 1(b), specifically, Table 1.1 of the TSD. (Docket EPA–HQ–OAR–2010–0799).

[556] ‘‘EPA's Denial of the Petitions to Reconsider the Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act,'' 75 FR 49,556 (Aug. 13, 2010) (‘‘Reconsideration Denial'').

[557] Intergovernmental Panel on Climate Change (IPCC). 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA.

[558] Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[559] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. Available at *http://nca2014.globalchange.gov.*

[560] National Research Council (NRC). 2010. Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean. National Academies Press. Washington, DC.

[561] National Research Council (NRC). 2011. Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia. National Academies Press, Washington, DC.

[562] National Research Council (NRC) 2011. National Security Implications of Climate Change for U.S. Naval Forces. National Academies Press. Washington, DC.

[563] National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and

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the Coasts of California, Oregon, and Washington: Past, Present, and Future,'' [564] ''Climate and Social Stress: Implications for Security Analysis,'' [565] and ''Abrupt Impacts of Climate Change'' (Abrupt Impacts) assessments.[566]

EPA has reviewed these assessments and finds that, in general, the improved understanding of the climate system they present is consistent with the assessments underlying the 2009 Endangerment Finding.

The most recent assessments released were the IPCC AR5 assessments between September 2013 and April 2014, the NRC Abrupt Impacts assessment in December of 2013, and the U.S. National Climate Assessment in May of 2014. The NRC Abrupt Impacts report examines the potential for tipping points, thresholds beyond which major and rapid changes occur in the Earth's climate system or other systems impacted by the climate. The Abrupt Impacts report did find less cause for concern than some previous assessments regarding some abrupt events within the next century, such as disruption of the Atlantic Meridional Overturning Circulation (AMOC) and sudden releases of high-latitude methane from hydrates and permafrost, but found that the potential for abrupt changes in ecosystems, weather and climate extremes, and groundwater supplies critical for agriculture now seem more likely, severe, and imminent. The assessment found that some abrupt changes were already underway (Arctic sea ice retreat and increases in extinction risk due to the speed of climate change) but cautioned that even abrupt changes such as the AMOC disruption that are not expected in this century can have severe impacts when they happen.

The IPCC AR5 assessments are also generally consistent with the underlying science supporting the 2009 Endangerment Finding. For example, confidence in attributing recent warming to human causes has increased: The IPCC stated that it is extremely likely (≤95 percent confidence) that human influences have been the dominant cause of recent warming. Moreover, the IPCC found that the last 30 years were likely (≤66 percent confidence) the warmest 30 year period in the Northern Hemisphere of the past 1400 years, that the rate of ice loss of worldwide glaciers and the Greenland and Antarctic ice sheets has likely increased, that there is medium confidence that the recent summer sea ice retreat in the Arctic is larger than it has been in 1450 years, and that concentrations of carbon dioxide and several other of the major greenhouse gases are higher than they have been in at least 800,000 years. Climate-change induced impacts have been observed in changing precipitation patterns, melting snow and ice, species migration, negative impacts on crops, increased heat and decreased cold mortality, and altered ranges for water-borne illnesses and disease vectors. Additional risks from future changes include death, injury, and disrupted livelihoods in coastal zones and regions vulnerable to inland flooding, food insecurity linked to warming, drought, and flooding, especially for poor populations, reduced access to drinking and irrigation water for those with minimal capital in semi-arid regions, and decreased biodiversity in marine ecosystems, especially in the Arctic and tropics, with implications for coastal livelihoods. The IPCC determined that ''[c]ontinued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gases emissions.''

Finally, the recently released National Climate Assessment stated, ''Climate change is already affecting the American people in far reaching ways. Certain types of extreme weather events with links to climate change have become more frequent and/or intense, including prolonged periods of heat, heavy downpours, and, in some regions, floods and droughts. In addition, warming is causing sea level to rise and glaciers and Arctic sea ice to melt, and oceans are becoming more acidic as they absorb carbon dioxide. These and other aspects of climate change are disrupting people's lives and damaging some sectors of our economy.''

Assessments from these bodies represent the current state of knowledge, comprehensively cover and synthesize thousands of individual studies to obtain the majority conclusions from the body of scientific literature and undergo a rigorous and exacting standard of review by the peer expert community and U.S. government.

Based on modeling analysis performed by the agencies, reductions in CO_2 and other GHG emissions associated with these final rules will affect future climate change. Since GHGs are well-mixed in the atmosphere and have long atmospheric lifetimes, changes in GHG emissions will affect atmospheric concentrations of greenhouse gases and future climate for decades to millennia, depending on the gas. This section provides estimates of the projected change in atmospheric CO_2 concentrations based on the emission reductions estimated for these final rules, compared to the reference case. In addition, this section analyzes the response to the changes in GHG concentrations of the following climate-related variables: Global mean temperature, sea level rise, and ocean pH.

(2) Projected Change in Atmospheric CO_2 Concentrations, Global Mean Surface Temperature and Sea Level Rise

To assess the impact of the emissions reductions from the final rules, EPA estimated changes in projected atmospheric CO_2 concentrations, global mean surface temperature and sea-level rise to 2100 using the GCAM (Global Change Assessment Model, formerly MiniCAM), integrated assessment model [567] coupled with the MAGICC (Model for the Assessment of Greenhouse-gas Induced Climate Change) simple climate model.[568] GCAM was used to create the globally and temporally consistent set of climate relevant emissions required for running MAGICC. MAGICC was then used to estimate the projected change in relevant climate variables over time. Given the magnitude of the estimated

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Washington: Past, Present, and Future. National Academies Press. Washington, DC.

[564] National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. National Academies Press. Washington, DC.

[565] National Research Council (NRC). 2013. Climate and Social Stress: Implications for Security Analysis. National Academies Press. Washington, DC.

[566] National Research Council (NRC). 2013. Abrupt Impacts of Climate Change: Anticipating Surprises. National Academies Press. Washington, DC.

[567] GCAM is a long-term, global integrated assessment model of energy, economy, agriculture and land use that considers the sources of emissions of a suite of greenhouse gases (GHG's), emitted in 14 globally disaggregated regions, the fate of emissions to the atmosphere, and the consequences of changing concentrations of greenhouse related gases for climate change. GCAM begins with a representation of demographic and economic developments in each region and combines these with assumptions about technology development to describe an internally consistent representation of energy, agriculture, land-use, and economic developments that in turn shape global emissions.

[568] MAGICC consists of a suite of coupled gas-cycle, climate and ice-melt models integrated into a single framework. The framework allows the user to determine changes in greenhouse-gas concentrations, global-mean surface air temperature and sea-level resulting from anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), reactive gases (CO, NO_X, VOCs), the halocarbons (*e.g.* HCFCs, HFCs, PFCs) and sulfur dioxide (SO_2). MAGICC emulates the global-mean temperature responses of more sophisticated coupled Atmosphere/Ocean General Circulation Models (AOGCMs) with high accuracy.

emissions reductions associated with these rules, a simple climate model such as MAGICC is appropriate for estimating the atmospheric and climate response.

The analysis projects that the final rules will reduce atmospheric concentrations of CO_2, global climate warming, ocean acidification, and sea level rise relative to the reference case. Although the projected reductions and improvements are small in comparison to the total projected climate change, they are quantifiable, directionally consistent, and will contribute to reducing the risks associated with climate change. Climate change is a global phenomenon, and EPA recognizes that this one national action alone will not prevent it; EPA notes this would be true for any given GHG mitigation action when taken alone or when considered in isolation. EPA also notes that a substantial portion of CO_2 emitted into the atmosphere is not removed by natural processes for millennia, and therefore each unit of CO_2 not emitted into the atmosphere due to this rules avoids essentially permanent climate change on centennial time scales.

EPA determines that the projected reductions in atmospheric CO_2, global mean temperature, sea level rise, and ocean pH are meaningful in the context of this action. The results of the analysis, summarized in Table VII–25, demonstrate that relative to the reference case, by 2100 projected atmospheric CO_2 concentrations are estimated to be reduced by 1.2 to 1.3 part per million by volume (ppmv), global mean temperature is estimated to be reduced by 0.0027 to 0.0065 °C, and sea-level rise is projected to be reduced by approximately 0.026 to 0.058 cm, based on a range of climate sensitivities (described below). Details about this modeling analysis can be found in the RIA Chapter 6.3.

TABLE VII–25—IMPACT OF GHG EMISSIONS REDUCTIONS ON PROJECTED CHANGES IN GLOBAL CLIMATE ASSOCIATED WITH PHASE 2 STANDARDS FOR MY 2018–2024

[Based on a range of climate sensitivities from 1.5–6 °C]

Variable	Units	Year	Projected change
Atmospheric CO_2 Concentration	ppmv	2100	−1.2 to −1.3
Global Mean Surface Temperature	°C	2100	−0.0027 to −0.0065
Sea Level Rise	cm	2100	−0.026 to −0.058
Ocean pH	pH units	2100	+0.0006 [a]

Note:

[a] The value for projected change in ocean pH is based on a climate sensitivity of 3.0.

The projected reductions are small relative to the change in temperature (1.8–4.8 °C), CO_2 concentration (404 to 470 ppm), sea level rise (23–56 cm), and ocean acidity (−0.30 pH units) from 1990 to 2100 from the MAGICC simulations for the GCAM reference case. However, this is to be expected given the magnitude of emissions reductions expected from the program in the context of global emissions. Moreover, these effects are occurring everywhere around the globe, so benefits that appear to be marginal for any one location, such as a reduction in sea level rise of half a millimeter, can be sizable when the effects are summed along thousands of miles of coastline. This uncertainty range does not include the effects of uncertainty in future emissions. It should also be noted that the calculations in MAGICC do not include the possible effects of accelerated ice flow in Greenland and/or Antarctica: estimates of sea level rise from the recent NRC, IPCC, and NCA assessments range from 26 cm to 2 meters depending on the emissions scenario, the processes included, and the likelihood range assessed; inclusion of these effects would lead to correspondingly larger benefits of mitigation. Further discussion of EPA's modeling analysis is found in the RIA, Chapter 6.3.

Based on the projected atmospheric CO_2 concentration reductions resulting from these final rules, EPA calculates an increase in ocean pH of 0.0006 pH units in 2100 relative to the baseline case (this is a reduction in the expected acidification of the ocean of a decrease of 0.3 pH units from 1990 to 2100 in the baseline case). Thus, this analysis indicates the projected decrease in atmospheric CO_2 concentrations from the Phase 2 standards will result in an increase in ocean pH (*i.e.,* a reduction in the expected acidification of the ocean in the reference case). A more detailed discussion of the modeling analysis associated with ocean pH is provided in the RIA, Chapter 6.3.

The 2011 NRC assessment on ''Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia'' determined how a number of climate impacts—such as heaviest daily rainfalls, crop yields, and Arctic sea ice extent—would change with a temperature change of 1 degree Celsius (C) of warming. These relationships of impacts with temperature change could be combined with the calculated reductions in warming in Table VII–25 to estimate changes in these impacts associated with this final rulemaking.

As a substantial portion of CO_2 emitted into the atmosphere is not removed by natural processes for millennia, each unit of CO_2 not emitted into the atmosphere avoids some degree of effectively permanent climate change. Therefore, reductions in emissions in the near term are important in determining climate impacts experienced not just over the next decades but over thousands of years.[569] Though the magnitude of the avoided climate change projected here in isolation is small in comparison to the total projected changes, these reductions represent a reduction in the adverse risks associated with climate change (though these risks were not formally estimated for this action) across a range of equilibrium climate sensitivities. In addition, these reductions are part of a larger suite of domestic and international mitigation actions, and should be considered in that context.

EPA's analysis of this final rule's impact on global climate conditions is intended to quantify these potential reductions using the best available science. EPA's modeling results show consistent reductions relative to the baseline case in changes of CO_2 concentration, temperature, sea-level rise, and ocean pH over the next century.

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[569] National Research Council (NRC) (2011). Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia. National Academy Press. Washington, DC. (Docket EPA–HQ–OAR–2010–0799).

VIII. How will these rules impact non-GHG emissions and their associated effects?

The heavy-duty vehicle standards are expected to influence the emissions of criteria air pollutants and several hazardous air pollutants (air toxics). This section describes the projected impacts of the final rules on non-GHG emissions and air quality and the health and environmental effects associated with these pollutants. NHTSA further analyzes these projected health and environmental effects resulting from its final rules and reasonable alternatives in Chapter 4 of its FEIS.

A. Health Effects of Non-GHG Pollutants

In this section, we discuss health effects associated with exposure to some of the criteria and air toxic pollutants impacted by the final heavy-duty vehicle standards.

(1) Particulate Matter

(a) Background

Particulate matter is a highly complex mixture of solid particles and liquid droplets distributed among numerous atmospheric gases which interact with solid and liquid phases. Particles range in size from those smaller than 1 nanometer (10^{-9} meter) to over 100 micrometers (µm, or 10^{-6} meter) in diameter (for reference, a typical strand of human hair is 70 µm in diameter and a grain of salt is about 100 µm). Atmospheric particles can be grouped into several classes according to their aerodynamic and physical sizes. Generally, the three broad classes of particles include ultrafine particles (UFPs, generally considered as particulates with a diameter less than or equal to 0.1 µm [typically based on physical size, thermal diffusivity or electrical mobility])), ‘‘fine’’ particles ($PM_{2.5}$; particles with a nominal mean aerodynamic diameter less than or equal to 2.5 µm), and ‘‘thoracic’’ particles (PM_{10}; particles with a nominal mean aerodynamic diameter less than or equal to 10 µm).[570] Particles that fall within the size range between $PM_{2.5}$ and PM_{10}, are referred to as ‘‘thoracic coarse particles’’ ($PM_{10-2.5}$, particles with a nominal mean aerodynamic diameter less than or equal to 10 µm and greater than 2.5 µm). EPA currently has standards that regulate $PM_{2.5}$ and PM_{10}.[571]

Particles span many sizes and shapes and may consist of hundreds of different chemicals. Particles are emitted directly from sources and are also formed through atmospheric chemical reactions; the former are often referred to as ‘‘primary’’ particles, and the latter as ‘‘secondary’’ particles. Particle concentration and composition varies by time of year and location, and, in addition to differences in source emissions, is affected by several weather-related factors, such as temperature, clouds, humidity, and wind. A further layer of complexity comes from particles’ ability to shift between solid/liquid and gaseous phases, which is influenced by concentration and meteorology, especially temperature.

Fine particles are produced primarily by combustion processes and by transformations of gaseous emissions (*e.g.,* sulfur oxides (SO_X), oxides of nitrogen, and volatile organic compounds (VOC)) in the atmosphere. The chemical and physical properties of $PM_{2.5}$ may vary greatly with time, region, meteorology, and source category. Thus, $PM_{2.5}$ may include a complex mixture of different components including sulfates, nitrates, organic compounds, elemental carbon and metal compounds. These particles can remain in the atmosphere for days to weeks and travel hundreds to thousands of kilometers.

(b) Health Effects of PM

Scientific studies show exposure to ambient PM is associated with a broad range of health effects. These health effects are discussed in detail in the Integrated Science Assessment for Particulate Matter (PM ISA), which was finalized in December 2009.[572] The PM ISA summarizes health effects evidence for short- and long-term exposures to $PM_{2.5}$, $PM_{10-2.5}$, and ultrafine particles.[573] The PM ISA concludes that human exposures to ambient $PM_{2.5}$ are associated with a number of adverse health effects and characterizes the weight of evidence for broad health categories (*e.g.,* cardiovascular effects, respiratory effects, etc.).[574] The discussion below highlights the PM ISA’s conclusions pertaining to health effects associated with both short- and long-term PM exposures. Further discussion of health effects associated with PM can also be found in the rulemaking documents for the most recent review of the PM NAAQS completed in 2012.[575] [576]

EPA has concluded that ‘‘a causal relationship exists’’ between both long- and short-term exposures to $PM_{2.5}$ and premature mortality and cardiovascular effects and that ‘‘a causal relationship is likely to exist’’ between long- and short-term $PM_{2.5}$ exposures and respiratory effects. Further, there is evidence ‘‘suggestive of a causal relationship’’ between long-term $PM_{2.5}$ exposures and other health effects, including developmental and reproductive effects (*e.g.,* low birth weight, infant mortality) and carcinogenic, mutagenic, and genotoxic effects (*e.g.,* lung cancer mortality).[577]

As summarized in the final rule resulting from the last review (2012) of the PM NAAQS, and discussed extensively in the 2009 p.m. ISA, the available scientific evidence significantly strengthens the link between long- and short-term exposure to $PM_{2.5}$ and mortality, while providing indications that the magnitude of the $PM_{2.5}$- mortality association with long-term exposures may be larger than previously estimated.[578] [579] The strongest evidence comes from recent

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[570] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. Figure 3–1.

[571] Regulatory definitions of PM size fractions, and information on reference and equivalent methods for measuring PM in ambient air, are provided in 40 CFR parts 50, 53, and 58. With regard to national ambient air quality standards (NAAQS) which provide protection against health and welfare effects, the 24-hour PM_{10} standard provides protection against effects associated with short-term exposure to thoracic coarse particles (*i.e.,* $PM_{10-2.5}$).

[572] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F.

[573] The ISA also evaluated evidence for PM components but did not reach causal determinations for components.

[574] The causal framework draws upon the assessment and integration of evidence from across epidemiological, controlled human exposure, and toxicological studies, and the related uncertainties that ultimately influence our understanding of the evidence. This framework employs a five-level hierarchy that classifies the overall weight of evidence and causality using the following categorizations: causal relationship, likely to be causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship (U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Table 1–3).

[575] 78 FR 3103–3104, January 15, 2013.

[576] 77 FR 38906–38911, June 29, 2012.

[577] These causal inferences are based not only on the more expansive epidemiological evidence available in this review but also reflect consideration of important progress that has been made to advance our understanding of a number of potential biologic modes of action or pathways for PM-related cardiovascular and respiratory effects (U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Chapter 5).

[578] 78 FR 3103–3104, January 15, 2013.

[579] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Chapter 6 (Section 6.5) and Chapter 7 (Section 7.6).

studies investigating long-term exposure to $PM_{2.5}$ and cardiovascular-related mortality. The evidence supporting a causal relationship between long-term $PM_{2.5}$ exposure and mortality also includes consideration of studies that demonstrated an improvement in community health following reductions in ambient fine particles.

Several studies evaluated in the 2009 p.m. ISA have examined the association between cardiovascular effects and long-term $PM_{2.5}$ exposures in multi-city epidemiological studies conducted in the U.S. and Europe. These studies have provided new evidence linking long-term exposure to $PM_{2.5}$ with an array of cardiovascular effects such as heart attacks, congestive heart failure, stroke, and mortality. This evidence is coherent with studies of effects associated with short-term exposure to $PM_{2.5}$ that have observed associations with a continuum of effects ranging from subtle changes in indicators of cardiovascular health to serious clinical events, such as increased hospitalizations and emergency department visits due to cardiovascular disease and cardiovascular mortality.[580]

As detailed in the 2009 p.m. ISA, extended analyses of seminal epidemiological studies, as well as more recent epidemiological studies conducted in the U.S. and abroad, provide strong evidence of respiratory-related morbidity effects associated with long-term $PM_{2.5}$ exposure. The strongest evidence for respiratory-related effects is from studies that evaluated decrements in lung function growth (in children), increased respiratory symptoms, and asthma development. The strongest evidence from short-term $PM_{2.5}$ exposure studies has been observed for increased respiratory-related emergency department visits and hospital admissions for chronic obstructive pulmonary disease (COPD) and respiratory infections.[581]

The body of scientific evidence detailed in the 2009 PM ISA is still limited with respect to associations between long-term $PM_{2.5}$ exposures and developmental and reproductive effects as well as cancer, mutagenic, and genotoxic effects. The strongest evidence for an association between $PM_{2.5}$ and developmental and reproductive effects comes from epidemiological studies of low birth weight and infant mortality, especially due to respiratory causes during the post-neonatal period (*i.e.,* 1 month to 12 months of age).[582] With regard to cancer effects, ''[m]ultiple epidemiologic studies have shown a consistent positive association between $PM_{2.5}$ and lung cancer mortality, but studies have generally not reported associations between $PM_{2.5}$ and lung cancer incidence.'' [583]

In addition to evaluating the health effects attributed to short- and long-term exposure to $PM_{2.5}$, the 2009 PM ISA also evaluated whether specific components or sources of $PM_{2.5}$ are more strongly associated with specific health effects. An evaluation of those studies resulted in the 2009 PM ISA concluding that ''many [components] of PM can be linked with differing health effects and the evidence is not yet sufficient to allow differentiation of those [components] or sources that are more closely related to specific health outcomes.'' [584]

For $PM_{10-2.5}$, the 2009 PM ISA concluded that available evidence was ''suggestive of a causal relationship'' between short-term exposures to $PM_{10-2.5}$ and cardiovascular effects (*e.g.,* hospital admissions and Emergency Department (ED) visits, changes in cardiovascular function), respiratory effects (*e.g.,* ED visits and hospital admissions, increase in markers of pulmonary inflammation), and premature mortality. The scientific evidence was ''inadequate to infer a causal relationship'' between long-term exposure to $PM_{10-2.5}$ and various health effects.[585] [586] [587]

For UFPs, the 2009 PM ISA concluded that the evidence was ''suggestive of a causal relationship'' between short-term exposures and cardiovascular effects, including changes in heart rhythm and vasomotor function (the ability of blood vessels to expand and contract). It also concluded that there was evidence ''suggestive of a causal relationship'' between short-term exposure to UFPs and respiratory effects, including lung function and pulmonary inflammation, with limited and inconsistent evidence for increases in ED visits and hospital admissions. Scientific evidence was ''inadequate to infer a causal relationship'' between short-term exposure to UFPs and additional health effects including premature mortality as well as long-term exposure to UFPs and all health outcomes evaluated.[588] [589]

The 2009 PM ISA conducted an evaluation of specific groups within the general population potentially at increased risk for experiencing adverse health effects related to PM exposures.[590] [591] [592] [593] The evidence detailed in the 2009 PM ISA expands our understanding of previously identified at-risk populations and lifestages (*i.e.,* children, older adults, and individuals with pre-existing heart and lung disease) and supports the identification of additional at-risk populations (*e.g.,* persons with lower socioeconomic status, genetic differences). Additionally, there is emerging, though still limited, evidence for additional potentially at-risk populations and lifestages, such as those with diabetes, people who are obese, pregnant women, and the developing fetus.[594]

(2) Ozone

(a) Background

Ground-level ozone pollution is typically formed through reactions involving VOC and NO_X in the lower atmosphere in the presence of sunlight. These pollutants, often referred to as ozone precursors, are emitted by many types of pollution sources, such as highway and nonroad motor vehicles and engines, power plants, chemical

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[580] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Chapter 2 (Section 2.3.1 and 2.3.2) and Chapter 6.

[581] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Chapter 2 (Section 2.3.1 and 2.3.2) and Chapter 6.

[582] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, Chapter 2 (Section 2.3.1 and 2.3.2) and Chapter 7.

[583] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. pg 2–13.

[584] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. pg 2–26.

[585] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. Section 2.3.4 and Table 2–6.

[586] 78 FR 3167–3168, January 15, 2013.

[587] 77 FR 38947–38951, June 29, 2012.

[588] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. Section 2.3.5 and Table 2–6.

[589] 78 FR 3121, January 15, 2013.

[590] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. Chapter 8 and Chapter 2.

[591] 77 FR 38890, June 29, 2012.

[592] 78 FR 3104, January 15, 2013.

[593] U.S. EPA. (2011). Policy Assessment for the Review of the PM NAAQS. U.S. Environmental Protection Agency, Washington, DC, EPA/452/R–11–003. Section 2.2.1.

[594] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F. Chapter 8 and Chapter 2 (Section 2.4.1).

plants, refineries, makers of consumer and commercial products, industrial facilities, and smaller area sources.

The science of ozone formation, transport, and accumulation is complex. Ground-level ozone is produced and destroyed in a cyclical set of chemical reactions, many of which are sensitive to temperature and sunlight. When ambient temperatures and sunlight levels remain high for several days and the air is relatively stagnant, ozone and its precursors can build up and result in more ozone than typically occurs on a single high-temperature day. Ozone and its precursors can be transported hundreds of miles downwind from precursor emissions, resulting in elevated ozone levels even in areas with low local VOC or NO_X emissions.

(b) Health Effects of Ozone

This section provides a summary of the health effects associated with exposure to ambient concentrations of ozone.[595] The information in this section is based on the information and conclusions in the February 2013 Integrated Science Assessment for Ozone (Ozone ISA), which formed the basis for EPA's revision to the primary and secondary standards in 2015.[596] The Ozone ISA concludes that human exposures to ambient concentrations of ozone are associated with a number of adverse health effects and characterizes the weight of evidence for these health effects.[597] The discussion below highlights the Ozone ISA's conclusions pertaining to health effects associated with both short-term and long-term periods of exposure to ozone.

For short-term exposure to ozone, the Ozone ISA concludes that respiratory effects, including lung function decrements, pulmonary inflammation, exacerbation of asthma, respiratory-related hospital admissions, and mortality, are causally associated with ozone exposure. It also concludes that cardiovascular effects, including decreased cardiac function and increased vascular disease, and total mortality are likely to be causally associated with short-term exposure to ozone and that evidence is suggestive of a causal relationship between central nervous system effects and short-term exposure to ozone.

For long-term exposure to ozone, the Ozone ISA concludes that respiratory effects, including new onset asthma, pulmonary inflammation and injury, are likely to be causally related with ozone exposure. The Ozone ISA characterizes the evidence as suggestive of a causal relationship for associations between long-term ozone exposure and cardiovascular effects, reproductive and developmental effects, central nervous system effects and total mortality. The evidence is inadequate to infer a causal relationship between chronic ozone exposure and increased risk of lung cancer.

Finally, inter-individual variation in human responses to ozone exposure can result in some groups being at increased risk for detrimental effects in response to exposure. In addition, some groups are at increased risk of exposure due to their activities, such as outdoor workers or children. The Ozone ISA identified several groups that are at increased risk for ozone-related health effects. These groups are people with asthma, children and older adults, individuals with reduced intake of certain nutrients (*i.e.,* Vitamins C and E), outdoor workers, and individuals having certain genetic variants related to oxidative metabolism or inflammation. Ozone exposure during childhood can have lasting effects through adulthood. Such effects include altered function of the respiratory and immune systems. Children absorb higher doses (normalized to lung surface area) of ambient ozone, compared to adults, due to their increased time spent outdoors, higher ventilation rates relative to body size, and a tendency to breathe a greater fraction of air through the mouth. Children also have a higher asthma prevalence compared to adults. Additional children's vulnerability and susceptibility factors are listed in Section XIV.

(3) Nitrogen Oxides

(a) Background

Oxides of nitrogen (NO_X) refers to nitric oxide and nitrogen dioxide (NO_2). For the NO_X NAAQS, NO_2 is the indicator. Most NO_2 is formed in the air through the oxidation of nitric oxide (NO) emitted when fuel is burned at a high temperature. NO_X is also a major contributor to secondary $PM_{2.5}$ formation. The health effects of ambient PM are discussed in Section VIII.A.1.b of this Preamble. NO_X and VOC are the two major precursors of ozone. The health effects of ozone are covered in Section VIII.A.2.b.

(b) Health Effects of Nitrogen Oxides

The most recent review of the health effects of oxides of nitrogen completed by EPA can be found in the 2016 Integrated Science Assessment for Oxides of Nitrogen—Health Criteria (Oxides of Nitrogen ISA).[598] The primary source of NO_2 is motor vehicle emissions, and ambient NO_2 concentrations tend to be highly correlated with other traffic-related pollutants. Thus, a key issue in characterizing the causality of NO_2-health effect relationships was evaluating the extent to which studies supported an effect of NO_2 that is independent of other traffic-related pollutants. EPA concluded that the findings for asthma exacerbation integrated from epidemiologic and controlled human exposure studies provided evidence that is sufficient to infer a causal relationship between respiratory effects and short-term NO_2 exposure. The strongest evidence supporting an independent effect of NO_2 exposure comes from controlled human exposure studies demonstrating increased airway responsiveness in individuals with asthma following ambient-relevant NO_2 exposures. The coherence of this evidence with epidemiologic findings for asthma hospital admissions and ED visits as well as lung function decrements and increased pulmonary inflammation in children with asthma describe a plausible pathway by which NO_2 exposure can cause an asthma exacerbation. The 2016 ISA for Oxides of Nitrogen also concluded that there is likely to be a causal relationship between long-term NO_2 exposure and respiratory effects. This conclusion is based on new epidemiologic evidence for associations of NO_2 with asthma development in children combined with biological plausibility from experimental studies.

In evaluating a broader range of health effects, the 2016 ISA for Oxides of Nitrogen concluded evidence is ''suggestive of, but not sufficient to infer, a causal relationship'' between

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[595] Human exposure to ozone varies over time due to changes in ambient ozone concentration and because people move between locations which have notable different ozone concentrations. Also, the amount of ozone delivered to the lung is not only influenced by the ambient concentrations but also by the individuals breathing route and rate.

[596] U.S. EPA. Integrated Science Assessment of Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–10/076F, 2013. The ISA is available at *http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492#Download.*

[597] The ISA evaluates evidence and draws conclusions on the causal nature of relationship between relevant pollutant exposures and health effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of, but not sufficient to infer, a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For more information on these levels of evidence, please refer to Table II in the Preamble of the ISA.

[598] U.S. EPA. Integrated Science Assessment for Oxides of Nitrogen—Health Criteria (2016 Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–15/068, 2016.

short-term NO_2 exposure and cardiovascular effects and mortality and between long-term NO_2 exposure and cardiovascular effects and diabetes, birth outcomes, and cancer. In addition, the scientific evidence is inadequate (insufficient consistency of epidemiologic and toxicological evidence) to infer a causal relationship for long-term NO_2 exposure with fertility, reproduction, and pregnancy, as well as with postnatal development. A key uncertainty in understanding the relationship between these non-respiratory health effects and short- or long-term exposure to NO_2 is copollutant confounding, particularly by other roadway pollutants. The available evidence for non-respiratory health effects does not adequately address whether NO_2 has an independent effect or whether it primarily represents effects related to other or a mixture of traffic-related pollutants.

The 2016 ISA for Oxides of Nitrogen concluded that people with asthma, children, and older adults are at increased risk for NO_2-related health effects. In these groups and lifestages, NO_2 is consistently related to larger effects on outcomes related to asthma exacerbation, for which there is confidence in the relationship with NO_2 exposure.

(4) Sulfur Oxides

(a) Background

Sulfur dioxide (SO_2), a member of the sulfur oxide (SO_X) family of gases, is formed from burning fuels containing sulfur (*e.g.,* coal or oil derived), extracting gasoline from oil, or extracting metals from ore. SO_2 and its gas phase oxidation products can dissolve in water droplets and further oxidize to form sulfuric acid which reacts with ammonia to form sulfates, which are important components of ambient PM. The health effects of ambient PM are discussed in Section VIII.A.1.b of this Preamble.

(b) Health Effects of SO_2

Information on the health effects of SO_2 can be found in the 2008 Integrated Science Assessment for Sulfur Oxides—Health Criteria (SO_X ISA).[599] Short-term peaks (5–10 minutes) of SO_2 have long been known to cause adverse respiratory health effects, particularly among individuals with asthma. In addition to those with asthma (both children and adults), potentially at-risk lifestages include all children and the elderly. During periods of elevated ventilation, asthmatics may experience symptomatic bronchoconstriction within minutes of exposure. Following an extensive evaluation of health evidence from epidemiologic and laboratory studies, EPA concluded that there is a causal relationship between respiratory health effects and short-term exposure to SO_2. Separately, based on an evaluation of the epidemiologic evidence of associations between short-term exposure to SO_2 and mortality, EPA concluded that the overall evidence is suggestive of a causal relationship between short-term exposure to SO_2 and mortality. Additional information on the health effects of SO_2 is available in Chapter 6.1.1.4.2 of the RIA.

(5) Carbon Monoxide

(a) Background

Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Nationally, particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources.[600]

(b) Health Effects of Carbon Monoxide

Information on the health effects of CO can be found in the January 2010 Integrated Science Assessment for Carbon Monoxide (CO ISA).[601] The CO ISA presents conclusions regarding the presence of causal relationships between CO exposure and categories of adverse health effects.[602] This section provides a summary of the health effects associated with exposure to ambient concentrations of CO, along with the ISA conclusions.[603]

Controlled human exposure studies of subjects with coronary artery disease show a decrease in the time to onset of exercise-induced angina (chest pain) and electrocardiogram changes following CO exposure. In addition, epidemiologic studies observed associations between short-term CO exposure and cardiovascular morbidity, particularly increased emergency room visits and hospital admissions for coronary heart disease (including ischemic heart disease, myocardial infarction, and angina). Some epidemiologic evidence is also available for increased hospital admissions and emergency room visits for congestive heart failure and cardiovascular disease as a whole. The CO ISA concludes that a causal relationship is likely to exist between short-term exposures to CO and cardiovascular morbidity. It also concludes that available data are inadequate to conclude that a causal relationship exists between long-term exposures to CO and cardiovascular morbidity.

Animal studies show various neurological effects with in-utero CO exposure. Controlled human exposure studies report central nervous system and behavioral effects following low-level CO exposures, although the findings have not been consistent across all studies. The CO ISA concludes the evidence is suggestive of a causal relationship with both short- and long-term exposure to CO and central nervous system effects.

A number of studies cited in the CO ISA have evaluated the role of CO exposure in birth outcomes such as preterm birth or cardiac birth defects. There is limited epidemiologic evidence of a CO-induced effect on preterm births and birth defects, with weak evidence for a decrease in birth weight. Animal toxicological studies have found perinatal CO exposure to affect birth weight, as well as other developmental outcomes. The CO ISA concludes the evidence is suggestive of a causal relationship between long-term exposures to CO and developmental effects and birth outcomes.

Epidemiologic studies provide evidence of associations between short-term CO concentrations and respiratory morbidity such as changes in pulmonary function, respiratory symptoms, and hospital admissions. A limited number of epidemiologic studies considered copollutants such as ozone, SO_2, and PM in two-pollutant models and found that CO risk estimates were generally robust, although this limited evidence makes it difficult to disentangle effects attributed to CO itself from those of the larger complex air pollution mixture. Controlled human exposure studies have not extensively

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[599] U.S. EPA. (2008). *Integrated Science Assessment (ISA) for Sulfur Oxides—Health Criteria (Final Report).* EPA/600/R–08/047F. Washington, DC: U.S. Environmental Protection Agency.

[600] U.S. EPA, (2010). Integrated Science Assessment for Carbon Monoxide (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/019F, 2010. Available at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=218686.* See Section 2.1.

[601] U.S. EPA, (2010). Integrated Science Assessment for Carbon Monoxide (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/019F, 2010. Available at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=218686.*

[602] The ISA evaluates the health evidence associated with different health effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For definitions of these levels of evidence, please refer to Section 1.6 of the ISA.

[603] Personal exposure includes contributions from many sources, and in many different environments. Total personal exposure to CO includes both ambient and nonambient components; and both components may contribute to adverse health effects.

evaluated the effect of CO on respiratory morbidity. Animal studies at levels of 50–100 ppm CO show preliminary evidence of altered pulmonary vascular remodeling and oxidative injury. The CO ISA concludes that the evidence is suggestive of a causal relationship between short-term CO exposure and respiratory morbidity, and inadequate to conclude that a causal relationship exists between long-term exposure and respiratory morbidity.

Finally, the CO ISA concludes that the epidemiologic evidence is suggestive of a causal relationship between short-term concentrations of CO and mortality. Epidemiologic evidence suggests an association exists between short-term exposure to CO and mortality, but limited evidence is available to evaluate cause-specific mortality outcomes associated with CO exposure. In addition, the attenuation of CO risk estimates which was often observed in copollutant models contributes to the uncertainty as to whether CO is acting alone or as an indicator for other combustion-related pollutants. The CO ISA also concludes that there is not likely to be a causal relationship between relevant long-term exposures to CO and mortality.

(6) Diesel Exhaust

(a) Background

Diesel exhaust consists of a complex mixture composed of particulate matter, carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, nitrogen compounds, sulfur compounds and numerous low-molecular-weight hydrocarbons. A number of these gaseous hydrocarbon components are individually known to be toxic, including aldehydes, benzene and 1,3-butadiene. The diesel particulate matter present in diesel exhaust consists mostly of fine particles (<2.5 µm), of which a significant fraction is ultrafine particles (<0.1 µm). These particles have a large surface area which makes them an excellent medium for adsorbing organics, and their small size makes them highly respirable. Many of the organic compounds present in the gases and on the particles, such as polycyclic organic matter, are individually known to have mutagenic and carcinogenic properties.

Diesel exhaust varies significantly in chemical composition and particle sizes between different engine types (heavy-duty, light-duty), engine operating conditions (idle, acceleration, deceleration), and fuel formulations (high/low sulfur fuel). Also, there are emissions differences between on-road and nonroad engines because the nonroad engines are generally of older technology. After being emitted in the engine exhaust, diesel exhaust undergoes dilution as well as chemical and physical changes in the atmosphere. The lifetime for some of the compounds present in diesel exhaust ranges from hours to days.

(b) Health Effects of Diesel Exhaust

In EPA's 2002 Diesel Health Assessment Document (Diesel HAD), exposure to diesel exhaust was classified as likely to be carcinogenic to humans by inhalation from environmental exposures, in accordance with the revised draft 1996/1999 EPA cancer guidelines.[604] [605] A number of other agencies (National Institute for Occupational Safety and Health, the International Agency for Research on Cancer, the World Health Organization, California EPA, and the U.S. Department of Health and Human Services) had made similar hazard classifications prior to 2002. EPA also concluded in the 2002 Diesel HAD that it was not possible to calculate a cancer unit risk for diesel exhaust due to limitations in the exposure data for the occupational groups or the absence of a dose-response relationship.

In the absence of a cancer unit risk, the Diesel HAD sought to provide additional insight into the significance of the diesel exhaust cancer hazard by estimating possible ranges of risk that might be present in the population. An exploratory analysis was used to characterize a range of possible lung cancer risk. The outcome was that environmental risks of cancer from long-term diesel exhaust exposures could plausibly range from as low as 10^{-5} to as high as 10^{-3}. Because of uncertainties, the analysis acknowledged that the risks could be lower than 10^{-5}, and a zero risk from diesel exhaust exposure could not be ruled out.

Non-cancer health effects of acute and chronic exposure to diesel exhaust emissions are also of concern to EPA. EPA derived a diesel exhaust reference concentration (RfC) from consideration of four well-conducted chronic rat inhalation studies showing adverse pulmonary effects. The RfC is 5 µg/m^3 for diesel exhaust measured as diesel particulate matter. This RfC does not consider allergenic effects such as those associated with asthma or immunologic or the potential for cardiac effects. There was emerging evidence in 2002, discussed in the Diesel HAD, that exposure to diesel exhaust can exacerbate these effects, but the exposure-response data were lacking at that time to derive an RfC based on these then-emerging considerations. The EPA Diesel HAD states, ''With [diesel particulate matter] being a ubiquitous component of ambient PM, there is an uncertainty about the adequacy of the existing [diesel exhaust] noncancer database to identify all of the pertinent [diesel exhaust]-caused noncancer health hazards.'' The Diesel HAD also notes ''that acute exposure to [diesel exhaust] has been associated with irritation of the eye, nose, and throat, respiratory symptoms (cough and phlegm), and neurophysiological symptoms such as headache, lightheadedness, nausea, vomiting, and numbness or tingling of the extremities.'' The Diesel HAD noted that the cancer and noncancer hazard conclusions applied to the general use of diesel engines then on the market and as cleaner engines replace a substantial number of existing ones, the applicability of the conclusions would need to be reevaluated.

It is important to note that the Diesel HAD also briefly summarizes health effects associated with ambient PM and discusses EPA's then-annual $PM_{2.5}$ NAAQS of 15 µg/m^3. In 2012, EPA revised the annual $PM_{2.5}$ NAAQS to 12 µg/m^3. There is a large and extensive body of human data showing a wide spectrum of adverse health effects associated with exposure to ambient PM, of which diesel exhaust is an important component. The $PM_{2.5}$ NAAQS is designed to provide protection from the noncancer health effects and premature mortality attributed to exposure to $PM_{2.5}$. The contribution of diesel PM to total ambient PM varies in different regions of the country and also, within a region, from one area to another. The contribution can be high in near-roadway environments, for example, or in other locations where diesel engine use is concentrated.

Since 2002, several new studies have been published which continue to report increased lung cancer risk with occupational exposure to diesel exhaust from older engines. Of particular note since 2011 are three new epidemiology studies which have examined lung cancer in occupational populations, for example, truck drivers, underground nonmetal miners and other diesel

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[604] U.S. EPA. (1999). *Guidelines for Carcinogen Risk Assessment.* Review Draft. NCEA–F–0644, July. Washington, DC: U.S. EPA. Retrieved on March 19, 2009 from *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54932.*

[605] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust.* EPA/600/8–90/057F Office of Research and Development, Washington DC. Retrieved on March 17, 2009 from *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.* pp. 1–1 1–2.

motor-related occupations. These studies reported increased risk of lung cancer with exposure to diesel exhaust with evidence of positive exposure-response relationships to varying degrees.[606][607][608] These newer studies (along with others that have appeared in the scientific literature) add to the evidence EPA evaluated in the 2002 Diesel HAD and further reinforces the concern that diesel exhaust exposure likely poses a lung cancer hazard. The findings from these newer studies do not necessarily apply to newer technology diesel engines since the newer engines have large reductions in the emission constituents compared to older technology diesel engines.

In light of the growing body of scientific literature evaluating the health effects of exposure to diesel exhaust, in June 2012 the World Health Organization's International Agency for Research on Cancer (IARC), a recognized international authority on the carcinogenic potential of chemicals and other agents, evaluated the full range of cancer-related health effects data for diesel engine exhaust. IARC concluded that diesel exhaust should be regarded as ''carcinogenic to humans.'' [609] This designation was an update from its 1988 evaluation that considered the evidence to be indicative of a ''probable human carcinogen.''

(7) Air Toxics

(a) Background

Heavy-duty vehicle emissions contribute to ambient levels of air toxics that are known or suspected human or animal carcinogens, or that have noncancer health effects. The population experiences an elevated risk of cancer and other noncancer health effects from exposure to the class of pollutants known collectively as ''air toxics.'' [610] These compounds include, but are not limited to, benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic organic matter, and naphthalene. These compounds were identified as national or regional risk drivers or contributors in the 2011 National-scale Air Toxics Assessment and have significant inventory contributions from mobile sources.[611]

(b) Benzene

EPA's Integrated Risk Information System (IRIS) database lists benzene as a known human carcinogen (causing leukemia) by all routes of exposure, and concludes that exposure is associated with additional health effects, including genetic changes in both humans and animals and increased proliferation of bone marrow cells in mice.[612][613][614] EPA states in its IRIS database that data indicate a causal relationship between benzene exposure and acute lymphocytic leukemia and suggest a relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia. EPA's IRIS documentation for benzene also lists a range of 2.2×10^{-6} to 7.8×10^{-6} per $\mu g/m^3$ as the unit risk estimate (URE) for benzene.[615][616] The International Agency for Research on Cancer (IARC) has determined that benzene is a human carcinogen and the U.S. Department of Health and Human Services (DHHS) has characterized benzene as a known human carcinogen.[617][618]

A number of adverse noncancer health effects including blood disorders, such as pre- leukemia and aplastic anemia, have also been associated with long-term exposure to benzene.[619][620] The most sensitive noncancer effect observed in humans, based on current data, is the depression of the absolute lymphocyte count in blood.[621][622] EPA's inhalation reference concentration (RfC) for benzene is 30 $\mu g/m^3$. The RfC is based on suppressed absolute lymphocyte counts seen in humans under occupational exposure conditions. In addition, recent work, including studies sponsored by the Health Effects Institute, provides evidence that biochemical responses are occurring at lower levels of benzene exposure than previously known.[623][624][625][626] EPA's IRIS program has not yet evaluated these new data. EPA does not currently have an acute reference concentration for benzene. The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) for acute exposure to benzene is 29 $\mu g/m^3$ for 1–14 days exposure.[627][628]

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[606] Garshick, Eric, Francine Laden, Jaime E. Hart, Mary E. Davis, Ellen A. Eisen, and Thomas J. Smith. 2012. Lung cancer and elemental carbon exposure in trucking industry workers. Environmental Health Perspectives 120(9): 1301–1306.

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[608] Olsson, Ann C., et al. ''Exposure to diesel motor exhaust and lung cancer risk in a pooled analysis from case-control studies in Europe and Canada.'' American journal of respiratory and critical care medicine 183.7 (2011): 941–948.

[609] IARC [International Agency for Research on Cancer]. (2013). Diesel and gasoline engine exhausts and some nitroarenes. IARC Monographs Volume 105. [Online at *http://monographs.iarc.fr/ENG/Monographs/vol105/index.php*].

[610] U.S. EPA. (2015) Summary of Results for the 2011 National-Scale Assessment. *http://www3.epa.gov/sites/production/files/2015-12/documents/2011-nata-summary-results.pdf.*

[611] U.S. EPA (2015) 2011 National Air Toxics Assessment. *http://www3.epa.gov/national-air-toxics-assessment/2011-national-air-toxics-assessment.*

[612] U.S. EPA. (2000). Integrated Risk Information System File for Benzene. This material is available electronically at: *http://www3.epa.gov/iris/subst/0276.htm.*

[613] International Agency for Research on Cancer, IARC monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, some industrial chemicals and dyestuffs, International Agency for Research on Cancer, World Health Organization, Lyon, France 1982.

[614] Irons, R.D.; Stillman, W.S.; Colagiovanni, D.B.; Henry, V.A. (1992). Synergistic action of the benzene metabolite hydroquinone on myelopoietic stimulating activity of granulocyte/macrophage colony-stimulating factor in vitro, Proc. Natl. Acad. Sci. 89:3691–3695.

[615] A unit risk estimate is defined as the increase in the lifetime risk of an individual who is exposed for a lifetime to 1 µg/m3 benzene in air.

[616] U.S. EPA. (2000). Integrated Risk Information System File for Benzene. This material is available electronically at: *http://www3.epa.gov/iris/subst/0276.htm.*

[617] International Agency for Research on Cancer (IARC). (1987). Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Supplement 7, Some industrial chemicals and dyestuffs, World Health Organization, Lyon, France.

[618] NTP. (2014). 13th Report on Carcinogens. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

[619] Aksoy, M. (1989). Hematotoxicity and carcinogenicity of benzene. Environ. Health Perspect. 82: 193–197.

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[622] U.S. EPA. (2002). Toxicological Review of Benzene (Noncancer Effects). Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington DC. This material is available electronically at *http://www3.epa.gov/iris/subst/0276.htm.*

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[626] Turtletaub, K.W. and Mani, C. (2003). Benzene metabolism in rodents at doses relevant to human exposure from Urban Air. Research Reports Health Effect Inst. Report No.113.

[627] U.S. Agency for Toxic Substances and Disease Registry (ATSDR). (2007). Toxicological profile for benzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. *http://www.atsdr.cdc.gov/ToxProfiles/tp3.pdf.*

[628] A minimal risk level (MRL) is defined as an estimate of the daily human exposure to a

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(c) 1,3-Butadiene

EPA has characterized 1,3-butadiene as carcinogenic to humans by inhalation.[629] [630] The IARC has determined that 1,3-butadiene is a human carcinogen and the U.S. DHHS has characterized 1,3-butadiene as a known human carcinogen.[631] [632] [633] There are numerous studies consistently demonstrating that 1,3-butadiene is metabolized into genotoxic metabolites by experimental animals and humans. The specific mechanisms of 1,3-butadiene-induced carcinogenesis are unknown; however, the scientific evidence strongly suggests that the carcinogenic effects are mediated by genotoxic metabolites. Animal data suggest that females may be more sensitive than males for cancer effects associated with 1,3-butadiene exposure; there are insufficient data in humans from which to draw conclusions about sensitive subpopulations. The URE for 1,3-butadiene is 3×10^{-5} per µg/m^3.[634] 1,3-butadiene also causes a variety of reproductive and developmental effects in mice; no human data on these effects are available. The most sensitive effect was ovarian atrophy observed in a lifetime bioassay of female mice.[635] Based on this critical effect and the benchmark concentration methodology, an RfC for chronic health effects was calculated at 0.9 ppb (approximately 2 µg/m^3).

(d) Formaldehyde

In 1991, EPA concluded that formaldehyde is a carcinogen based on nasal tumors in animal bioassays.[636] An Inhalation URE for cancer and a Reference Dose for oral noncancer effects were developed by the agency and posted on the IRIS database. Since that time, the National Toxicology Program (NTP) and International Agency for Research on Cancer (IARC) have concluded that formaldehyde is a known human carcinogen.[637] [638]

The conclusions by IARC and NTP reflect the results of epidemiologic research published since 1991 in combination with previous animal, human and mechanistic evidence. Research conducted by the National Cancer Institute reported an increased risk of nasopharyngeal cancer and specific lymph hematopoietic malignancies among workers exposed to formaldehyde.[639] [640] [641] A National Institute of Occupational Safety and Health study of garment workers also reported increased risk of death due to leukemia among workers exposed to formaldehyde.[642] Extended follow-up of a cohort of British chemical workers did not report evidence of an increase in nasopharyngeal or lymph hematopoietic cancers, but a continuing statistically significant excess in lung cancers was reported.[643] Finally, a study of embalmers reported formaldehyde exposures to be associated with an increased risk of myeloid leukemia but not brain cancer.[644]

Health effects of formaldehyde in addition to cancer were reviewed by the Agency for Toxics Substances and Disease Registry in 1999 [645], supplemented in 2010,[646] and by the World Health Organization.[647] These organizations reviewed the scientific literature concerning health effects linked to formaldehyde exposure to evaluate hazards and dose response relationships and defined exposure concentrations for minimal risk levels (MRLs). The health endpoints reviewed included sensory irritation of eyes and respiratory tract, reduced pulmonary function, nasal histopathology, and immune system effects. In addition, research on reproductive and developmental effects and neurological effects were discussed along with several studies that suggest that formaldehyde may increase the risk of asthma—particularly in the young.

EPA released a draft Toxicological Review of Formaldehyde—Inhalation Assessment through the IRIS program for peer review by the National Research Council (NRC) and public comment in June 2010.[648] The draft assessment reviewed more recent research from animal and human studies on cancer and other health effects. The NRC released their review report in April 2011.[649] EPA is currently developing a revised draft assessment in response to this review.

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hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure.

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[630] U.S. EPA. (2002). ''Full IRIS Summary for 1,3-butadiene (CASRN 106–99–0)'' Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *http://www3.epa.gov/iris/subst/0139.htm*.

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[632] International Agency for Research on Cancer (IARC). (2008). Monographs on the evaluation of carcinogenic risk of chemicals to humans, 1,3-Butadiene, Ethylene Oxide and Vinyl Halides (Vinyl Fluoride, Vinyl Chloride and Vinyl Bromide) Volume 97, World Health Organization, Lyon, France.

[633] NTP. (2014). 13th Report on Carcinogens. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

[634] U.S. EPA. (2002). ''Full IRIS Summary for 1,3-butadiene (CASRN 106–99–0)'' Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *http://www3.epa.gov/iris/subst/0139.htm*.

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[637] NTP. (2014). 13th Report on Carcinogens. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

[638] IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 100F (2012): Formaldehyde.

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[640] Hauptmann, M.; Lubin, J. H.; Stewart, P. A.; Hayes, R. B.; Blair, A. 2004. Mortality from solid cancers among workers in formaldehyde industries. American Journal of Epidemiology 159: 1117–1130.

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[644] Hauptmann, M,; Stewart P. A.; Lubin J. H.; Beane Freeman, L. E.; Hornung, R. W.; Herrick, R. F.; Hoover, R. N.; Fraumeni, J. F.; Hayes, R. B. 2009. Mortality from lymph hematopoietic malignancies and brain cancer among embalmers exposed to formaldehyde. Journal of the National Cancer Institute 101:1696–1708.

[645] ATSDR. 1999. Toxicological Profile for Formaldehyde, U.S. Department of Health and Human Services (HHS), July 1999.

[646] ATSDR. 2010. Addendum to the Toxicological Profile for Formaldehyde. U.S. Department of Health and Human Services (HHS), October 2010.

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[648] EPA (U.S. Environmental Protection Agency). 2010. Toxicological Review of Formaldehyde (CAS No. 50–00–0)—Inhalation Assessment: In Support of Summary Information on the Integrated Risk Information System (IRIS). External Review Draft. EPA/635/R–10/002A. U.S. Environmental Protection Agency, Washington DC [online]. Available: *http://cfpub.epa.gov/ncea/irs_drats/recordisplay.cfm?deid=223614*.

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(e) Acetaldehyde

Acetaldehyde is classified in EPA's IRIS database as a probable human carcinogen, based on nasal tumors in rats, and is considered toxic by the inhalation, oral, and intravenous routes.[650] The URE in IRIS for acetaldehyde is 2.2×10^{-6} per $\mu g/m^3$.[651] Acetaldehyde is reasonably anticipated to be a human carcinogen by the U.S. DHHS in the 13th Report on Carcinogens and is classified as possibly carcinogenic to humans (Group 2B) by the IARC.[652] [653] Acetaldehyde is currently listed on the IRIS Program Multi-Year Agenda for reassessment within the next few years.

The primary noncancer effects of exposure to acetaldehyde vapors include irritation of the eyes, skin, and respiratory tract.[654] In short-term (4 week) rat studies, degeneration of olfactory epithelium was observed at various concentration levels of acetaldehyde exposure.[655] [656] Data from these studies were used by EPA to develop an inhalation reference concentration of 9 $\mu g/m^3$. Some asthmatics have been shown to be a sensitive subpopulation to decrements in functional expiratory volume (FEV1 test) and bronchoconstriction upon acetaldehyde inhalation.[657]

(f) Acrolein

EPA most recently evaluated the toxicological and health effects literature related to acrolein in 2003 and concluded that the human carcinogenic potential of acrolein could not be determined because the available data were inadequate. No information was available on the carcinogenic effects of acrolein in humans and the animal data provided inadequate evidence of carcinogenicity.[658] The IARC determined in 1995 that acrolein was not classifiable as to its carcinogenicity in humans.[659]

Lesions to the lungs and upper respiratory tract of rats, rabbits, and hamsters have been observed after subchronic exposure to acrolein.[660] The agency has developed an RfC for acrolein of 0.02 $\mu g/m^3$ and an RfD of 0.5 μg/kg-day.[661]

Acrolein is extremely acrid and irritating to humans when inhaled, with acute exposure resulting in upper respiratory tract irritation, mucus hypersecretion and congestion. The intense irritancy of this carbonyl has been demonstrated during controlled tests in human subjects, who suffer intolerable eye and nasal mucosal sensory reactions within minutes of exposure.[662] These data and additional studies regarding acute effects of human exposure to acrolein are summarized in EPA's 2003 Toxicological Review of Acrolein.[663] Studies in humans indicate that levels as low as 0.09 ppm (0.21 mg/m^3) for five minutes may elicit subjective complaints of eye irritation with increasing concentrations leading to more extensive eye, nose and respiratory symptoms. Acute exposures in animal studies report bronchial hyper-responsiveness. Based on animal data (more pronounced respiratory irritancy in mice with allergic airway disease in comparison to non-diseased mice)[664] and demonstration of similar effects in humans (*e.g.,* reduction in respiratory rate), individuals with compromised respiratory function (*e.g.,* emphysema, asthma) are expected to be at increased risk of developing adverse responses to strong respiratory irritants such as acrolein. EPA does not currently have an acute reference concentration for acrolein. The available health effect reference values for acrolein have been summarized by EPA and include an ATSDR MRL for acute exposure to acrolein of 7 $\mu g/m^3$ for 1–14 days exposure; and Reference Exposure Level (REL) values from the California Office of Environmental Health Hazard Assessment (OEHHA) for one-hour and 8-hour exposures of 2.5 $\mu g/m^3$ and 0.7 $\mu g/m^3$, respectively.[665]

(g) Polycyclic Organic Matter

The term polycyclic organic matter (POM) defines a broad class of compounds that includes the polycyclic aromatic hydrocarbon compounds (PAHs). One of these compounds, naphthalene, is discussed separately below. POM compounds are formed primarily from combustion and are present in the atmosphere in gas and particulate form. Cancer is the major concern from exposure to POM. Epidemiologic studies have reported an increase in lung cancer in humans exposed to diesel exhaust, coke oven emissions, roofing tar emissions, and cigarette smoke; all of these mixtures contain POM compounds.[666] [667] Animal studies have reported respiratory tract tumors from inhalation exposure to

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[650] U.S. EPA (1991). Integrated Risk Information System File of Acetaldehyde. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www3.epa.gov/iris/subst/0290.htm.*

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[655] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www3.epa.gov/iris/subst/0364.htm.*

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[661] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at *http://www3.epa.gov/iris/subst/0364.htm.*

[662] U.S. EPA. (2003) Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R–03/003. p. 10. Available online at: *http://www3.epa.gov/ncea/iris/toxreviews/0364tr.pdf.*

[663] U.S. EPA. (2003) Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R–03/003. Available online at: *http://www3.epa.gov/ncea/iris/toxreviews/0364tr.pdf.*

[664] Morris JB, Symanowicz PT, Olsen JE, et al. (2003). Immediate sensory nerve-mediated respiratory responses to irritants in healthy and allergic airway-diseased mice. J Appl Physiol 94(4):1563–1571.

[665] U.S. EPA. (2009). Graphical Arrays of Chemical-Specific Health Effect Reference Values for Inhalation Exposures (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/061, 2009. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=211003.*

[666] Agency for Toxic Substances and Disease Registry (ATSDR). (1995). Toxicological profile for Polycyclic Aromatic Hydrocarbons (PAHs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available electronically at *http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=122&tid=25.*

[667] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust.* EPA/600/8–90/057F Office of Research and Development, Washington DC. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.*

benzo[a]pyrene and alimentary tract and liver tumors from oral exposure to benzo[a]pyrene.[668] In 1997 EPA classified seven PAHs (benzo[a]pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) as Group B2, probable human carcinogens.[669] Since that time, studies have found that maternal exposures to PAHs in a population of pregnant women were associated with several adverse birth outcomes, including low birth weight and reduced length at birth, as well as impaired cognitive development in preschool children (3 years of age).[670] [671] These and similar studies are being evaluated as a part of the ongoing IRIS reassessment of health effects associated with exposure to benzo[a]pyrene.

(h) Naphthalene

Naphthalene is found in small quantities in gasoline and diesel fuels. Naphthalene emissions have been measured in larger quantities in both gasoline and diesel exhaust compared with evaporative emissions from mobile sources, indicating it is primarily a product of combustion. Acute (short-term) exposure of humans to naphthalene by inhalation, ingestion, or dermal contact is associated with hemolytic anemia and damage to the liver and the nervous system.[672] Chronic (long term) exposure of workers and rodents to naphthalene has been reported to cause cataracts and retinal damage.[673] EPA released an external review draft of a reassessment of the inhalation carcinogenicity of naphthalene based on a number of recent animal carcinogenicity studies.[674] The draft reassessment completed external peer review.[675] Based on external peer review comments received, a revised draft assessment that considers all routes of exposure, as well as cancer and noncancer effects, is under development. The external review draft does not represent official agency opinion and was released solely for the purposes of external peer review and public comment. The National Toxicology Program listed naphthalene as ‘‘reasonably anticipated to be a human carcinogen’’ in 2004 on the basis of bioassays reporting clear evidence of carcinogenicity in rats and some evidence of carcinogenicity in mice.[676] California EPA has released a new risk assessment for naphthalene, and the IARC has reevaluated naphthalene and re-classified it as Group 2B: possibly carcinogenic to humans.[677]

Naphthalene also causes a number of chronic non-cancer effects in animals, including abnormal cell changes and growth in respiratory and nasal tissues.[678] The current EPA IRIS assessment includes noncancer data on hyperplasia and metaplasia in nasal tissue that form the basis of the inhalation RfC of 3 $\mu g/m^3$.[679] The ATSDR MRL for acute exposure to naphthalene is 0.6 mg/kg/day.

(i) Other Air Toxics

In addition to the compounds described above, other compounds in gaseous hydrocarbon and PM emissions from motor vehicles will be affected by this action. Mobile source air toxic compounds that will potentially be impacted include ethylbenzene, propionaldehyde, toluene, and xylene. Information regarding the health effects of these compounds can be found in EPA's IRIS database.[680]

(8) Exposure and Health Effects Associated With Traffic

Locations in close proximity to major roadways generally have elevated concentrations of many air pollutants emitted from motor vehicles. Hundreds of such studies have been published in peer-reviewed journals, concluding that concentrations of CO, NO, NO$_2$, benzene, aldehydes, particulate matter, black carbon, and many other compounds are elevated in ambient air within approximately 300–600 meters (about 1,000–2,000 feet) of major roadways. Highest concentrations of most pollutants emitted directly by motor vehicles are found at locations within 50 meters (about 165 feet) of the edge of a roadway's traffic lanes.

A large-scale review of air quality measurements in the vicinity of major roadways between 1978 and 2008 concluded that the pollutants with the steepest concentration gradients in vicinities of roadways were CO, ultrafine particles, metals, elemental carbon (EC), NO, NO$_X$, and several VOCs.[681] These pollutants showed a large reduction in concentrations within 100 meters downwind of the roadway. Pollutants that showed more gradual reductions with distance from roadways included benzene, NO$_2$, PM$_{2.5}$, and PM$_{10}$. In the review article, results varied based on the method of statistical analysis used to determine the trend.

For pollutants with relatively high background concentrations relative to near-road concentrations, detecting concentration gradients can be difficult. For example, many aldehydes have high background concentrations as a result of photochemical breakdown of precursors from many different organic compounds. This can make detection of gradients around roadways and other primary emission sources difficult.

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[672] U. S. EPA. 1998. Toxicological Review of Naphthalene (Reassessment of the Inhalation Cancer Risk), Environmental Protection Agency, Integrated Risk Information System, Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www3.epa.gov/iris/subst/0436.htm.*

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[679] U.S. EPA. (1998). Toxicological Review of Naphthalene. Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *http://www3.epa.gov/iris/subst/0436.htm.*

[680] U.S. EPA Integrated Risk Information System (IRIS) database is available at: *www3.epa.gov/iris.*

[681] Karner, A.A.; Eisinger, D.S.; Niemeier, D.A. (2010). Near-roadway air quality: synthesizing the findings from real-world data. Environ Sci Technol 44: 5334–5344.

However, several studies have measured aldehydes in multiple weather conditions and found higher concentrations of many carbonyls downwind of roadways.[682] [683] These findings suggest a substantial roadway source of these carbonyls.

In the past 15 years, many studies have been published with results reporting that populations who live, work, or go to school near high-traffic roadways experience higher rates of numerous adverse health effects, compared to populations far away from major roads.[684] In addition, numerous studies have found adverse health effects associated with spending time in traffic, such as commuting or walking along high-traffic roadways.[685] [686] [687] [688] The health outcomes with the strongest evidence linking them with traffic-associated air pollutants are respiratory effects, particularly in asthmatic children, and cardiovascular effects.

Numerous reviews of this body of health literature have been published as well. In 2010, an expert panel of the Health Effects Institute (HEI) published a review of hundreds of exposure, epidemiology, and toxicology studies.[689] The panel rated how the evidence for each type of health outcome supported a conclusion of a causal association with traffic-associated air pollution as either ''sufficient,'' ''suggestive but not sufficient,'' or ''inadequate and insufficient.'' The panel categorized evidence of a causal association for exacerbation of childhood asthma as ''sufficient.'' The panel categorized evidence of a causal association for new onset asthma as between ''sufficient'' and ''suggestive but not sufficient.'' ''Suggestive of a causal association'' was how the panel categorized evidence linking traffic-associated air pollutants with exacerbation of adult respiratory symptoms and lung function decrement. It categorized as ''inadequate and insufficient'' evidence of a causal relationship between traffic-related air pollution and health care utilization for respiratory problems, new onset adult asthma, chronic obstructive pulmonary disease (COPD), nonasthmatic respiratory allergy, and cancer in adults and children. Other literature reviews have been published with conclusions generally similar to the HEI panel's.[690] [691] [692] [693] However, in 2014, researchers from the U.S. Centers for Disease Control and Prevention (CDC) published a systematic review and meta-analysis of studies evaluating the risk of childhood leukemia associated with traffic exposure and reported positive associations between ''postnatal'' proximity to traffic and leukemia risks, but no such association for ''prenatal'' exposures.[694]

Health outcomes with few publications suggest the possibility of other effects still lacking sufficient evidence to draw definitive conclusions. Among these outcomes with a small number of positive studies are neurological impacts (*e.g.,* autism and reduced cognitive function) and reproductive outcomes (*e.g.,* preterm birth, low birth weight).[695] [696] [697] [698]

In addition to health outcomes, particularly cardiopulmonary effects, conclusions of numerous studies suggest mechanisms by which traffic-related air pollution affects health. Numerous studies indicate that near-roadway exposures may increase systemic inflammation, affecting organ systems, including blood vessels and lungs.[699] [700] [701] [702] Long-term exposures in near-road environments have been associated with inflammation-associated conditions, such as atherosclerosis and asthma.[703] [704] [705]

Several studies suggest that some factors may increase susceptibility to the effects of traffic-associated air pollution. Several studies have found stronger respiratory associations in children experiencing chronic social stress, such as in violent neighborhoods or in homes with high family stress.[706] [707] [708]

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[684] In the widely-used PubMed database of health publications, between January 1, 1990 and August 18, 2011, 605 publications contained the keywords ''traffic, pollution, epidemiology,'' with approximately half the studies published after 2007.

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Continued

The risks associated with residence, workplace, or schools near major roads are of potentially high public health significance due to the large population in such locations. According to the 2009 American Housing Survey, over 22 million homes (17.0 percent of all U.S. housing units) were located within 300 feet of an airport, railroad, or highway with four or more lanes. This corresponds to a population of more than 50 million U.S. residents in close proximity to high-traffic roadways or other transportation sources. Based on 2010 Census data, a 2013 publication estimated that 19 percent of the U.S. population (over 59 million people) lived within 500 meters of roads with at least 25,000 annual average daily traffic (AADT), while about 3.2 percent of the population lived within 100 meters (about 300 feet) of such roads.[709] Another 2013 study estimated that 3.7 percent of the U.S. population (about 11.3 million people) lived within 150 meters (about 500 feet) of interstate highways or other freeways and expressways.[710] As discussed in Section VIII.A.(9), on average, populations near major roads have higher fractions of minority residents and lower socioeconomic status. Furthermore, on average, Americans spend more than an hour traveling each day, bringing nearly all residents into a high-exposure microenvironment for part of the day.

In light of these concerns, EPA has required through the NAAQS process that air quality monitors be placed near high-traffic roadways for determining concentrations of CO, NO$_2$, and PM$_{2.5}$ (in addition to those existing monitors located in neighborhoods and other locations farther away from pollution sources). Near-roadway monitors for NO$_2$ begin operation between 2014 and 2017 in Core Based Statistical Areas (CBSAs) with population of at least 500,000. Monitors for CO and PM$_{2.5}$ begin operation between 2015 and 2017. These monitors will further our understanding of exposure in these locations.

EPA and DOT continue to research near-road air quality, including the types of pollutants found in high concentrations near major roads and health problems associated with the mixture of pollutants near roads.

(9) Environmental Justice

Environmental justice (EJ) is a principle asserting that all people deserve fair treatment and meaningful involvement with respect to environmental laws, regulations, and policies. EPA seeks to provide the same degree of protection from environmental health hazards for all people. DOT shares this goal and is informed about the potential environmental impacts of its rulemakings through its NEPA process (see NHTSA's DEIS). As referenced below, numerous studies have found that some environmental hazards are more prevalent in areas where racial/ethnic minorities and people with low socioeconomic status (SES) represent a higher fraction of the population compared with the general population. In addition, compared to non-Hispanic whites, some types of minorities may have greater levels of health problems during some life stages. For example, in 2014, about 13 percent of Black, non-Hispanic and 24 percent of Puerto Rican children were estimated to currently have asthma, compared with 8 percent of white, non-Hispanic children.[711]

As discussed in Section VIII.A.(8) of this document and NHTSA's FEIS, concentrations of many air pollutants are elevated near high-traffic roadways. If minority populations and low-income populations disproportionately live near such roads, then an issue of EJ may be present. We reviewed existing scholarly literature examining the potential for disproportionate exposure among minorities and people with low SES, and we conducted our own evaluation of two national datasets: The U.S. Census Bureau's American Housing Survey for calendar year 2009 and the U.S. Department of Education's database of school locations.

Publications that address EJ issues generally report that populations living near major roadways (and other types of transportation infrastructure) tend to be composed of larger fractions of nonwhite residents. People living in neighborhoods near such sources of air pollution also tend to be lower in income than people living elsewhere. Numerous studies evaluating the demographics and socioeconomic status of populations or schools near roadways have found that they include a greater percentage of minority residents, as well as lower SES (indicated by variables such as median household income). Locations in these studies include Los Angeles, CA; Seattle, WA; Wayne County, MI; Orange County, FL; and the State of California [712] [713] [714] [715] [716] [717] Such disparities may be due to multiple factors.[718]

People with low SES often live in neighborhoods with multiple stressors and health risk factors, including reduced health insurance coverage rates, higher smoking and drug use rates, limited access to fresh food, visible neighborhood violence, and elevated rates of obesity and some diseases such as asthma, diabetes, and ischemic heart disease. Although questions remain, several studies find stronger associations between air pollution and health in locations with such chronic neighborhood stress, suggesting that populations in these areas may be more susceptible to the effects of air pollution. [719] [720] [721] [722] Household-level

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stressors such as parental smoking and relationship stress also may increase susceptibility to the adverse effects of air pollution.[723] [724]

More recently, three publications report nationwide analyses that compare the demographic patterns of people who do or do not live near major roadways.[725] [726] [727] All three of these studies found that people living near major roadways are more likely to be minorities or low in SES. They also found that the outcomes of their analyses varied between regions within the U.S. However, only one such study looked at whether such conclusions were confounded by living in a location with higher population density and how demographics differ between locations nationwide. In general, it found that higher density areas have higher proportions of low income and minority residents.

We analyzed two national databases that allowed us to evaluate whether homes and schools were located near a major road and whether disparities in exposure may be occurring in these environments. The American Housing Survey (AHS) includes descriptive statistics of over 70,000 housing units across the nation. The study survey is conducted every two years by the U.S. Census Bureau. The second database we analyzed was the U.S. Department of Education's Common Core of Data, which includes enrollment and location information for schools across the U.S.

In analyzing the 2009 AHS, we focused on whether or not a housing unit was located within 300 feet of ''4-or-more lane highway, railroad, or airport.'' [728] We analyzed whether there were differences between households in such locations compared with those in locations farther from these transportation facilities.[729] We included other variables, such as land use category, region of country, and housing type. We found that homes with a nonwhite householder were 22–34 percent more likely to be located within 300 feet of these large transportation facilities than homes with white householders. Homes with a Hispanic householder were 17–33 percent more likely to be located within 300 feet of these large transportation facilities than homes with non-Hispanic householders. Households near large transportation facilities were, on average, lower in income and educational attainment, more likely to be a rental property and located in an urban area compared with households more distant from transportation facilities.

In examining schools near major roadways, we examined the Common Core of Data (CCD) from the U.S. Department of Education, which includes information on all public elementary and secondary schools and school districts nationwide.[730] To determine school proximities to major roadways, we used a geographic information system (GIS) to map each school and roadways based on the U.S. Census's TIGER roadway file.[731] We found that minority students were overrepresented at schools within 200 meters of the largest roadways, and that schools within 200 meters of the largest roadways also had higher than expected numbers of students eligible for free or reduced-price lunches. For example, Black students represent 22 percent of students at schools located within 200 meters of a primary road, whereas Black students represent 17 percent of students in all U.S. schools. Hispanic students represent 30 percent of students at schools located within 200 meters of a primary road, whereas Hispanic students represent 22 percent of students in all U.S. schools.

Overall, there is substantial evidence that people who live or attend school near major roadways are more likely to be of a minority race, Hispanic ethnicity, and/or low SES. The emission reductions from these final rules will likely result in widespread air quality improvements, but the impact on pollution levels in close proximity to roadways will be most direct. Thus, these final rules will likely help in mitigating the disparity in racial, ethnic, and economically based exposures.

B. Environmental Effects of Non-GHG Pollutants

(1) Visibility

Visibility can be defined as the degree to which the atmosphere is transparent to visible light.[732] Visibility impairment is caused by light scattering and absorption by suspended particles and gases. Visibility is important because it has direct significance to people's enjoyment of daily activities in all parts of the country. Individuals value good visibility for the well-being it provides them directly, where they live and work, and in places where they enjoy recreational opportunities. Visibility is also highly valued in significant natural areas, such as national parks and wilderness areas, and special emphasis is given to protecting visibility in these areas. For more information on visibility see the final 2009 p.m. ISA.[733]

EPA is working to address visibility impairment. Reductions in air pollution from implementation of various programs associated with the Clean Air Act Amendments of 1990 (CAAA) provisions have resulted in substantial improvements in visibility and will continue to do so in the future. Because trends in haze are closely associated with trends in particulate sulfate and nitrate due to the relationship between their concentration and light extinction, visibility trends have improved as emissions of SO_2 and NO_X have decreased over time due to air pollution

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[726] Tian, N.; Xue, J.; Barzyk. T.M. (2013) Evaluating socioeconomic and racial differences in traffic-related metrics in the United States using a GIS approach. J Exposure Sci Environ Epidemiol 23: 215–222.

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[728] This variable primarily represents roadway proximity. According to the Central Intelligence Agency's World Factbook, in 2010, the United States had 6,506,204 km or roadways, 224,792 km of railways, and 15,079 airports. Highways thus represent the overwhelming majority of transportation facilities described by this factor in the AHS.

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[730] *http://nces.ed.gov/ccd/*.

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regulations such as the Acid Rain Program.[734]

In the Clean Air Act Amendments of 1977, Congress recognized visibility's value to society by establishing a national goal to protect national parks and wilderness areas from visibility impairment caused by manmade pollution.[735] In 1999, EPA finalized the regional haze program to protect the visibility in Mandatory Class I Federal areas.[736] There are 156 national parks, forests and wilderness areas categorized as Mandatory Class I Federal areas.[737] These areas are defined in CAA Section 162 as those national parks exceeding 6,000 acres, wilderness areas and memorial parks exceeding 5,000 acres, and all international parks which were in existence on August 7, 1977.

EPA has also concluded that $PM_{2.5}$ causes adverse effects on visibility in other areas that are not targeted by the Regional Haze Rule, such as urban areas, depending on $PM_{2.5}$ concentrations and other factors such as dry chemical composition and relative humidity (*i.e.,* an indicator of the water composition of the particles). EPA revised the $PM_{2.5}$ standards in December 2012 and established a target level of protection that is expected to be met through attainment of the existing secondary standards for $PM_{2.5}$.

(2) Plant and Ecosystem Effects of Ozone

The welfare effects of ozone can be observed across a variety of scales, *i.e.* subcellular, cellular, leaf, whole plant, population and ecosystem. Ozone effects that begin at small spatial scales, such as the leaf of an individual plant, when they occur at sufficient magnitudes (or to a sufficient degree) can result in effects being propagated along a continuum to larger and larger spatial scales. For example, effects at the individual plant level, such as altered rates of leaf gas exchange, growth and reproduction, can, when widespread, result in broad changes in ecosystems, such as productivity, carbon storage, water cycling, nutrient cycling, and community composition.

Ozone can produce both acute and chronic injury in sensitive species depending on the concentration level and the duration of the exposure.[738] In those sensitive species,[739] effects from repeated exposure to ozone throughout the growing season of the plant tend to accumulate, so that even low concentrations experienced for a longer duration have the potential to create chronic stress on vegetation.[740] Ozone damage to sensitive species includes impaired photosynthesis and visible injury to leaves. The impairment of photosynthesis, the process by which the plant makes carbohydrates (its source of energy and food), can lead to reduced crop yields, timber production, and plant productivity and growth. Impaired photosynthesis can also lead to a reduction in root growth and carbohydrate storage below ground, resulting in other, more subtle plant and ecosystems impacts.[741] These latter impacts include increased susceptibility of plants to insect attack, disease, harsh weather, interspecies competition and overall decreased plant vigor. The adverse effects of ozone on areas with sensitive species could potentially lead to species shifts and loss from the affected ecosystems,[742] resulting in a loss or reduction in associated ecosystem goods and services. Additionally, visible ozone injury to leaves can result in a loss of aesthetic value in areas of special scenic significance like national parks and wilderness areas and reduced use of sensitive ornamentals in landscaping.[743]

The most recent Integrated Science Assessment (ISA) for Ozone presents more detailed information on how ozone affects vegetation and ecosystems.[744] The ISA concludes that ambient concentrations of ozone are associated with a number of adverse welfare effects and characterizes the weight of evidence for different effects associated with ozone.[745] The ISA concludes that visible foliar injury effects on vegetation, reduced vegetation growth, reduced productivity in terrestrial ecosystems, reduced yield and quality of agricultural crops, and alteration of below-ground biogeochemical cycles are causally associated with exposure to ozone. It also concludes that reduced carbon sequestration in terrestrial ecosystems, alteration of terrestrial ecosystem water cycling, and alteration of terrestrial community composition are likely to be causally associated with exposure to ozone.

(3) Atmospheric Deposition

Wet and dry deposition of ambient particulate matter delivers a complex mixture of metals (*e.g.,* mercury, zinc, lead, nickel, aluminum, and cadmium), organic compounds (*e.g.,* polycyclic organic matter, dioxins, and furans) and inorganic compounds (*e.g.,* nitrate, sulfate) to terrestrial and aquatic ecosystems. The chemical form of the compounds deposited depends on a variety of factors including ambient conditions (*e.g.,* temperature, humidity, oxidant levels) and the sources of the material. Chemical and physical transformations of the compounds occur in the atmosphere as well as the media onto which they deposit. These transformations in turn influence the fate, bioavailability and potential toxicity of these compounds.

Adverse impacts to human health and the environment can occur when particulate matter is deposited to soils, water, and biota.[746] Deposition of heavy metals or other toxics may lead to the human ingestion of contaminated fish, impairment of drinking water, damage to terrestrial, freshwater and marine ecosystem components, and limits to recreational uses. Atmospheric deposition has been identified as a key component of the environmental and human health hazard posed by several pollutants including mercury, dioxin and PCBs.[747]

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[734] U.S. EPA. 2009 Final Report: Integrated Science Assessment for Particulate Matter. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, 2009.

[735] See Section 169(a) of the Clean Air Act.

[736] 64 FR 35714, July 1, 1999.

[737] 62 FR 38680–38681, July 18, 1997.

[738] 73 FR 16486, March 27, 2008.

[739] 73 FR 16491, March 27, 2008. Only a small percentage of all the plant species growing within the U.S. (over 43,000 species have been catalogued in the USDA PLANTS database) have been studied with respect to ozone sensitivity.

[740] The concentration at which ozone levels overwhelm a plant's ability to detoxify or compensate for oxidant exposure varies. Thus, whether a plant is classified as sensitive or tolerant depends in part on the exposure levels being considered. Chapter 9, Section 9.3.4 of U.S. EPA, 2013 Integrated Science Assessment for Ozone and Related Photochemical Oxidants. Office of Research and Development/National Center for Environmental Assessment. U.S. Environmental Protection Agency. EPA 600/R–10/076F.

[741] 73 FR 16492, March 27, 2008.

[742] 73 FR 16493–16494, March 27, 2008, Ozone impacts could be occurring in areas where plant species sensitive to ozone have not yet been studied or identified.

[743] 73 FR 16490–16497, March 27, 2008.

[744] U.S. EPA. Integrated Science Assessment of Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–10/076F, 2013. The ISA is available at *http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492#Download.*

[745] The Ozone ISA evaluates the evidence associated with different ozone related health and welfare effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For more information on these levels of evidence, please refer to Table II of the ISA.

[746] U.S. EPA. Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F, 2009.

[747] U.S. EPA. (2000). Deposition of Air Pollutants to the Great Waters: Third Report to Congress. Office of Air Quality Planning and Standards. EPA–453/R–00–0005.

The ecological effects of acidifying deposition and nutrient enrichment are detailed in the Integrated Science Assessment for Oxides of Nitrogen and Sulfur-Ecological Criteria.[748] Atmospheric deposition of nitrogen and sulfur contributes to acidification, altering biogeochemistry and affecting animal and plant life in terrestrial and aquatic ecosystems across the United States. The sensitivity of terrestrial and aquatic ecosystems to acidification from nitrogen and sulfur deposition is predominantly governed by geology. Prolonged exposure to excess nitrogen and sulfur deposition in sensitive areas acidifies lakes, rivers and soils. Increased acidity in surface waters creates inhospitable conditions for biota and affects the abundance and biodiversity of fishes, zooplankton and macroinvertebrates and ecosystem function. Over time, acidifying deposition also removes essential nutrients from forest soils, depleting the capacity of soils to neutralize future acid loadings and negatively affecting forest sustainability. Major effects in forests include a decline in sensitive tree species, such as red spruce (*Picea rubens*) and sugar maple (*Acer saccharum*). In addition to the role nitrogen deposition plays in acidification, nitrogen deposition also leads to nutrient enrichment and altered biogeochemical cycling. In aquatic systems increased nitrogen can alter species assemblages and cause eutrophication. In terrestrial systems nitrogen loading can lead to loss of nitrogen-sensitive lichen species, decreased biodiversity of grasslands, meadows and other sensitive habitats, and increased potential for invasive species. For a broader explanation of the topics treated here, refer to the description in Chapter 8.1.2.3 of the RIA.

Building materials including metals, stones, cements, and paints undergo natural weathering processes from exposure to environmental elements (*e.g.,* wind, moisture, temperature fluctuations, sunlight, etc.). Pollution can worsen and accelerate these effects. Deposition of PM is associated with both physical damage (materials damage effects) and impaired aesthetic qualities (soiling effects). Wet and dry deposition of PM can physically affect materials, adding to the effects of natural weathering processes, by potentially promoting or accelerating the corrosion of metals, by degrading paints and by deteriorating building materials such as stone, concrete and marble.[749] The effects of PM are exacerbated by the presence of acidic gases and can be additive or synergistic due to the complex mixture of pollutants in the air and surface characteristics of the material. Acidic deposition has been shown to have an effect on materials including zinc/galvanized steel and other metal, carbonate stone (as monuments and building facings), and surface coatings (paints).[750] The effects on historic buildings and outdoor works of art are of particular concern because of the uniqueness and irreplaceability of many of these objects.

(4) Environmental Effects of Air Toxics

Emissions from producing, transporting and combusting fuel contribute to ambient levels of pollutants that contribute to adverse effects on vegetation. Volatile organic compounds, some of which are considered air toxics, have long been suspected to play a role in vegetation damage.[751] In laboratory experiments, a wide range of tolerance to VOCs has been observed.[752] Decreases in harvested seed pod weight have been reported for the more sensitive plants, and some studies have reported effects on seed germination, flowering and fruit ripening. Effects of individual VOCs or their role in conjunction with other stressors (*e.g.,* acidification, drought, temperature extremes) have not been well studied. In a recent study of a mixture of VOCs including ethanol and toluene on herbaceous plants, significant effects on seed production, leaf water content and photosynthetic efficiency were reported for some plant species.[753]

Research suggests an adverse impact of vehicle exhaust on plants, which has in some cases been attributed to aromatic compounds and in other cases to nitrogen oxides.[754] [755] [756]

C. Emissions Inventory Impacts

As described in Section VII, the agencies conducted two analyses for these rules using DOT's CAFE model and EPA's MOVES model, relative to different reference cases (*i.e.,* different baselines). The agencies used EPA's MOVES model to estimate the non-GHG impacts for tractor-trailers (including the engine that powers the vehicle) and vocational vehicles (including the engine that powers the vehicle). For heavy-duty pickups and vans, the agencies performed separate analyses using the CAFE model (included in NHTSA's ''Method A;'' See Section VI) and the MOVES model (included in EPA's ''Method B;'' See Section VI) to estimate non-GHG emissions from these vehicles. For these methods, the agencies analyzed the impact of the rules relative to two different reference cases—flat and dynamic. The flat baseline projects very little improvement in new vehicles in the absence of new Phase 2 standards. In contrast, the dynamic baseline projects more significant improvements in vehicle fuel efficiency. The agencies considered both reference cases. The results for all of the regulatory alternatives relative to both reference cases, derived via the same methodologies discussed in Section VII of the Preamble, are presented in Section X of the Preamble.

For brevity, a subset of these analyses are presented in this section and the reader is referred to both Chapter 11 of the RIA and NHTSA's FEIS Chapters 3, 4 and 5 for complete sets of these analyses. In this section, Method A is presented for the final standards, relative to both the dynamic baseline (Alternative 1b) and the flat baseline (Alternative 1a). Method B is presented for the final standards, relative only to the flat baseline.

The following subsections summarize two slightly different analyses of the annual non-GHG emissions reductions expected from these standards. Section VIII.A.(1) presents the impacts of the

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[748] NO_X and SO_X secondary ISA[1] U.S. EPA. Integrated Science Assessment (ISA) for Oxides of Nitrogen and Sulfur Ecological Criteria (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/082F, 2008.

[749] U.S. Environmental Protection Agency (U.S. EPA). 2009. Integrated Science Assessment for Particulate Matter (Final Report). EPA–600–R–08–139F. National Center for Environmental Assessment—RTP Division. December. Available on the Internet at <*http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546*>.

[750] Irving, P.M., e.d. 1991. Acid Deposition: State of Science and Technology, Volume III, Terrestrial, Materials, Health, and Visibility Effects, The U.S. National Acid Precipitation Assessment Program, Chapter 24, page 24–76.

[751] U.S. EPA. (1991). Effects of organic chemicals in the atmosphere on terrestrial plants. EPA/600/3–91/001.

[752] Cape JN, ID Leith, J Binnie, J Content, M Donkin, M Skewes, DN Price AR Brown, AD Sharpe. (2003). Effects of VOCs on herbaceous plants in an open-top chamber experiment. Environ. Pollut. 124:341–343.

[753] Cape JN, ID Leith, J Binnie, J Content, M Donkin, M Skewes, DN Price AR Brown, AD Sharpe. (2003). Effects of VOCs on herbaceous plants in an open-top chamber experiment. Environ. Pollut. 124:341–343.

[754] Viskari E–L. (2000). Epicuticular wax of Norway spruce needles as indicator of traffic pollutant deposition. Water, Air, and Soil Pollut. 121:327–337.

[755] Ugrekhelidze D, F Korte, G Kvesitadze. (1997). Uptake and transformation of benzene and toluene by plant leaves. Ecotox. Environ. Safety 37:24–29.

[756] Kammerbauer H, H Selinger, R Rommelt, A Ziegler-Jons, D Knoppik, B Hock. (1987). Toxic components of motor vehicle emissions for the spruce Picea abies. Environ. Pollut. 48:235–243.

final rules on non-GHG emissions using the analytical Method A, relative to two different reference cases—flat and dynamic. Section VIII.A.(2) presents the impacts of these standards, relative to the flat reference case only, using the MOVES model for all heavy-duty vehicle categories.

(1) Impacts of the Final Rules Using Analysis Method A

(a) Calendar Year Analysis

(i) Upstream Impacts of the Final Program

Increasing efficiency in heavy-duty vehicles will result in reduced fuel demand and, therefore, reductions in the emissions associated with all processes involved in getting petroleum to the pump. Both Method A and Method B project these impacts for fuel consumed by vocational vehicles and combination tractor-trailers, using EPA's MOVES model. See Section VII.A. for the description of this methodology. To project these impacts for fuel consumed by HD pickups and vans, Method A used similar calculations and inputs applicable to the CAFE model, as discussed above in Section VI. More information on the development of the emission factors used in this analysis can be found in Chapter 5 of the RIA.

The following two tables summarize the projected upstream emission impacts of the final program on both criteria pollutants and air toxics from the heavy-duty sector, relative to Alternative 1b (dynamic baseline conditions under the No-Action Alternative) and Alternative 1a (flat baseline conditions under the No-Action Alternative), using analysis method A. Using either No-Action Alternative shows decreases in upstream emissions of all criteria pollutants, precursors, and air toxics; using Alternative 1a as the reference point attributes more of the emission reduction to the standards. Note that the rule is projected, in all analyses, of reducing emissions of NO$_X$, contrary to implications in some of the public comments that fuel efficiency/GHG controls come at the expense of increased NO$_X$ emissions.

TABLE VIII–1—ANNUAL UPSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1b USING ANALYSIS METHOD A [a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	−1	−4.9	−4	−18	−5	−19
Acetaldehyde	−3	−4.4	−14	−15	−16	−16
Acrolein	−0.4	−4.6	−2	−16	−2	−17
Benzene	−23	−4.8	−88	−16	−105	−18
CO	−3,785	−4.9	−14,714	−17	−17,629	−19
Formaldehyde	−18	−4.9	−71	−17	−86	−19
NO$_X$	−9,255	−4.9	−35,964	−17	−43,089	−19
PM$_{2.5}$	−975	−4.9	−3,850	−18	−4,618	−19
SO$_X$	−5,804	−4.9	−22,550	−17	−27,019	−19
VOC	−4,419	−4.8	−14,857	−15	−17,385	−16

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE VIII–2—ANNUAL UPSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD A [a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	−1	−5.3	−4	−20	−5	−21
Acetaldehyde	−4	−4.6	−15	−16	−17	−17
Acrolein	−0.4	−4.9	−2	−17	−2	−18
Benzene	−25	−5.1	−96	−18	−115	−19
CO	−4,142	−5.4	−16,298	−19	−19,558	−20
Formaldehyde	−20	−5.3	−79	−19	−95	−20
NO$_X$	−10,124	−5.4	−39,813	−19	−47,779	−20
PM$_{2.5}$	−1,065	−5.3	−4,258	−19	−5,117	−21
SO$_X$	−6,349	−5.4	−24,961	−19	−29,958	−20
VOC	−4,810	−5.2	−16,218	−16	−19,004	−17

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(ii) Downstream Impacts of the Final Program

For vocational vehicles and tractor-trailers, the agencies used the MOVES model to determine non-GHG emissions inventories. The improvements in engine efficiency and road load, the increased use of APUs, and VMT rebound were included in the MOVES analysis. For NHTSA's Method A analysis, presented in this section, the DOT CAFE model was used for HD pickups and vans. Further information about DOT's CAFE model is available in Section VI.C and Chapter 10 of the RIA. The following two tables summarize the projected downstream emission impacts of the final program on both criteria pollutants and air toxics from the heavy-duty sector, relative to Alternative 1b and Alternative 1a, using analysis Method A. Using either baseline shows a reduction in all criteria pollutants and air toxics—except for 1,3-Butadiene, and CY2025 levels of acrolein, which show small increases in downstream emissions.

TABLE VIII–3—ANNUAL DOWNSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1b USING ANALYSIS METHOD A[a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	1	0.5	4	3.6	4	3.4
Acetaldehyde	−1	0.0	−16	−0.7	−19	−0.8
Acrolein	0.2	0.0	−0.3	−0.1	−1	−0.4
Benzene	−2	−0.1	−13	−1.2	−13	−1.1
CO	−9,045	−0.6	−34,702	−2.8	−42,095	−3.0
Formaldehyde	−21	−0.3	−96	−1.6	−119	−1.8
NO_X	−12,082	−1.3	−53,254	−9.1	−65,068	−9.9
$PM_{2.5}$ [b]	−58	−0.2	−363	−2.0	−453	−2.2
SO_X	−201	−4.1	−851	−16	−1,028	−17
VOC	−769	−0.8	−3,436	−5.3	−4,128	−5.8

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] $PM_{2.5}$ from tire wear and brake wear are included.

TABLE VIII–4—ANNUAL DOWNSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD A[a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	1	0.5	4	3.7	4	3.5
Acetaldehyde	−1	0.0	−14	−0.7	−18	−0.8
Acrolein	0.2	0.0	−0.3	−0.1	−1	−0.4
Benzene	−2	−0.2	−13	−1.2	−14	−1.2
CO	−8,944	−0.6	−34,502	−2.8	−41,880	−3.0
Formaldehyde	−20	−0.3	−91	−1.6	−113	−1.7
NO_X	−13,368	−1.5	−60,594	−10.2	−74,206	−11
$PM_{2.5}$ [b]	−78	−0.2	−473	−2.6	−591	−2.9
SO_X	−219	−4.5	−941	−17	−1,138	−19
VOC	−831	−0.8	−3,736	−5.8	−4,499	−6.3

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] $PM_{2.5}$ from tire wear and brake wear are included.

(iii) Total Impacts of the Final Program

The following two tables summarize the projected upstream emission impacts of the final program on both criteria pollutants and air toxics from the heavy-duty sector, relative to Alternative 1b and Alternative 1a, using analysis Method A. Under both baselines, Method A predicts a decrease in total emissions by calendar year 2050, but the amount attributable to the standards is larger using the flat baseline than the dynamic baseline.

TABLE VIII–5—ANNUAL TOTAL IMPACTS (UPSTREAM AND DOWNSTREAM) OF CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1b USING ANALYSIS METHOD A[a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	0.3	0.1	0.1	0.1	−0.4	−0.3
Acetaldehyde	−4	−0.1	−30	−1.3	−35	−1.4
Acrolein	−0.2	0.0	−2	−0.7	−3	−0.9
Benzene	−25	−1.2	−101	−6.3	−118	−6.7
CO	−12,830	−0.9	−49,416	−3.7	−59,724	−4.0
Formaldehyde	−39	−0.5	−167	−2.7	−205	−2.9
NO_X	−21,337	−2.0	−89,218	−11	−108,157	−12
$PM_{2.5}$	−1,033	−2.0	−4,213	−10	−5,071	−11
SO_X	−6,005	−4.9	−23,401	−17	−28,047	−19
VOC	−5,188	−2.7	−18,293	−11	−21,513	−12

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE VIII–6—ANNUAL TOTAL IMPACTS (UPSTREAM AND DOWNSTREAM) OF CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD A [a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	0.2	0.1	−0.2	−0.1	−1.0	−0.5
Acetaldehyde	−5	−0.2	−29	−1.3	−35	−1.4
Acrolein	−0.2	0.0	−2	−0.7	−3	−1.0
Benzene	−27	−1.4	−109	−6.8	−129	−7.2
CO	−13,086	−0.9	−50,800	−3.8	−61,438	−4.1
Formaldehyde	−40	−0.5	−170	−2.7	−208	−2.9
NO_X	−23,492	−2.2	−100,407	−12	−121,985	−14
$PM_{2.5}$	−1,143	−2.2	−4,731	−12	−5,708	−13
SO_X	−6,568	−5.3	−25,902	−19	−31,096	−20
VOC	−5,641	−3.0	−19,954	−12	−23,503	−13

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(b) Model Year Lifetime Analysis

Table VIII–7 shows the lifetime Non-GHG reductions for model years 2018–2029 attributable to the standards using Method A relative to both No-Action Alternatives. For NO_X, approximately half of the emission reductions are downstream and half are upstream. However, for $PM_{2.5}$ and SO_X proportionally more of the emission reductions are attributable to upstream emission reductions than to downstream emission reductions. A similar pattern emerges as with single calendar year snapshots; more emission reductions are attributable to the standards using the 1a baseline as the reference point than by using the 1b baseline as the reference point.

TABLE VIII–7—LIFETIME NON-GHG REDUCTIONS USING ANALYSIS METHOD A—SUMMARY FOR MODEL YEARS 2018–2029

[U.S. Short Tons] [a]

NO–action alternative (baseline)	Final program	
	1b (Dynamic)	1a (Flat)
NO_X	494,495	548,630
Downstream	246,509	276,413
Upstream	247,986	272,217
$PM_{2.5}$	27,827	30,838
Downstream[b]	1,437	1,891
Upstream	26,390	28,947
SO_X	159,367	174,918
Downstream	3,849	4,214
Upstream	155,518	170,704

Notes:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.
[b] $PM_{2.5}$ from tire wear and brake wear are included.

(2) Impacts of the Final Rules Using Analysis Method B

(a) Calendar Year Analysis

(i) Upstream Impacts of the Final Program

Increasing efficiency in heavy-duty vehicles will result in reduced fuel demand and, therefore, reductions in the emissions associated with all processes involved in getting petroleum to the pump. To project these impacts, Method B estimated the impact of reduced petroleum volumes on the extraction and transportation of crude oil as well as the production and distribution of finished gasoline and diesel. For the purpose of assessing domestic-only emission reductions, it was necessary to estimate the fraction of fuel savings attributable to domestic finished gasoline and diesel and, of this fuel, what fraction is produced from domestic crude. Method B estimated the emissions associated with production and distribution of gasoline and diesel from crude oil based on emission factors in the ‘‘Greenhouse Gases, Regulated Emissions, and Energy used in Transportation’’ model (GREET) developed by DOE's Argonne National Laboratory. In some cases, the GREET values were modified or updated by the agencies to be consistent with the National Emission Inventory (NEI) and emission factors from MOVES. Method B estimated the projected corresponding changes in upstream emissions using the same tools originally created for the Renewable Fuel Standard 2 (RFS2) rulemaking analysis,[757] used in the LD

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[757] U.S. EPA. Draft Regulatory Impact Analysis: Changes to Renewable Fuel Standard Program.

GHG rulemakings,[758] HD GHG Phase 1,[759] and updated for the current analysis. More information on the development of the emission factors used in this analysis can be found in Chapter 5 of the RIA.

Table VIII–8 summarizes the projected upstream emission impacts of the final program on both criteria pollutants and air toxics from the heavy-duty sector, relative to Alternative 1a, using analysis Method B. The comparable estimates relative to Alternative 1b are presented in Section VIII.C.(1).

TABLE VIII–8—ANNUAL UPSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B[a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	−1	−4.8	−5	−19.0	−6	−20.6
Acetaldehyde	−7	−3.2	−35	−14.5	−38	−15.9
Acrolein	−1	−3.5	−3	−15.2	−4	−16.7
Benzene	−30	−3.8	−143	−16.1	−166	−17.6
CO	−3,809	−4.8	−16,884	−18.9	−20,227	−20.5
Formaldehyde	−20	−4.6	−90	−18.3	−107	−19.9
NO_X	−9,314	−4.8	−41,280	−18.9	−49,462	−20.5
$PM_{2.5}$	−1,037	−4.7	−4,619	−18.7	−5,520	−20.3
SO_X	−5,828	−4.8	−25,811	−18.9	−30,941	−20.5
VOC	−4,234	−3.7	−20,010	−15.9	−23,240	−17.4

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(ii) Downstream Impacts of the Final Program

The final program will impact the downstream emissions of non-GHG pollutants. These pollutants include oxides of nitrogen (NO_X), oxides of sulfur (SO_X), volatile organic compounds (VOC), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), and air toxics. The agencies expect reductions in downstream emissions of NO_X, $PM_{2.5}$, VOC, SO_X, CO, and air toxics. Much of these estimated net reductions are a result of the agencies' anticipation of increased use of auxiliary power units (APUs) in combination tractors during extended idling; APUs emit these pollutants at a lower rate than on-road engines during extended idle operation, with the exception of $PM_{2.5}$. As discussed in Section III.C.3, EPA is adopting Phase 1 and Phase 2 requirements to control $PM_{2.5}$ emissions from APUs installed in new tractors and therefore, eliminate the unintended consequence of increased $PM_{2.5}$ emissions from increased APU use.

Additional reductions in tailpipe emissions of NO_X and CO and refueling emissions of VOC will be achieved through improvements in engine efficiency and reduced road load (improved aerodynamics and tire rolling resistance), which reduces the amount of work required to travel a given distance and increases fuel economy. For vehicle types not affected by road load improvements, such as HD pickups and vans [760], non-GHG emissions will increase very slightly due to VMT rebound. In addition, brake wear and tire wear emissions of $PM_{2.5}$ will also increase very slightly due to VMT rebound. The agencies estimate that downstream emissions of SO_X will be reduced, because they are roughly proportional to fuel consumption.

For vocational vehicles and tractor-trailers, the agencies used MOVES to determine non-GHG emissions impacts of the final rules, relative to the flat baseline (Alternative 1a) and the dynamic baseline (Alternative 1b). The improvements in engine efficiency and road load, the increased use of APUs, and VMT rebound were included in the MOVES analysis. For this analysis, Method B also used the MOVES model for HD pickups and vans.

The downstream criteria pollutant and air toxics impacts of the final program, relative to Alternative 1a, using analysis Method B, are presented in Table VIII–9.

TABLE VIII–9—ANNUAL DOWNSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B[a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	−1	−0.2	−3	−1.5	−3	−1.8
Acetaldehyde	−3	−0.1	−18	−0.8	−23	−0.9
Acrolein	−0.1	0	−1	−0.3	−1	−0.4
Benzene	−5	−0.2	−22	−1.4	−26	−1.6
CO	−9,445	−0.4	−35,710	−2.4	−43,642	−2.7

Chapters 2 and 3. May 26, 2009. Docket ID: EPA–HQ–OAR–2009–0472–0119.

[758] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards (77 FR 62623, October 15, 2012).

[759] Greenhouse Gas Emission Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (76 FR 57106, September 15, 2011).

[760] HD pickups and vans are subject to gram per mile (distance) emission standards, as opposed to larger heavy-duty vehicles which are certified to a gram per brake horsepower (work) standard.

TABLE VIII–9—ANNUAL DOWNSTREAM IMPACTS ON CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B [a]—Continued

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
Formaldehyde	−20	−0.2	−97	−1.5	−120	−1.7
NO$_X$	−13,396	−1.4	−60,681	−9.7	−74,362	−10.8
PM$_{2.5}$ [b]	−73	−0.2	−462	−2.2	−580	−2.5
SO$_X$	−252	−4.7	−1,122	−18.5	−1,341	−20.1
VOC	−1,071	−0.8	−5,060	−5.9	−6,013	−6.6

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] PM$_{2.5}$ from tire wear and brake wear are included.

As noted above, EPA is adopting Phase 1 and Phase 2 requirements to control PM$_{2.5}$ emissions from APUs installed in new tractors. In the NPRM, EPA projected an unintended increase in downstream PM$_{2.5}$ emissions because engines powering APUs are currently required to meet less stringent PM standards (40 CFR 1039.101) than on-road engines (40 CFR 86.007–11) and because the increase in emissions from APUs more than offset the reduced tailpipe emissions from improved engine efficiency and road load. However, with the new requirements for APUs, the final program is projected to lead to reduced downstream PM$_{2.5}$ emissions of 462 tons in 2040 and 580 tons in 2050 (Table VIII–9). The net reductions in national PM$_{2.5}$ emissions from the requirements for APUs are 927 tons and 1,114 tons in 2040 and 2050, respectively (Table VIII–10). See Section III.C.3 of the Preamble for additional details on EPA's PM emission standards for APUs. The development of APU emission rates with PM control is documented in a memorandum to the docket.[761]

TABLE VIII–10—IMPACT ON PM$_{2.5}$ EMISSIONS OF FURTHER PM$_{2.5}$ CONTROL ON APUS—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B

[US Short Tons] [a]

CY	Baseline national heavy-duty vehicle PM$_{2.5}$ emissions (tons)	Final HD phase 2 program national PM$_{2.5}$ emissions without further PM control (tons)	Final HD phase 2 program national PM$_{2.5}$ emissions with further PM control (tons)	Net impact on national PM$_{2.5}$ emission with further PM control on APUs (tons)
2040	20,939	21,403	20,476	−927
2050	22,995	23,529	22,416	−1,114

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

It is worth noting that the emission reductions shown in Table VIII–9 are not incremental to the emissions reductions projected in the Phase 1 rulemaking. This is because, as described in Sections III.D.(1).a of the Preamble, the agencies have revised their assumptions about the adoption rate of APUs. This final rule assumes that without the Phase 2 program (*i.e.,* in the Phase 2 baselines), the APU adoption rate will be 9 percent for model years 2010 and later. EPA conducted an analysis to estimate the combined emissions impacts of the Phase 1 and the Phase 2 programs for NO$_X$, VOC, SO$_X$ and PM$_{2.5}$ in calendar year 2050 using MOVES2014a. The results are shown in Table VIII–11. For NO$_X$ and PM$_{2.5}$ only, we also estimated the combined Phase 1 and Phase 2 downstream and upstream emissions impacts for calendar year 2025, and project that the two rules combined will reduce NO$_X$ by up to 55,000 tons and PM$_{2.5}$ by up to 33,000 tons in that year. For additional details, see Chapter 5 of the RIA.

TABLE VIII–11—COMBINED PHASE 1 AND PHASE 2 ANNUAL DOWNSTREAM IMPACTS ON CRITERIA POLLUTANTS FROM HEAVY-DUTY SECTOR IN CALENDAR YEAR 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B

[US Short Tons] [a]

CY	NO$_X$	VOC	SO$_X$	PM$_{2.5}$ [b]
2050	−100,878	−10,067	−2,249	−1,001

Notes:

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[761] U.S. EPA. Updates to MOVES for Emissions Analysis of Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2 FRM. Docket No. EPA–HQ–OAR–2016, July 2016.

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

(iii) Total Impacts of the Final Program

As shown in Table VIII–12, EPA estimates that the final program will result in overall net reductions of NO_X, VOC, SO_X, CO, $PM_{2.5}$, and air toxics emissions. The results are shown both in changes in absolute tons and in percent reductions from the flat reference to the final program for the heavy-duty sector.

TABLE VIII–12—ANNUAL TOTAL IMPACTS (UPSTREAM AND DOWNSTREAM) OF CRITERIA POLLUTANTS AND AIR TOXICS FROM HEAVY-DUTY SECTOR IN CALENDAR YEARS 2025, 2040 AND 2050—FINAL PROGRAM VS. ALT 1a USING ANALYSIS METHOD B [a]

Pollutant	CY2025		CY2040		CY2050	
	US short tons	% Change	US short tons	% Change	US short tons	% Change
1,3-Butadiene	−2	−0.5	−8	−3.7	−9	−4.1
Acetaldehyde	−10	−0.3	−53	−2.0	−61	−2.1
Acrolein	−1	−0.1	−4	−1.3	−5	−1.3
Benzene	−35	−1.1	−165	−6.8	−192	−7.5
CO	−13,254	−0.6	−52,594	−3.3	−63,869	−3.8
Formaldehyde	−40	−0.5	−187	−2.7	−227	−2.9
NO_X	−22,710	−1.9	−101,961	−12.1	−123,824	−13.3
$PM_{2.5}$	−1,110	−1.9	−5,081	−11.1	−6,100	−12.1
SO_X	−6,080	−4.8	−26,933	−18.9	−32,282	−20.5
VOC	−5,305	−2.2	−25,070	−11.9	−29,253	−13.0

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(b) Model Year Lifetime Analysis

In addition to the annual non-GHG emissions reductions expected from the final rules, EPA estimated the combined (downstream and upstream) non-GHG impacts for the lifetime of the impacted vehicles. Table VIII–13 shows the fleet-wide reductions of NO_X, $PM_{2.5}$ and SO_X from the final program, relative to Alternative 1a, through the lifetime [762] of heavy-duty vehicles. For the lifetime non-GHG reductions by vehicle categories, see Chapter 5 of the RIA.

TABLE VIII–13—LIFETIME NON-GHG REDUCTIONS USING ANALYSIS METHOD B—SUMMARY FOR MODEL YEARS 2018–2029

[U.S. Short Tons] [a]

No-action alternative (baseline)	Final program
	1a (Flat)
NO_X	549,881
Downstream	277,644
Upstream	272,237
$PM_{2.5}$	32,251
Downstream [b]	1,824
Upstream	30,427
SO_X	175,202
Downstream	4,931
Upstream	170,272

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.
[b] $PM_{2.5}$ from tire wear and brake wear are included.

D. Air Quality Impacts of Non-GHG Pollutants

Changes in emissions of non-GHG pollutants due to these rules will impact air quality. Information on current air quality and the results of our air quality modeling of the projected impacts of these rules are summarized in the following section. Additional information is available in Chapter 6 of the RIA.

(1) Current Concentrations of Non-GHG Pollutants

Nationally, levels of $PM_{2.5}$, ozone, NO_X, SO_X, CO and air toxics are declining.[763] However, as of April 22, 2016, more than 125 million people lived in counties designated nonattainment for one or more of the NAAQS, and this figure does not include the people living in areas with a risk of exceeding a NAAQS in the future.[764] Many Americans continue to be exposed to ambient concentrations of air toxics at levels which have the potential to cause adverse health effects.[765] In addition, populations who live, work, or attend school near major roads experience elevated exposure concentrations to a wide range of air pollutants.[766]

(a) Particulate Matter

There are two primary NAAQS for $PM_{2.5}$: An annual standard (12.0 micrograms per cubic meter (μg/m³)) set in 2012 and a 24-hour standard (35 μg/m³) set in 2006, and two secondary NAAQS for $PM_{2.5}$: An annual standard (15.0 μg/m³) set in 1997 and a 24-hour standard (35 μg/m³) set in 2006.

There are many areas of the country that are currently in nonattainment for the annual and 24-hour primary $PM_{2.5}$ NAAQS. In 2005 the EPA designated 39 nonattainment areas for the 1997 $PM_{2.5}$ NAAQS.[767] As of April 22, 2016, more than 23 million people lived in the 7 areas that are still designated as nonattainment for the 1997 annual $PM_{2.5}$ NAAQS. These $PM_{2.5}$

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[762] A lifetime of 30 years is assumed in MOVES.

[763] U.S. EPA, 2011. Our Nation's Air: Status and Trends through 2010. EPA–454/R–12–001. February 2012. Available at: *http://www3.epa.gov/airtrends/2011/*.

[764] Data come from Summary Nonattainment Area Population Exposure Report, current as of April 22, 2016 at: *https://www3.epa.gov/airquality/greenbk/popexp.html* and contained in Docket EPA–HQ–OAR–2014–0827.

[765] U.S. EPA. (2015) Summary of Results for the 2011 National-Scale Assessment. *https://www3.epa.gov/sites/production/files/2015-12/documents/2011-nata-summary-results.pdf*.

[766] Health Effects Institute Panel on the Health Effects of Traffic-Related Air Pollution. (2010) Traffic-related air pollution: A critical review of the literature on emissions, exposure, and health effects. HEI Special Report 17. Available at *http://www.healtheffects.org*].

[767] 70 FR 19844 (April 14, 2005).

nonattainment areas are comprised of 33 full or partial counties. In December 2014 EPA designated 14 nonattainment areas for the 2012 annual $PM_{2.5}$ NAAQS.[768] In March 2015, EPA changed the initial designation from nonattainment to unclassifiable/attainment for four areas based on the availability of complete, certified 2014 air quality data showing these areas met the 2012 annual $PM_{2.5}$ NAAQS. The EPA also changed the initial 2012 annual $PM_{2.5}$ NAAQS designation from nonattainment to unclassifiable for the Louisville, Indiana-Kentucky area. [769] As of April 22, 2016, 9 of these areas remain designated as nonattainment, and they are composed of 20 full or partial counties with a population of over 23 million. On November 13, 2009 and February 3, 2011, the EPA designated 32 nonattainment areas for the 2006 24-hour $PM_{2.5}$ NAAQS.[770] As of April 22, 2016, 16 of these areas remain designated as nonattainment for the 2006 24-hour $PM_{2.5}$ NAAQS, and they are composed of 46 full or partial counties with a population of over 32 million. In total, there are currently 24 $PM_{2.5}$ nonattainment areas with a population of more than 39 million people.[771]

The EPA has already adopted many mobile source emission control programs that are expected to reduce ambient PM concentrations. As a result of these and other federal, state and local programs, the number of areas that fail to meet the $PM_{2.5}$ NAAQS in the future is expected to decrease. However, even with the implementation of all current state and federal regulations, there are projected to be counties violating the $PM_{2.5}$ NAAQS well into the future. States will need to meet the 2006 24-hour standards in the 2015–2019 timeframe and the 2012 primary annual standard in the 2021–2025 timeframe. The emission reductions and improvements in ambient $PM_{2.5}$ concentrations from this action, which will take effect as early as model year 2018, will be helpful to states as they work to attain and maintain the $PM_{2.5}$ NAAQS.[772] The standards can assist areas with attainment dates in 2018 and beyond in attaining the NAAQS as expeditiously as practicable and may relieve areas with already stringent local regulations from some of the burden associated with adopting additional local controls.

(b) Ozone

The primary and secondary NAAQS for ozone are 8-hour standards with a level of 0.07 ppm. The most recent revision to the ozone standards was in 2015; the previous 8-hour ozone primary standard, set in 2008, had a level of 0.075 ppm. Final nonattainment designations for the 2008 ozone standard were issued on April 30, 2012, and May 31, 2012.[773] As of April 22, 2016, there were 44 ozone nonattainment areas for the 2008 ozone NAAQS, composed of 216 full or partial counties, with a population of more than 120 million. In addition, EPA plans to finalize nonattainment areas for the 2015 ozone NAAQS in October 2017.

States with ozone nonattainment areas are required to take action to bring those areas into attainment. The attainment date assigned to an ozone nonattainment area is based on the area's classification. The attainment dates for areas designated nonattainment for the 2008 8-hour ozone NAAQS are in the 2015 to 2032 timeframe, depending on the severity of the problem in each area. Nonattainment area attainment dates associated with areas designated for the 2015 NAAQS will be in the 2020–2037 timeframe, depending on the severity of the problem in each area.[774]

EPA has already adopted many emission control programs that are expected to reduce ambient ozone levels. As a result of these and other federal, state and local programs, 8-hour ozone levels are expected to improve in the future. However, even with the implementation of all current state and federal regulations, there are projected to be counties violating the ozone NAAQS well into the future. The emission reductions from this action, which will take effect as early as model year 2018, will be helpful to states as they work to attain and maintain the ozone NAAQS.[775] The standards can assist areas with attainment dates in 2018 and beyond in attaining the NAAQS as expeditiously as practicable and may relieve areas with already stringent local regulations from some of the burden associated with adopting additional local controls.

(c) Nitrogen Dioxide

The EPA most recently completed a review of the primary NAAQS for NO_2 in January 2010. There are two primary NAAQS for NO_2: An annual standard (53 ppb) and a 1-hour standard (100 ppb). The EPA promulgated area designations in the **Federal Register** on February 17, 2012. In this initial round of designations, all areas of the country were designated as ''unclassifiable/attainment'' for the 2010 NO_2 NAAQS based on data from the existing air quality monitoring network. The EPA and state agencies are working to establish an expanded network of NO_2 monitors, expected to be deployed in the 2014–2017 time frame. Once three years of air quality data have been collected from the expanded network, the EPA will be able to evaluate NO_2 air quality in additional locations.[776] [777]

(d) Sulfur Dioxide

The EPA most recently completed a review of the primary SO_2 NAAQS in June 2010. The current primary NAAQS for SO_2 is a 1-hour standard of 75 ppb. The EPA finalized the initial area designations for 29 nonattainment areas in 16 states in a notice published in the **Federal Register** on August 5, 2013. In this first round of designations, EPA only designated nonattainment areas that were violating the standard based on existing air quality monitoring data provided by the states. The agency did not have sufficient information to designate any area as ''attainment'' or make final decisions about areas for which additional modeling or monitoring is needed (78 FR 47191, August 5, 2013). On March 2, 2015, the U.S. District Court for the Northern District of California accepted, as an enforceable order, an agreement between the EPA and Sierra Club and Natural Resources Defense Council to resolve litigation concerning the deadline for completing designations.[778] The court's order directs the EPA to complete designations for all remaining

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[768] EPA 2014. Fact Sheet: Final Area Designations for the Annual Fine Particle Standard. *https://www3.epa.gov/pmdesignations/2012standards/final/20141218fs.pdf.*

[769] *https://www3.epa.gov/pmdesignations/2012standards/final/20150331fs.pdf.*

[770] 74 FR 58688 (November 13, 2009) and 76 FR 6056 (February 3, 2011).

[771] The 39 million total is calculated by summing, without double counting, the 1997, 2006 and 2012 $PM_{2.5}$ nonattainment populations contained in the Summary Nonattainment Area Population Exposure report (*https://www3.epa.gov/airquality/greenbk/popexp.html*). If there is a population associated with more than one of the 1997, 2006 and 2012 nonattainment areas, and they are not the same, then the larger of the populations is included in the sum.

[772] The final Phase 2 trailer standards and PM controls for APUs begin with model year 2018.

[773] 77 FR 30088 (May 21, 2012) and 77 FR 34221 (June 11, 2012).

[774] *https://www3.epa.gov/ozone-pollution/2015-ozone-naaqs-timelines.*

[775] The final Phase 2 trailer standards begin with model year 2018.

[776] U.S. EPA. (2012). Fact Sheet—Air Quality Designations for the 2010 Primary Nitrogen Dioxide (NO_2) National Ambient Air Quality Standards. *http://www3.epa.gov/airquality/nitrogenoxides/designations/pdfs/20120120FS.pdf.*

[777] U.S. Environmental Protection Agency (2013). Revision to Ambient Nitrogen Dioxide Monitoring Requirements. March 7, 2013. *http://www3.epa.gov/airquality/nitrogenoxides/pdfs/20130307fr.pdf.*

[778] *Sierra Club* v. *McCarthy,* No. 3–13–cv–3953 (SI) (N.D. Cal. Mar. 2, 2015).

areas in the country in up to three additional rounds: The first round by July 2, 2016, the second round by December 31, 2017, and the final round by December 31, 2020.

(e) Carbon Monoxide

There are two primary NAAQS for CO: An 8-hour standard (9 ppm) and a 1-hour standard (35 ppm). The primary NAAQS for CO were retained in August 2011. There are currently no CO nonattainment areas; as of September 27, 2010, all CO nonattainment areas have been redesignated to attainment.

The past designations were based on the existing community-wide monitoring network. EPA is making changes to the ambient air monitoring requirements for CO. The new requirements are expected to result in approximately 52 CO monitors operating near roads within 52 urban areas by January 2015 (76 FR 54294, August 31, 2011).

(f) Diesel Exhaust PM

Because DPM is part of overall ambient PM and cannot be easily distinguished from overall PM, we do not have direct measurements of DPM in the ambient air. DPM concentrations are estimated using ambient air quality modeling based on DPM emission inventories. DPM emission inventories are computed as the exhaust PM emissions from mobile sources combusting diesel or residual oil fuel. DPM concentrations were recently estimated as part of the 2011 NATA.[779] Areas with high concentrations are clustered in the Northeast, Great Lake States, California, and the Gulf Coast States and are also distributed throughout the rest of the U.S. The median DPM concentration calculated nationwide is 0.76 $\mu g/m^3$. Half of the DPM can be attributed to heavy-duty diesel vehicles.

(g) Air Toxics

The most recent available data indicate that the majority of Americans continue to be exposed to ambient concentrations of air toxics at levels which have the potential to cause adverse health effects. The levels of air toxics to which people are exposed vary depending on where people live and work and the kinds of activities in which they engage, as discussed in detail in EPA's most recent Mobile Source Air Toxics Rule.[780] According to the National Air Toxic Assessment (NATA) for 2011, mobile sources were responsible for 50 percent of outdoor anthropogenic toxic emissions and were the largest contributor to cancer and noncancer risk from directly emitted pollutants.[781] [782] Mobile sources are also large contributors to precursor emissions which react to form air toxics. Formaldehyde is the largest contributor to cancer risk of all 71 pollutants quantitatively assessed in the 2011 NATA. Mobile sources were responsible for more than 25 percent of primary anthropogenic emissions of this pollutant in 2011 and are major contributors to formaldehyde precursor emissions. Benzene is also a large contributor to cancer risk, and mobile sources account for almost 80 percent of ambient exposure. Over the years, EPA has implemented a number of mobile source and fuel controls which have resulted in VOC reductions, which also reduced formaldehyde, benzene and other air toxic emissions.

(2) Impacts of the Rule on Projected Air Quality

Along with reducing GHGs, the Phase 2 standards also have an impact on non-GHG, criteria and air toxic pollutant, emissions. As shown above in Section VIII.C, the standards will impact exhaust emissions of these pollutants from vehicles and will also impact emissions that occur during the refining and distribution of fuel (upstream sources). Reductions in emissions of NO_X, VOC, $PM_{2.5}$ and air toxics expected as a result of the Phase 2 standards will lead to improvements in air quality, specifically decreases in ambient concentrations of $PM_{2.5}$, ozone, NO_2 and air toxics, as well as better visibility and reduced deposition.

Emissions and air quality modeling decisions are made early in the analytical process because of the time and resources associated with full-scale photochemical air quality modeling. As a result, the inventories used in the air quality modeling and the benefits modeling are different from the final emissions inventories presented in Section VIII.C. The air quality inventories and the final inventories are consistent in many ways, but there are some important differences. For example, in this final rulemaking, EPA is adopting Phase 1 and Phase 2 requirements to control $PM_{2.5}$ emissions from APUs installed in new tractors, so we do not expect increases in downstream $PM_{2.5}$ emissions from the Phase 2 program; however, the air quality inventories do not reflect these requirements and therefore show increases in downstream $PM_{2.5}$ emissions. Chapter 5 of the RIA has more detail on the differences between the air quality and final inventories. The results of our air quality modeling of the criteria pollutant and air toxics impacts of the Phase 2 standards are summarized in the RIA and presented in more detail in Appendix 6A to the RIA.

IX. Economic and Other Impacts

This section presents the costs, benefits and other economic impacts of the Phase 2 standards. It is important to note that NHTSA's fuel consumption standards and EPA's GHG standards will both be in effect, and each will lead to average fuel efficiency increases and GHG emission reductions.

The net benefits of the Phase 2 standards consist of the effects of the program on:

- vehicle program costs (costs of complying with the vehicle CO_2 and fuel consumption standards)
- changes in fuel expenditures associated with reduced fuel use resulting from more efficient vehicles and increased fuel use associated with the ''rebound'' effect, both of which result from the program
- economic value of reductions in GHGs
- economic value of reductions in non-GHG pollutants
- costs associated with increases in noise, congestion, and crashes resulting from increased vehicle use
- savings in drivers' time from less frequent refueling
- benefits of increased vehicle use associated with the ''rebound'' effect
- economic value of improvements in U.S. energy security

The benefits and costs of these rules are analyzed using 3 percent and 7 percent discount rates, consistent with current OMB guidance.[783] These rates

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[779] U.S. EPA (2015) 2011 National-Scale Air Toxics Assessment. *https://www3.epa.gov/national-air-toxics-assessment/2011-nata-assessment-results#emissions.*

[780] U.S. Environmental Protection Agency (2007). Control of Hazardous Air Pollutants from Mobile Sources; Final Rule. 72 FR 8434, February 26, 2007.

[781] U.S. EPA. (2015) 2011 NATA: Assessment Results. *https://www3.epa.gov/national-air-toxics-assessment/2011-nata-assessment-results.*

[782] NATA also includes estimates of risk attributable to background concentrations, which includes contributions from long-range transport, persistent air toxics, and natural sources; as well as secondary concentrations, where toxics are formed via secondary formation. Mobile sources substantially contribute to long-range transport and secondarily formed air toxics.

[783] The range of Social Cost of Carbon (SC–CO_2) values uses several discount rates because the literature shows that the SC–CO_2 is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context (where costs and benefits are incurred by different generations). Refer to Section IX.F.1 for more information.

are intended to represent consumers' preference for current over future consumption (3 percent), and the real rate of return on private investment (7 percent) which indicates the opportunity cost of capital. However, neither of these rates necessarily represents the discount rate that individual decision-makers use.

The program may also have other economic effects that are not included here. As discussed in Sections III through VI of this Preamble and in Chapter 2 of the RIA, the technology cost estimates developed here take into account the costs to hold other vehicle attributes, such as size and performance, constant. With these assumptions, and because welfare losses represent monetary estimates of how much buyers would have to be compensated to be made as well off as they would have been in the absence of this regulation,[784] price increases for new vehicles measure the welfare losses to the vehicle buyers.[785] If the full technology cost gets passed along to the buyer as an increase in price, the technology cost thus measures the primary welfare loss of the standards, including impacts on buyers. Increasing fuel efficiency would have to lead to other changes in the vehicles that buyers find undesirable for there to be additional welfare losses that are not included in the technology costs.

As the 2012–2016 and 2017–2025 light-duty GHG/CAFE rules discussed, if other vehicle attributes are not held constant, then the technology cost estimates do not capture the losses to vehicle buyers associated with these changes.[786] The light-duty rules also discussed other potential issues that could affect the calculation of the welfare impacts of these types of changes, such as aspects of buyers' behavior that might affect the demand for technology investments, uncertainty in buyers' investment horizons, and the rate at which truck owner's trade off higher vehicle purchase price against future fuel savings.

Where possible, we identify the uncertain aspects of these economic impacts and attempt to quantify them (*e.g.,* sensitivity ranges associated with quantified and monetized GHG impacts; range of dollar-per-ton values to monetize non-GHG health benefits; uncertainty with respect to learning and markups). The agencies have examined the sensitivity of oil prices on fuel expenditures; results of this sensitivity analysis can be found in Chapter 8 of the RIA. NHTSA's EIS also characterizes the uncertainty in economic impacts associated with the HD national program. For other impacts, however, there is inadequate information to inform a thorough, quantitative assessment of uncertainty. EPA and NHTSA continue to work toward developing a comprehensive strategy for characterizing the aggregate impact of uncertainty in key elements of its analyses and we will continue to work to refine these uncertainty analyses in the future as time and resources permit.

This and other sections of the Preamble address Section 317 of the Clean Air Act on economic analysis. Section IX.L addresses Section 321 of the Clean Air Act on employment analysis. The total monetized benefits and costs of the program are summarized in Section IX.K for the final program and in Section X for all alternatives.

The agencies sought comment on numerous aspects of the analyses presented in this section, such as the potential omissions of costs or benefits, additional impacts of the standards on vehicle attributes and performance, and the quantification of uncertainty. Responses to comments on specific aspects of the analysis are addressed as appropriate in the relevant sections below, and in Sections III through VI of this Preamble as they relate to certain technologies. Further detail can be found in Section 11 of the RTC.

A. Conceptual Framework

The HD Phase 2 standards will implement both the 2007 Energy Independence and Security Act requirement that NHTSA establish fuel efficiency standards for medium- and heavy-duty vehicles and the Clean Air Act requirement that EPA adopt technology-based standards to control pollutant emissions from motor vehicles and engines contributing to air pollution that endangers public health and welfare. NHTSA's statutory mandate is intended to further the agency's long-standing goals of reducing U.S. consumption and imports of petroleum energy to improve the nation's energy security.

From an economics perspective, government actions to improve our nation's energy security and to protect our nation from the potential threats of climate change address ''externalities,'' or economic consequences of decisions by individuals and businesses that extend beyond those who make these decisions. For example, users of transportation fuels increase the entire U.S. economy's risk of having to make costly adjustments due to rapid increases in oil prices, but these users generally do not consider such costs when they decide to consume more fuel.

Similarly, consuming transportation fuel also increases emissions of greenhouse gases and other more localized air pollutants that occur when fuel is refined, distributed, and consumed. Some of these emissions increase the likelihood and severity of potential climate-related economic damages, and others cause economic damages by adversely affecting human health. The need to address these external costs and other adverse effects provides a well-established economic rationale that supports the statutory direction given to government agencies to establish regulatory programs that reduce the magnitude of these adverse effects at reasonable costs.

The Phase 2 standards will require manufacturers of new heavy-duty vehicles, including trailers (HDVs), to improve the fuel efficiency of the products that they produce. As HDV users purchase and operate these new vehicles, they will consume significantly less fuel, in turn reducing U.S. petroleum consumption and imports as well as emissions of GHGs and other air pollutants. Thus, as a consequence of the agencies' efforts to meet our statutory obligations to improve U.S. energy security and EPA's obligation to issue standards ''to regulate emissions of the deleterious pollutant . . . from motor vehicles'' that endangers public health and welfare,[787]

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[784] This approach describes the economic concept of compensating variation, a payment of money after a change that would make a consumer as well off after the change as before it. A related concept, equivalent variation, estimates the income change that would be an alternative to the change taking place. The difference between them is whether the consumer's point of reference is her welfare before the change (compensating variation) or after the change (equivalent variation). In practice, these two measures are typically very close together.

[785] Indeed, it is likely to be an overestimate of the loss to the consumer, because the buyer has choices other than buying the same vehicle with a higher price; she could choose a different vehicle, or decide not to buy a new vehicle. The buyer would choose one of those options only if the alternative involves less loss than paying the higher price. Thus, the increase in price that the buyer faces would be the upper bound of loss of consumer welfare, unless there are other changes to the vehicle due to the fuel efficiency improvements that make the vehicle less desirable to consumers.

[786] Environmental Protection Agency and Department of Transportation, ''Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule,'' 75 FR 25324, May 7, 2010, especially Sections III.H.1 (25510–25513) and IV.G.6 (25651–25657); Environmental Protection Agency and Department of Transportation, ''2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule,'' 77 FR 62624, October 15, 2012, especially Sections III.H.1 (62913–62919) and IV.G.5.a (63102–63104).

[787] *State of Massachusetts* v. *EPA,* 549 U.S. at 533.

the fuel efficiency and GHG emission standards will also reduce HDV operators' outlays for fuel purchases. These fuel savings are one measure of the final rule's effectiveness in promoting NHTSA's statutory goal of conserving energy, as well as EPA's obligation under section 202(a)(1) and (2) of the Clean Air Act to assess the cost of standards. Although these savings are not the agencies' primary motivation for adopting higher fuel efficiency standards, these substantial fuel savings represent significant additional economic benefits of these rules.

Potential savings in fuel costs appear to offer HDV buyer's strong incentives to pay higher prices for vehicles that feature technology or equipment that reduces fuel consumption. These potential savings also appear to offer HDV manufacturers similarly strong incentives to produce more fuel-efficient vehicles. Economic theory suggests that interactions between vehicle buyers and sellers in a normally-functioning competitive market would lead HDV manufacturers to incorporate all technologies that contribute to lower net costs into the vehicles they offer, and buyers to purchase them willingly. Nevertheless, many readily available technologies that appear to offer cost-effective increases in HDV fuel efficiency (when evaluated over their expected lifetimes using conventional discount rates) have not been widely adopted, despite their potential to repay buyers' initial investments rapidly.

This economic situation is commonly known as the ''energy efficiency gap'' or ''energy paradox.'' This situation is perhaps more challenging to understand with respect to the heavy-duty sector versus the light-duty vehicle sector. Unlike light-duty vehicles—which are purchased and used mainly by individuals and households—the vast majority of HDVs are purchased and operated by profit-seeking businesses for which fuel costs represent a substantial operating expense. We asked for comments on our hypotheses about causes of the gap, as well as data or other information that can inform our understanding of why this situation seems to persist. The California Air Resources Board, CALSTART, Consumer Federation of America, Institute for Policy Integrity at NYU School of Law, and International Council on Clean Transportation supported, either in whole or in part, the agencies' arguments for potential barriers to market adoption. Caterpillar Inc. et al., Competitive Enterprise Institute (CEI), Randall Lutter, Brian Mannix, NAFA Fleet Management Association (NAFA), Owner-Operator Independent Drivers Association (OOIDA), Truck Renting and Leasing Association (TRALA), and Utility Trailer Manufacturing Company express skepticism or raise concerns about the agencies' discussion. The skeptical comments, discussed in more depth in context below, generally find it implausible that regulations can save money for profit-seeking businesses. If the savings were real, they argue, then private markets would have adopted these technologies without regulations; the agencies must therefore have exaggerated the benefits or underestimated the costs of the standards. Problems exist not in private market operations, they claim, but rather in the economic analysis of those operations.

The economic analysis of these standards is based on the engineering analysis of the costs and effectiveness of the technologies. The agencies have detailed their findings on costs and effectiveness in Preamble Sections III, IV, V, and VI, and RIA Chapter 2. If these cost and effectiveness estimates are correct, and if the agencies have not omitted key costs or benefits, then the efficiency gap exists, even if it seems implausible to some. As will be discussed further below, comments that raise issues with that technical analysis, such as concerns about maintenance and reliability costs of the technologies, present possible reasons that the gap is not as large as the agencies have found, and are discussed in the cost and effectiveness sections mentioned above. Comments that question the explanations provided for the gap without addressing the cost and effectiveness analyses do not provide evidence of an absence of the gap. Explaining why the gap exists is a separate and difficult challenge from observing the existence of the gap, because of the difficulties involved in developing tests of the different possible explanations. As discussed below, there is very little empirical evidence on behaviors that might lead to the gap, even while there continues to be substantial evidence, via the cost and effectiveness analysis, of the gap's existence. On the basis of that evidence, the agencies believe that a significant number of fuel efficiency improving technologies would remain far less widely adopted in the absence of these standards.

Economic research offers several possible explanations for why the prospect of these apparent savings might not lead HDV manufacturers and buyers to adopt technologies that would be expected to reduce HDV operating costs. Some of these explanations involve failures of the HDV market for reasons other than the externalities caused by producing and consuming fuel. Examples include situations where information about the performance of fuel economy technologies is incomplete, costly to obtain, or available only to one party to a transaction (or ''asymmetrical''), as well as behavioral rigidities in either the HDV manufacturing or HDV-operating industries, such as standardized or inflexibly administered operating procedures, or requirements of other regulations on HDVs. Examples that do not involve market failures include possible effects on the performance, reliability, carrying capacity, maintenance requirements of new technology under the demands of everyday use, or transaction or adjustment costs. We note again that these and other hypotheses are presented as potential explanations of the finding of an efficiency gap based on an engineering analysis. They are not themselves the basis for regulation.

In the HD Phase 1 rulemaking (which, in contrast to these standards, did not apply to trailers), and in the Phase 2 NPRM, the agencies raised various hypotheses that might explain this energy efficiency gap or paradox.

- Imperfect information in the new vehicle market: Information available to prospective buyers about the effectiveness of some fuel-saving technologies for new vehicles may be inadequate or unreliable. If reliable information on their effectiveness in reducing fuel consumption is unavailable or difficult to obtain, HDV buyers will understandably be reluctant to pay higher prices to purchase vehicles equipped with unproven technologies.

Some commenters argue that this explanation implies implausibly that the agencies have information that those with profit motives do not, and that EPA's SmartWay Program has already served the function of sharing public information with the private sector. Other commenters agree with the agencies that imperfect information is a potential market barrier.

As discussed in the NPRM, one common theme from recent research [788]

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[788] Klemick, Heather, Elizabeth Kopits, Keith Sargent, and Ann Wolverton (2015). ''Heavy-Duty Trucking and the Energy Efficiency Paradox: Evidence form Focus Groups and Interviews.'' *Transportation Research Part A* 77: 154–166, Docket EPA–HQ–OAR–2014–0827; Roeth, Mike, Dave Kircher, Joel Smith, and Rob Swim (2013). ''Barriers to the Increased Adoption of Fuel Efficiency Technologies in the North American On-Road Freight Sector.'' NACFE report for the International Council on Clean Transportation,

Continued

is the inability of HDV buyers to obtain reliable information about the fuel savings, reliability, and maintenance costs of technologies that improve fuel efficiency. See 80 FR 40436. In the trucking industry, the performance of fuel-saving technology is likely to depend on many firm-specific attributes, including the intensity of HDV use, the typical distance and routing of HDV trips, driver characteristics, road conditions, regional geography and traffic patterns. As a result, businesses that operate HDVs have strong preferences for testing fuel-saving technologies ''in-house'' because they are concerned that their patterns of vehicle use may lead to different results from those reported in published information. Businesses with less capability to do in-house testing often seek information from peers, yet often remain skeptical of its applicability due to differences in the nature of their operations.

- Imperfect information in the resale market: Buyers in the used vehicle market may not be willing to pay adequate premiums for more fuel efficient vehicles when they are offered for resale to ensure that buyers of new vehicles can recover the remaining value of their original investment in higher fuel efficiency. The prospect of an inadequate return on their original owners' investments in higher fuel efficiency may contribute to the short payback periods that buyers of new vehicles appear to demand.[789]

CEI rejects this hypothesis, asserting that buyers in this market do consider the value of technologies on used vehicles; other commenters support this possibility.

The recent research cited above (Klemick et al. 2015, Roeth et al. 2013, Aarnink et al. 2012) found mixed evidence for imperfect information in the market for used HDVs. On the one hand, some studies noted that fuel-saving technology is often not appreciated in the used vehicle market, because of imperfect information about its benefits, or greater mistrust of its performance among buyers in the used vehicle market than among buyers of new vehicles. When buyers of new vehicles considered features that would affect value in the secondary market, those features were rarely related to fuel economy. In addition, some used-vehicle buyers might have a larger ''knowledge gap'' than new-vehicle buyers. In other cases, the lack of interest might be due to the intended use of the used HDVs, which may not reward the presence of certain fuel-saving technologies. In other cases, however, fuel-saving technology can lead to a premium in the used market, as for instance to meet the more stringent requirements for HDVs operating in California.

- Principal-agent problems causing split incentives: An HDV buyer may not be directly responsible for its future fuel costs, or the individual who will be responsible for fuel costs may not participate in the HDV purchase decision. In these cases, the signal to invest in higher fuel efficiency normally provided by savings in fuel costs may not be transmitted effectively to HDV buyers, and the incentives of HDV buyers and fuel buyers will diverge, or be ''split.'' The trailers towed by heavy-duty tractors, which are typically not supplied by the tractor manufacturer or seller, present an obvious potential situation of split incentives that was not addressed in the HD Phase 1 rulemaking, but which may apply in this rulemaking. If there is inadequate pass-through of price signals from trailer users to their buyers, then low adoption of fuel-saving technologies may result.

CEI argues that, even if these split incentives existed, vehicle purchasers still might not invest in fuel-saving technologies due to capital constraints. As discussed below, capital constraints may be an issue for smaller companies, but they do not appear to be a significant concern for larger companies. Mr. Lutter provides a working paper[790] in which the authors do not find a statistically significant or negative relationship when the box trailer has different ownership than the tractor, a result that does not support evidence of the split-incentives problem between tractors and trailers. As the papers below discuss, the split-incentives problem can take more forms than the difference in ownership between tractors and box trailers examined in this comment.

Other recent research identifies split incentives, or principal-agent problems, as a potential barrier to technology adoption. For instance, Vernon and Meier (2012) estimate that 23 percent of trailers may be exposed to split incentives due to businesses that own and lease trailers to HDV operators not having an incentive to invest in trailer-specific fuel-saving technology.[791] They also estimate that 5 percent of HDV fuel use is subject to split incentives that arise when the firm paying fuel costs does not make the tractor investment decision (*e.g.,* because a carrier subcontracts to an owner-operator but still pays for fuel). As CEI points out, in the case of a split incentive when the driver is not responsible for paying fuel costs, the owner is the principal who seeks fuel savings, and the driver is the agent with potentially low incentive to provide those savings; there are a number of potential sources of inefficiency in fuel use, though not all of them are expected to result in underinvestment in fuel-saving technologies. Vernon and Meier (2012) do not quantify the financial significance of these problems.

Klemick et al. (2015), Aarnink et al. (2012), and Roeth et al. (2013) provide mixed evidence on the severity of the split-incentive problem. Focus groups often identify diverging incentives between drivers and the decision-makers responsible for purchasing vehicles. Aarnink et al. (2012) and Roeth et al. (2013) cite examples of split incentives involving trailers and fuel surcharges, although the latter also cites other examples where these same issues do not lead to split incentives. In an effort to minimize problems that can arise from split incentives, many businesses that operate HDVs also train drivers in the use of specific technologies or to modify their driving behavior in order to improve fuel efficiency, while some also offer financial incentives to their drivers to conserve fuel. All of these options can help to reduce the split incentive problem.

- Uncertainty about future fuel cost savings: HDV buyers may be uncertain about future fuel prices, or about maintenance costs and reliability of some fuel efficiency technologies. In contrast, the costs of fuel-saving technologies are immediate. If buyers

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Docket EPA–HQ–OAR–2014–0827–0084; Aarnink, Sanne, Jasper Faber, and Eelco den Boer (2012). ''Market Barriers to Increased Efficiency in the European On-road Freight Sector.'' CE Delft report for the International Council on Clean Transportation, Docket EPA–HQ–OAR–2014–0827–0076.

[789] Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles; National Research Council; Transportation Research Board (2010). ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,'' (hereafter, ''NAS 2010''). Washington, DC The National Academies Press. Available electronically from the National Academies Press Web site at *http://www.nap.edu/catalog.php?record_id=12845* (accessed September 10, 2010), Docket EPA–HQ–OAR–2014–0827–0122.

[790] Fraas, Art, Randall Lutter, Zachary Porter, and Alexander Wallace (2016). ''The Energy Paradox and the Adoption of Energy-Saving Technologies in the Trucking Industry.'' Working Paper, Mercatus Center, George Mason University, Docket EPA–HQ–OAR–2014–0827–1879.

[791] Vernon, David and Alan Meier (2012). ''Identification and quantification of principal-agent problems affecting energy efficiency investments and use decisions in the trucking industry.'' Energy Policy, 49(C), pp. 266–273, Docket EPA–HQ–OAR–2014–0827–0090.

are loss-averse, they may react to this uncertainty by underinvesting in technologies to improve fuel economy. In this situation, potential variability about buyers' expected returns on capital investments to achieve higher fuel efficiency may shorten the payback period—the time required to repay those investments—they demand in order to make them.

Various commenters support this hypothesis. The CEI draws on the experience of nitrogen oxides (NO_X) regulations from 2004 and 2007 to support its arguments. As discussed more below, the NO_X standards are unlikely to provide much, if any, precedential value for the GHG/fuel economy standards. Other commenters raise questions related to uncertainty about future costs for fuel and maintenance, as well as about the reliability of new technology that could result in costly downtime. Section IX.D. below discusses maintenance expenditures under these standards. These examples illustrate the problem of uncertain or unreliable information about the actual performance of fuel efficiency technology discussed above. Roeth et al. (2013) and Klemick et al. (2015) both document the short payback periods that HDV buyers require on their investments—usually about 2 years—which may be partly attributable to these uncertainties.

- Adjustment and transactions costs: Potential resistance to new technologies—stemming, for example, from drivers' reluctance or slowness to adjust to changes in the way vehicles operate—may slow or inhibit new technology adoption. If a conservative approach to new technologies leads HDV buyers to adopt them slowly, then successful new technologies will be adopted over time without market intervention, but only with potentially significant delays in achieving the fuel saving, environmental, and energy security benefits they offer. There also may be costs associated with training drivers to realize potential fuel savings enabled by new technologies, or with accelerating fleet operators' scheduled fleet turnover and replacement to hasten their acquisition of vehicles equipped with these technologies. These factors might present real resource costs to firms that are not reflected in a typical engineering analysis.

CEI argues that these costs are normal aspects of the innovation process, and competition continually drives firms to innovate in most industries. As discussed below, innovation is not always a continual and smooth response to competition as CEI suggests.

Klemick et al. (2015), Roeth et al. (2013), and Aarnink et al. (2012) provide some support for the view that adjustment and transactions costs may impede HDV buyers from investing in higher fuel efficiency. These studies note that HDV buyers are less likely to select new technology when it is not available from their preferred manufacturers. Some technologies are only available as after-market additions, which can add other costs to adopting them.

- Driver acceptance of new equipment or technologies as a barrier to their adoption. HDV driver turnover is high in the U.S., and businesses that operate HDVs are concerned about retaining their best drivers. Therefore, they may avoid technologies that require significant new training or adjustments in driver behavior.

NAFA Fleet Management Association states that the standards will increase pressure on already strained driver and technician resources. The agencies understand that the industry experiences a great deal of driver turnover; we do not know how the standards will affect that turnover. Changes to vehicles that require some changes in driver behavior may increase driver turnover. For instance, drivers who prefer manual transmissions may respond poorly to vehicles with automatic transmissions. On the other hand, the switch to automatic transmissions may facilitate entry of new drivers who no longer need to learn as much about shifting.

For some technologies that can be used to meet these standards, such as automatic tire inflation systems, training costs are likely to be minimal. Other technologies, such as stop-start systems, may require drivers to adjust their expectations about vehicle operation, and it is difficult for the agencies to anticipate how drivers will respond to such changes.[792]

- Constraints on access to capital for investment. If buyers of new vehicles have limited funds available, then they must choose between investing in fuel-saving technology and other vehicle technologies or attributes.

CEI states that investments require tradeoffs: Investment in fuel economy crowds out other investments. There would be tradeoffs in purchasing choices if capital markets are constrained, and fuel-saving technologies do not provide returns sufficient to achieve the hurdle rates that the buyers require. Klemick et al. (2015) did not find capital constraints to be a problem for the medium- and large-sized businesses participating in their study. On the other hand, Roeth et al. (2013) noted that access to capital can be a significant challenge to smaller or independent businesses, and that price is always a concern to buyers. Section XIV.D. discusses the agencies' outreach to small businesses to learn about their special circumstances. These are reflected in various flexibilities for small businesses in the regulations.

- ''Network externalities,'' where the benefits to new users of a technology depend on how many others have already adopted it. If the value of a technology increases with increasing adoption, then it can be difficult for the adoption process to begin: Each potential adopter has an incentive to wait for others to adopt before making the investment. If all adopters wait for others, then adoption may not happen.

One example where network externalities seem likely to arise is the market for natural gas-fueled HDVs: The limited availability of refueling stations may reduce potential buyers' willingness to purchase natural gas-fueled HDVs, while the small number of such HDVs in use does not provide sufficient economic incentive to construct more natural gas refueling stations. Some businesses that operate HDVs may also be concerned about the difficulty in locating repair facilities or replacement parts, such as single-wide tires, wherever their vehicles operate. When a technology has been widely adopted, then it is likely to be serviceable even in remote or rural places, but until it becomes widely available, its early adopters may face difficulties with repairs or replacements. By accelerating the widespread adoption of these technologies, these standards may assist in overcoming these difficulties.

Consumer Federation of America states that network externalities are a potentially important barrier to adoption of fuel-saving technologies.

- First-mover disadvantage. Many manufacturers prefer to observe the market and follow other manufacturers rather than be the first to market with a specific technology. The ''first-mover disadvantage'' has been recognized in other research where the ''first-mover'' pays a higher proportion of the costs of developing technology, but loses the long-term advantage when other

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[792] The distinction between simply requiring drivers (or mechanics) to adjust their expectations and compromises in vehicle performance or utility is subtle. While the former may not impose significant compliance costs in the long run, the latter would represent additional economic costs of complying with the standard.

businesses follow quickly.[793] In this way, there may be barriers to innovation on the supply side that result in lower adoption rates of fuel-efficiency technology than would be optimal.

Several commenters support the existence of the first-mover disadvantage. Roeth et al. (2013) noted that HDV buyers often prefer to have technology or equipment installed by their favored original equipment manufacturers. However, some technologies may not be available through these preferred sources, or may be available only as after-market installations from third parties (Aarnink et al. 2012, Roeth et al. 2013). Manufacturers may be hesitant to offer technologies for which there is not strong demand, especially if the technologies require significant research and development expenses and other costs of bringing the technology to a market of uncertain demand. Roeth et al. (2013) noted that it can take years, and sometimes as much as a decade, for a specific technology to become available from all manufacturers.

As mentioned above, the Competitive Enterprise Institute argues that EPA regulations on nitrogen oxides (NO_X and other pollutants from heavy duty engines in the 2000s hindered development of fuel-saving technologies, in part because the technologies increased fuel consumption, and in part because, if manufacturers invested in NO_X controls, they could not invest in reducing fuel consumption. The agencies do not find these potential explanations compelling. Most obviously, the NO_X and other standards do not provide a useful analogy for industry response to the GHG/fuel efficiency standards, because those standards imposed costs without returning fuel savings to operators. In addition, as the discussion of technology cost and effectiveness indicates, technologies that are not in widespread use seem to be available to reduce fuel consumption with reasonable payback periods. Finally, the agencies consider it possible to reduce NO_X in the presence of GHG controls, and to reduce GHG emissions in the presence of NO_X controls; the cost analysis for this rulemaking accounts for achieving NO_X emissions standards. See also RTC Sections 11.2.2.3 and 11.7.2.

In summary, the agencies recognize that businesses that operate HDVs are under competitive pressure to reduce operating costs, which should compel HDV buyers to identify and rapidly adopt cost-effective fuel-saving technologies. Outlays for labor and fuel generally constitute the two largest shares of HDV operating costs, depending on the price of fuel, distance traveled, type of HDV, and commodity transported (if any), so businesses that operate HDVs face strong incentives to reduce these costs.[794] [795]

However, the relatively short payback periods that buyers of new HDVs appear to require suggest that some combination of the factors cited above impedes this process. Markets for both new and used HDVs may face these problems, although it is difficult to assess empirically the degree to which they actually do. Even if the benefits from widespread adoption of fuel-saving technologies exceed their costs, their use may remain limited or spread slowly because their early adopters bear a disproportionate share of those costs. In this case, as CFA says in its comments, these standards may help to overcome such barriers by ensuring that these measures will be widely adopted.

Providing information about fuel-saving technologies, offering incentives for their adoption, and sharing HDV operators' real-world experiences with their performance through voluntary programs such as EPA's SmartWay Transport Partnership should assist in the adoption of new cost-saving technologies. Nevertheless, other barriers that impede the diffusion of new technologies are likely to remain. Buyers who are willing to experiment with new technologies expect to find cost savings, but those savings may be difficult to verify or replicate. As noted previously, because benefits from employing these technologies are likely to vary with the characteristics of individual routes and traffic patterns, buyers of new HDVs may find it difficult to identify or verify the effects of fuel-saving technologies in their operations. Risk-averse buyers may also avoid new technologies out of concerns over the possibility of inadequate returns on their investments, or with other possible adverse impacts.

As various commenters note, competitive pressures in the HDV freight transport industry can provide a strong incentive to reduce fuel consumption and improve environmental performance. Nevertheless, HDV manufacturers may delay in investing in the development and production of new technologies, instead waiting for other manufacturers to bear the initial risks of those investments. In addition, not every HDV operator has the requisite ability or interest to access and utilize the technical information, or the resources necessary to evaluate this information within the context of his or her own operations.

As discussed previously, whether the technologies available to improve HDVs' fuel efficiency would be adopted widely in the absence of the program is challenging to assess. To the extent that these technologies would be adopted in its absence, neither their costs nor their benefits should be attributed to the program.

The agencies will continue to explore reasons for the slow adoption of readily available and apparently cost-effective technologies for improving fuel efficiency.

B. Vehicle-Related Costs Associated With the Program

(1) Technology Cost Methodology

(a) Direct Manufacturing Costs

The direct manufacturing costs (DMCs) used throughout this analysis are derived from several sources. Many of the tractor, vocational and trailer DMCs can be sourced to the Phase 1 rule which, in turn, were sourced largely from a contracted study by ICF International for EPA.[796] We have updated those costs by converting them to 2013 dollars, as described in Section IX.B.1.e below, and by continuing the learning effects described in the Phase 1 rule and in Section IX.B.1.c below. The new tractor, vocational and trailer costs can be sourced to a more recent study conducted by Tetra Tech under contract to NHTSA.[797] The cost methodology used by Tetra Tech was to estimate retail costs and work backward from there to derive a DMC for each technology. The agencies did not agree with the approach used by Tetra Tech

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[793] Blumstein, Carl and Margaret Taylor (2013). ''Rethinking the Energy-Efficiency Gap: Producers, Intermediaries, and Innovation,'' Energy Institute at Haas Working Paper 243, University of California at Berkeley, Docket EPA–HQ–OAR–2014–0827–0075; Tirole, Jean (1998). *The Theory of Industrial Organization.* Cambridge, MA: MIT Press, pp.400, 402, Docket EPA–HQ–OAR–2014–0827–0089. This first-mover disadvantage must be large enough to overcome the potential incentive for first movers to earn unusually high but temporary profit levels.

[794] American Transportation Research Institute, *An Analysis of the Operational Costs of Trucking,* September 2013 (Docket ID: EPA–HQ–OAR–2014–0827–0512).

[795] Transport Canada, Operating Cost of Trucks, 2005. See *http://www.tc.gc.ca/eng/policy/report-acg-operatingcost2005-2005-e-2-1727.htm,* accessed on July 16, 2010 (Docket ID: EPA–HQ–OAR–2014–0827–0070).

[796] ICF International. Investigation of Costs for Strategies to Reduce Greenhouse Gas Emissions for Heavy-Duty On-Road Vehicles. July 2010.

[797] Schubert, R., Chan, M., Law, K. (2015). Commercial Medium- and Heavy-Duty (MD/HD) Truck Fuel Efficiency Cost Study. Washington, DC: National Highway Traffic Safety Administration.

to move from retail cost to DMC as the approach was to simply divide retail costs by 2 and use the result as a DMC. Our research, discussed below, suggests that a divisor of 2 is too high. Therefore, where we have used a Tetra Tech derived retail estimate, we have divided by our researched markups to arrive at many of the DMCs used in this analysis. In this way, the agencies have used an approach consistent with past GHG/CAFE/fuel consumption rules by dividing estimated retail prices by our estimated retail price equivalent (RPE) markups to derive an appropriate DMC for each technology. We describe our RPEs in Section IX.B.1.b, below. Importantly, nearly all of the technology costs used in the final analysis are identical to those used in the proposal, except for updating those costs from 2012 dollars to 2013 dollars. Notable changes are the costs for waste heat recovery and the use of new technologies (*e.g.,* APU with DPF, battery powered APU and a different stop-start technology on vocational vehicles) that were not considered in the proposal. We describe these changes in Chapter 2 .11of the RIA.

Importantly, technology costs differ from package costs which include adoption rates. Package costs have changed more significantly due to changes to the adoption rates as described throughout the earlier sections of this Preamble and briefly below in Section IX.B.1.(d).

For HD pickups and vans, we have similarly used costs from the proposal except for the updating to 2013 dollars. As explained in the proposal, we relied primarily on the Phase 1 rule and the recent light-duty 2017–2025 model year rule since most technologies expected on these vehicles are, in effect, the same as those used on light-duty pickups. Many of those technology DMCs are based on cost teardown studies which the agencies consider to be the most robust method of cost estimation. However, because most of the HD versions of those technologies are expected to be more costly than their light-duty counterparts, we have scaled upward most of the light-duty DMCs for this analysis. We have also used some costs developed under contract to NHTSA by Tetra Tech.[798]

Importantly, in our methodology, all technologies are treated as being sourced from a supplier rather than being developed and produced in-house. As a result, some portion of the total indirect costs of making a technology or system—those costs incurred by the supplier for research, development, transportation, marketing etc.—are contained in the sales price to the engine and/or vehicle/trailer manufacturer (*i.e.,* the original equipment manufacturer (OEM)). That sale price paid by the OEM to the supplier is the DMC we estimate.

We present the details—sources, DMC values, scaling from light-duty values, markups, learning effects, adoption rates—behind all our costs in Chapter 2 of the RIA.

(b) Indirect Costs

To produce a unit of output, engine and truck manufacturers incur direct and indirect costs. Direct costs include cost of materials and labor costs. Indirect costs are all the costs associated with producing the unit of output that are not direct costs—for example, they may be related to production (such as research and development [R&D]), corporate operations (such as salaries, pensions, and health care costs for corporate staff), or selling (such as transportation, dealer support, and marketing). Indirect costs are generally recovered by allocating a share of the costs to each unit of good sold. Although it is possible to account for direct costs allocated to each unit of good sold, it is more challenging to account for indirect costs allocated to a unit of goods sold. To make a cost analysis process more feasible, markup factors, which relate total indirect costs to total direct costs, have been developed. These factors are often referred to as retail price equivalent (RPE) multipliers.

While the agencies have traditionally used RPE multipliers to estimate indirect costs, in recent GHG/CAFE/fuel consumption rules RPEs have been replaced in the primary analysis with indirect cost multipliers (ICMs). ICMs differ from RPEs in that they attempt to estimate not all indirect costs incurred to bring a product to point of sale, but only those indirect costs that change as a result of a government action or regulatory requirement. As such, some indirect costs, notably health and retirement benefits of retired employees, among other indirect costs, will not be expected to change due to a government action and, therefore, the portion of the RPE that covered those costs does not change.

Further, the ICM is not a ''one-size-fits-all'' markup as is the traditional RPE. With ICMs, higher complexity technologies like hybridization or moving from a manual to automatic transmission may require higher indirect costs—more research and development, more integration work, etc.—suggesting a higher markup. Conversely, lower complexity technologies like reducing friction or adding passive aero features may require fewer indirect costs thereby suggesting a lower markup.

Notably, ICMs are also not a simple multiplier as are traditional RPEs. The ICM is broken into two parts—warranty related and non-warranty related costs. The warranty related portion of the ICM is relatively small while the non-warranty portion represents typically over 95 percent of indirect costs. These two portions are applied to different DMC values to arrive at total costs (TC). The warranty portion of the markup is applied to a DMC that decreases year-over-year due to learning effects (described below in Section IX.B.1.c).[799] As learning effects decrease the DMC with production volumes, it makes sense that warranty costs will decrease since those parts replaced under warranty should be less costly. In contrast, the non-warranty portion of the markup is applied to a static DMC year-over-year resulting in static indirect costs. This is logical since the production plants and transportation networks and general overhead required to build parts, market them, deliver them and integrate them into vehicles do not necessarily decrease in cost year-over-year. Because the warranty and non-warranty portions of the ICM are applied differently, one cannot compare the markup itself to the RPE to determine which markup will result in higher indirect cost estimates, at least in the time periods typically considered in our rules (four to ten years).

In the NPRM, the agencies expressed concern that some potential costs associated with this rulemaking may not be adequately captured by our ICMs. ICMs are estimated based on a few specific technologies and these technologies may not be representative of the changes actually made to meet the requirements. We requested and received comment on this issue. Specifically, some commenters argued that we had underestimated costs associated with R&D and costs associated with our compliance programs, both of which are indirect costs. However, we address those indirect costs separately because GHG-related R&D and GHG-related

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[798] Schubert, R., Chan, M., Law, K. (2015). Commercial Medium- and Heavy-Duty (MD/HD) Truck Fuel Efficiency Cost Study. Washington, DC: National Highway Traffic Safety Administration.

[799] We note that the labor portion of warranty repairs does not decrease due to learning. However, we do not have data to separate this portion and so we apply learning to the entire warranty cost. Because warranty costs are a small portion of overall indirect costs, this has only a minor impact on the analysis.

compliance were not part of the retail price equivalent markups upon which our indirect cost multipliers are based. We discuss these R&D and compliance costs more below and in Chapter 7 of the RIA.

We provide more details on our ICM approach and the markups used for each technology in Chapter 2.12 of the RIA.

(c) Learning Effects on Direct and Indirect Costs

For some of the technologies considered in this analysis, manufacturer learning effects will be expected to play a role in the actual end costs. The ''learning curve'' or ''experience curve'' describes the reduction in unit production costs as a function of accumulated production volume. In theory, the cost behavior it describes applies to cumulative production volume measured at the level of an individual manufacturer, although it is often assumed—as both agencies have done in past regulatory analyses—to apply at the industry-wide level, particularly in industries that utilize many common technologies and component supply sources. Both agencies believe there are indeed many factors that cause costs to decrease over time. Research in the costs of manufacturing has consistently shown that, as manufacturers gain experience in production, they are able to apply innovations to simplify machining and assembly operations, use lower cost materials, and reduce the number or complexity of component parts. All of these factors allow manufacturers to lower the per-unit cost of production (*i.e.,* the manufacturing learning curve).[800]

In this analysis, the agencies are using the same approach to learning as done in the proposal and in past GHG/CAFE/ fuel consumption rules. In short, learning effects result in rapid cost reductions in the early years following introduction of a new technology. The agencies have estimated those cost reductions as resulting in 20 percent lower costs for every doubling of production volume. As production volumes increase, learning rates continue at the same pace but flatten asymptotically due to the nature of the persistent doubling of production required to realize that cost reduction. As such, the cost reductions flatten out as production volumes continue to increase. Consistent with the Phase 1 rule, we refer to these two distinct portions of the ''learning cost reduction curve'' or ''learning curve'' as the steeper and flatter portions of the curve. On that steep portion of the curve, costs are estimated to decrease by 20 percent for each double of production or, by proxy, in the third and then fifth year of production following introduction. On the flat portion of the curve, costs are estimated to decrease by 3 percent per year for 5 years, then 2 percent per year for 5 years, then 1 percent per year for 5 years. Also consistent with the Phase 1 rule, the majority of the technologies we expect will be adopted are considered to be on the flat portion of the learning curve meaning that the 20 percent cost reductions are rarely applied. The agencies requested and received comments on our approach to estimating learning effects, specifically with respect to cost reductions applied to waste heat recovery and APUs. Commenters suggested that, since waste heat recovery is not in production, the agencies should not have applied learning effect to that technology. They also argued that, since APUs have been around for years, applying any cost reduction effects to their costs is ''questionable.'' The agencies disagree with both of these comments. Whether production-related learning-by-doing cost reductions or from other factors, we are aware of dramatic changes to waste heat recovery systems that clearly make that technology less costly. We describe these changes in more detail in Chapter 2 of the RIA. Also, to suggest that APUs cannot undergo any cost reductions from learning does not seem reasonable. The agencies have placed that technology on the flat portion of the learning curve since it is well established. As a result, the estimated learning effects are not large in scale, but to suggest that an APU will cost the same in the 2020s as it does today, in constant dollar terms, is not reasonable. Further, the commenter provided no supporting data or information to support this claim.

We provide more details on the concept of learning-by-doing and the learning effects applied in this analysis in Chapter 2.11 of the RIA.

(d) Technology Adoption Rates and Developing Package Costs

Determining the stringency of these standards involves a balancing of relevant factors—chiefly technology feasibility and effectiveness, costs, and lead time. For vocational vehicles, tractors and trailers, the agencies have projected a technology path to achieve these standards reflecting an application rate of those technologies the agencies consider to be available at reasonable cost in the lead times provided. The agencies do not expect (and do not require) each of the technologies for which costs have been developed to be employed by all trucks and trailers across the board.[801] Further, many of today's vehicles are already equipped with some of the technologies and/or are expected to adopt them by MY 2018 to comply with the HD Phase 1 standards. Estimated adoption rates in both the reference and control cases are necessary for each vehicle/trailer category. The adoption rates for most technologies are zero in the reference case; however, for some technologies—notably aero and tire technologies—the adoption rate is not zero in the reference case. These reference and control case adoption rates are then applied to the technology costs with the result being a package cost for each vehicle/trailer category. Technology adoption rates were presented in Sections II through V for engines, tractors, vocational vehicles and trailers. Individual technology costs are presented in Chapter 2.11 of the final RIA.

For HD pickups and vans, the CAFE model determines the technology adoption rates that are estimated to most cost effectively meet the standards. Similar to vocational vehicles, tractors and trailers, package costs are rarely if ever a simple sum of all the technology costs since each technology will be expected to be adopted at different rates. The methods for estimating technology adoption rates and resultant costs per vehicle (and other impacts) for HD pickups and vans are discussed above in Section VI. Individual technology costs are presented in Chapter 2.11 of the final RIA.

We provide details of expected technology adoption rates for each of the regulatory subcategories in Chapter 2 of the RIA. We present package costs both in Sections III through VI of this Preamble and in more detail in Chapter 2 of the RIA.

(e) Conversion of Technology Costs to 2013 U.S. Dollars

As noted above in Section IX.B.1, the agencies are using technology costs from many different sources. These sources, having been published in different years, present costs in different year dollars (*i.e.,* 2009 dollars or 2010

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[800] See ''Learning Curves in Manufacturing,'' L. Argote and D. Epple, Science, Volume 247; ''Toward Cost Buy down Via Learning-by-Doing for Environmental Energy Technologies, R. Williams, Princeton University, Workshop on Learning-by-Doing in Energy Technologies, June 2003; ''Industry Learning Environmental and the Heterogeneity of Firm Performance, N. Balasubramanian and M. Lieberman, UCLA Anderson School of Management, December 2006, Discussion Papers, Center for Economic Studies, Washington DC.

[801] The one exception are the design standards for non-aero box vans and non-box trailers, which do mandate use of certain tire-related technologies.

dollars). For this analysis, the agencies sought to have all costs in terms of 2013 dollars to be consistent with the dollars used by AEO in its 2015 Annual Energy Outlook.[802] The agencies have used the GDP Implicit Price Deflator for Gross Domestic Product as the converter, with the actual factors used as shown in Table IX–1.[803]

TABLE IX–1—IMPLICIT PRICE DEFLATORS AND CONVERSION FACTORS FOR CONVERSION TO 2013$

	2006	2007	2008	2009	2010	2011	2012	2013
Price index for GDP	94.814	97.337	99.246	100	101.221	103.311	105.214	106.929
Factor applied for 2012$	1.128	1.099	1.077	1.069	1.056	1.035	1.016	1.000

(2) Compliance Program Costs

The agencies have also estimated additional and/or new compliance costs associated with these standards. Normally, compliance program costs will be considered part of the indirect costs and, therefore, will be accounted for via the markup applied to direct manufacturing costs. However, since the agencies are proposing new compliance elements that were not present during development of the indirect cost markups used in this analysis, additional compliance program costs are being accounted for via a separate ‘‘line-item.’’ New research and development costs (see below) are being handled in the same way.

The new compliance program elements included in this rule are new powertrain testing within the vocational vehicle program, and an all-new compliance program (since none has existed to date) for the trailer program. The remaining compliance provisions are identical to those in Phase 1, and the estimated costs therefore are derived using the same methodology used to estimate compliance costs in the Phase 1 rule. Compliance program costs cover costs associated with any necessary compliance testing and reporting to the agencies. The details behind the estimated compliance program costs are provided in Chapter 7 of the RIA.

The agencies requested and received comments on our compliance cost estimates. Some commenters were concerned that we had significantly underestimated costs. In response, we have adjusted our compliance costs estimates, including those for testing and reporting, and have increased our annual compliance costs from roughly $6 million per year to nearly $11 million per year. This excludes the estimated $16 million in 2020 to build and/or upgrade facilities to conduct testing. We discuss our updated estimates in more detail in Chapter 7 of the RIA.

(3) Research and Development Costs

Much like the compliance program costs described above, we have estimated additional HDD engine, vocational vehicle and tractor R&D associated with these standards that is not accounted for via the indirect cost markups used for these segments. Much like the Phase 1 rule, EPA is estimating these additional R&D costs will occur over a 4-year timeframe as these standards come into force and industry works on means to comply. After that period, the additional R&D costs go to $0 as R&D expenditures return to their normal levels and R&D costs are accounted for via the ICMs—and the RPEs behind them—used for these segments. The details behind the estimated R&D costs are provided in Chapter 7 of the RIA

The agencies requested and received comments on our R&D estimates. One commenter suggested that our estimate of $960 million over four years, for hundreds of types of disparate vehicles was unrealistic given the $80 million of R&D spent on the Super Truck program over 5 years. Unfortunately, no better estimate was provided by commenters. We have increased our estimated R&D, relative to that estimated in the proposal, by roughly $14 million per year for 4 years resulting in a total additional R&D estimate of over $1 billion. Importantly, as noted, this R&D spending is an additional expenditure above and beyond that estimated as part of the indirect cost markups which include in them an estimate of roughly 4 percent of revenues spent on R&D. Another way of stating this is that roughly 4 percent of our technology costs are actually estimated as R&D-related costs. Given our annual technology costs of $2 billion to $5 billion per year from 2021 through 2027, or over $24 billion over those 7 years, we are estimating another $1 billion in R&D via our indirect cost markups (4 percent of $24 billion). In other words, we are really estimating roughly $2 billion in R&D spending during the calendar years 2021 through 2027.

(4) Summary of Costs of the Vehicle Programs

The agencies have estimated the costs of the vehicle standards on an annual basis for the years 2018 through 2050, and have also estimated costs for the full model year lifetimes of MY 2018 through MY 2029 vehicles. Table IX–2 shows the annual costs of these standards along with net present values using both 3 percent and 7 percent discount rates. Table IX–3 shows the discounted model year lifetime costs of these standards at both 3 percent and 7 percent discount rates along with sums across applicable model years.

TABLE IX–2—ANNUAL COSTS OF THE FINAL PROGRAM AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Calendar year	New technology	Compliance	R&D	Sum
2018	$227	$0	$0	$227
2019	215	0	0	215
2020	220	17	0	237
2021	2,270	11	259	2,540

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[802] U.S. Energy Information Administration, Annual Energy Outlook 2015, Early Release; Report Number DOE/EIA–0383(2015), April 2015.

[803] Bureau of Economic Analysis, Table 1.1.9 Implicit Price Deflators for Gross Domestic Product; as revised on August 27, 2015.

TABLE IX–2—ANNUAL COSTS OF THE FINAL PROGRAM AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE—Continued

[$Millions of 2013$] [a]

Calendar year	New technology	Compliance	R&D	Sum
2022	2,243	11	259	2,512
2023	2,485	11	259	2,755
2024	3,890	11	259	4,160
2025	4,146	11	0	4,157
2026	4,203	11	0	4,213
2027	5,219	11	0	5,230
2028	5,176	11	0	5,186
2029	5,195	11	0	5,206
2030	5,219	11	0	5,229
2035	5,642	11	0	5,653
2040	6,245	11	0	6,255
2050	7,270	11	0	7,280
NPV, 3%	86,780	191	818	87,788
NPV, 7%	41,148	102	604	41,854

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–3—DISCOUNTED MY LIFETIME COSTS OF THE FINAL PROGRAM USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Model year	Discounted at 3%				Discounted at 7%			
	New technology	Compliance	R&D	Sum	New technology	Compliance	R&D	Sum
2018	$205	$0	$0	$205	$179	$0	$0	$179
2019	188	0	0	188	159	0	0	159
2020	187	14	0	201	152	12	0	163
2021	1,873	9	214	2,096	1,462	7	167	1,636
2022	1,797	8	207	2,013	1,350	6	156	1,513
2023	1,933	8	201	2,143	1,398	6	146	1,550
2024	2,938	8	195	3,141	2,046	6	136	2,187
2025	3,040	8	0	3,048	2,038	5	0	2,043
2026	2,992	8	0	2,999	1,930	5	0	1,935
2027	3,607	7	0	3,614	2,240	5	0	2,245
2028	3,473	7	0	3,480	2,076	4	0	2,080
2029	3,384	7	0	3,391	1,948	4	0	1,952
Sum	25,617	84	818	26,519	16,978	59	604	17,642

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

New technology costs begin in MY 2018 as trailers begin to add new technology. Compliance costs begin with the new standards with capital cost expenditure in that year for building and upgrading test facilities to conduct the powertrain testing in the vocational program. Research and development costs begin in 2021 and last for 4 years as engine, tractor and vocational vehicle manufacturers conduct research and development testing to integrate new technologies into their engines and vehicles.

C. Changes in Fuel Consumption and Expenditures

(1) Changes in Fuel Consumption

The new GHG and fuel consumption standards will result in significant improvements in the fuel efficiency of affected vehicles, and drivers of those vehicles will see corresponding savings associated with reduced fuel expenditures. The agencies have estimated the impacts on fuel consumption for these standards. Details behind how these changes in fuel consumption were calculated are presented in Section VII of this Preamble and in Chapter 5 of the RIA. The total number of miles that vehicles are driven each year is different under the regulatory alternatives than in the reference case due to the ‘‘rebound effect’’ (discussed below in Section IX.E), so the changes in fuel consumption associated with each alternative are not strictly proportional to differences in the fuel economy levels they require.

The expected annual impacts on fuel consumption are shown in Table IX–4. Table IX–5 shows the MY lifetime changes in fuel consumption. The gallons shown in these tables as reductions in fuel consumption reflect reductions due to these standards and include any increased consumption resulting from the rebound effect (discussed below in Section IX.E).

TABLE IX–4—ANNUAL FUEL CONSUMPTION REDUCTIONS DUE TO THE FINAL PROGRAM USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of gallons][a]

Calendar year	Retail gasoline			Diesel		
	Reference case	Fuel consumption reduction	% Reduction	Reference case	Fuel consumption reduction	% Reduction
2018	10,958	0	0	46,636	37	0
2019	11,118	0	0	47,056	76	0
2020	11,265	0	0	47,397	117	0
2021	11,391	28	0	47,548	428	1
2022	11,515	74	1	47,813	812	2
2023	11,633	138	1	48,146	1,211	3
2024	11,745	226	2	48,572	1,835	4
2025	11,843	330	3	48,941	2,457	5
2026	11,936	448	4	49,194	3,063	6
2027	12,039	588	5	49,483	3,853	8
2028	12,138	723	6	49,753	4,610	9
2029	12,234	852	7	50,036	5,335	11
2030	12,324	974	8	50,393	6,031	12
2035	12,680	1,454	11	52,492	8,883	17
2040	12,920	1,724	13	55,399	10,778	19
2050	13,185	1,904	14	61,663	12,986	21

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–5—MODEL YEAR LIFETIME FUEL CONSUMPTION REDUCTIONS DUE TO THE FINAL PROGRAM USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of gallons][a]

Model year	Retail gasoline			Diesel		
	Reference	Fuel consumption reduction	% Reduction	Reference	Fuel consumption reduction	% Reduction
2018	12,541	0	0	46,628	302	1
2019	12,409	0	0	47,583	293	1
2020	12,455	0	0	49,084	286	1
2021	12,328	322	3	48,950	4,643	9
2022	12,252	550	4	48,994	4,807	10
2023	12,233	772	6	48,884	4,947	10
2024	12,342	1,075	9	49,924	7,742	16
2025	12,452	1,301	10	50,364	7,954	16
2026	12,555	1,525	12	50,477	8,111	16
2027	12,591	1,836	15	50,664	10,646	21
2028	12,619	1,840	15	50,916	10,698	21
2029	12,631	1,841	15	51,381	10,800	21
Sum	149,408	11,062	7	593,848	71,229	12

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(2) Fuel Savings

We have also estimated the changes in fuel expenditures, or the fuel savings, using fuel prices estimated in the Energy and Information Administration's 2015 Annual Energy Outlook.[804] As the AEO fuel price projections go through 2040 and not beyond, fuel prices beyond 2040 were set equal to the 2040 values. These estimates do not account for the significant uncertainty in future fuel prices; the monetized fuel savings will be understated if actual fuel prices are higher (or overstated if fuel prices are lower) than estimated. The Annual Energy Outlook (AEO) is a standard reference used by NHTSA and EPA and many other government agencies to estimate the projected price of fuel. This has been done using both the pre-tax and post-tax fuel prices. Since the post-tax fuel prices are the prices paid at fuel pumps, the fuel savings calculated using these prices represent the changes fuel purchasers will see. The pre-tax fuel savings measure the value to society of the resources saved when less fuel is refined and consumed. Assuming no change in fuel tax rates, the difference between these two columns represents the reduction in fuel tax revenues that will be received by state and federal governments, or about $204 million in 2021 and $5.8 billion by 2050 as shown in Table IX–6 where annual changes in monetized fuel savings are shown along with net present values using 3 percent

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[804] U.S. Energy Information Administration, Annual Energy Outlook 2015; Report Number DOE/EIA–0383(2015), April 2015.

and 7 percent discount rates. Table IX–7 and Table IX–8 show the discounted model year lifetime fuel savings using 3 percent and 7 percent discount rates, respectively.

TABLE IX–6—ANNUAL FUEL SAVINGS AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B FOR THE FINAL PROGRAM AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Model year	Fuel savings—retail			Fuel savings—untaxed			Change in transfer
	Gasoline	Diesel	Sum	Gasoline	Diesel	Sum	
2018	$0	$114	$114	$0	$97	$97	$17
2019	0	237	237	0	202	202	35
2020	0	371	371	0	319	319	53
2021	78	1,384	1,462	67	1,191	1,258	204
2022	210	2,689	2,899	181	2,323	2,504	395
2023	396	4,081	4,476	342	3,548	3,889	587
2024	657	6,296	6,952	571	5,488	6,059	894
2025	973	8,576	9,550	848	7,495	8,343	1,207
2026	1,343	10,903	12,246	1,173	9,586	10,759	1,487
2027	1,787	13,985	15,772	1,564	12,328	13,892	1,880
2028	2,234	17,057	19,290	1,959	15,074	17,033	2,257
2029	2,675	20,114	22,789	2,351	17,873	20,224	2,565
2030	3,116	23,160	26,276	2,746	20,627	23,373	2,903
2035	5,131	37,840	42,971	4,593	34,287	38,880	4,091
2040	6,722	51,194	57,916	6,102	46,991	53,093	4,824
2050	7,426	61,684	69,109	6,740	56,619	63,359	5,750
NPV, 3%	65,703	511,060	576,763	59,061	464,240	523,301	53,462
NPR, 7%	26,936	209,666	236,602	24,131	189,702	213,833	22,769

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–7—DISCOUNTED MODEL YEAR LIFETIME FUEL SAVINGS, 3% DISCOUNT RATE USING METHOD B FOR THE FINAL PROGRAM AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Model year	Fuel savings—retail			Fuel savings—untaxed			Change in transfer
	Gasoline	Diesel	Sum	Gasoline	Diesel	Sum	
2018	$0	$781	$781	$0	$680	$680	$101
2019	0	747	747	0	653	653	94
2020	0	719	719	0	631	631	87
2021	674	11,497	12,171	590	10,155	10,746	1,426
2022	1,132	11,781	12,912	994	10,440	11,435	1,478
2023	1,567	11,990	13,557	1,381	10,660	12,041	1,516
2024	2,154	18,556	20,709	1,903	16,548	18,451	2,259
2025	2,571	18,849	21,420	2,278	16,859	19,137	2,283
2026	2,973	19,003	21,976	2,640	17,048	19,688	2,288
2027	3,532	24,648	28,180	3,144	22,171	25,315	2,865
2028	3,493	24,459	27,953	3,116	22,060	25,176	2,776
2029	3,449	24,378	27,828	3,084	22,044	25,128	2,700
Sum	21,545	167,408	188,954	19,131	149,950	169,081	19,873

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–8—DISCOUNTED MODEL YEAR LIFETIME FUEL SAVINGS, 7% DISCOUNT RATE USING METHOD B FOR THE FINAL PROGRAM AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Model year	Fuel savings—retail			Fuel savings—untaxed			Change in transfer
	Gasoline	Diesel	Sum	Gasoline	Diesel	Sum	
2018	$0	$558	$558	$0	$483	$483	$74
2019	0	510	510	0	444	444	66
2020	0	466	466	0	408	408	58
2021	420	7,031	7,451	367	6,188	6,554	897
2022	674	6,946	7,620	591	6,134	6,725	895
2023	896	6,814	7,710	788	6,038	6,826	884

TABLE IX–8—DISCOUNTED MODEL YEAR LIFETIME FUEL SAVINGS, 7% DISCOUNT RATE USING METHOD B FOR THE FINAL PROGRAM AND RELATIVE TO THE FLAT BASELINE—Continued

[$Millions of 2013$] [a]

Model year	Fuel savings—retail			Fuel savings—untaxed			Change in transfer
	Gasoline	Diesel	Sum	Gasoline	Diesel	Sum	
2024	1,186	10,161	11,347	1,045	9,033	10,078	1,269
2025	1,362	9,947	11,309	1,204	8,870	10,074	1,235
2026	1,516	9,666	11,182	1,343	8,648	9,991	1,191
2027	1,737	12,081	13,818	1,542	10,839	12,381	1,436
2028	1,655	11,551	13,206	1,474	10,393	11,866	1,340
2029	1,576	11,097	12,672	1,406	10,013	11,419	1,254
Sum	11,022	86,827	97,849	9,759	77,491	87,249	10,600

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

D. Maintenance Expenditures

The agencies expect increases in maintenance costs under these standards. In the NPRM, we estimated maintenance costs associated with lower rolling resistance tires. In the final rule, we have included maintenance costs for many more systems, including waste heat recovery, APUs, transmission fluids, etc. We have estimated that these maintenance costs will be incurred throughout the vehicle lifetime at intervals consistent with typical replacement intervals. Those intervals are difficult to quantify given the variety of vehicles and operating modes within the HD industry. We detail the inputs used to estimate maintenance impacts in Chapter 7.3.3 of the RIA.

We have heard from at least one source[805] that strong hybrid maintenance can be higher in some ways, including possible battery replacement, but may also be much lower for some vehicle systems like brakes and general engine wear. New for the FRM, relative to the proposal, are maintenance costs on hybrid battery systems in vocational vehicles and some reduction in oil change costs on vocational vehicles with stop-start systems since less idling should result in fewer oil changes. See RIA 2.11.7. We have also included new costs for axle fluid replacements for vocational vehicles adding high efficiency axles, and transmission fluid replacements for vehicles projected to move from manual to automated transmissions. For tractors, we have added these same axle and transmission fluid costs and for the same reasons. For tractors, we have also added maintenance costs associated with auxiliary power units and for fuel operated heaters. All of the new cost estimates and the maintenance intervals are presented in more detail in Chapter 7.2.3 of the RIA.

Table IX–9 shows the annual increased maintenance costs of the final program along with net present values using both 3 percent and 7 percent discount rates. Table IX–10 shows the discounted model year lifetime increased maintenance costs of the final program at both 3 percent and 7 percent discount rates along with sums across applicable model years.

TABLE IX–9—ANNUAL MAINTENANCE EXPENDITURE INCREASE DUE TO THE RULE AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Calendar year	Maintenance expenditure increase
2018	$1
2019	1
2020	2
2021	20
2022	39
2023	60
2024	83
2025	106
2026	127
2027	167
2028	206
2029	244
2030	244
2035	244
2040	244
2050	244
NPV, 3%	3,188
NPV, 7%	1,463

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–10—DISCOUNTED MY LIFETIME MAINTENANCE EXPENDITURE INCREASE DUE TO THE RULE USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[$Millions of 2013$] [a]

Model year	3% Discount rate	7% Discount rate
2018	$7	$5
2019	6	4
2020	6	4
2021	155	96
2022	156	94
2023	160	93
2024	175	98
2025	177	96
2026	165	86
2027	303	152
2028	293	141
2029	285	132
Sum	1,889	1,000

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

E. Analysis of the Rebound Effect

The ‘‘rebound effect’’ has been defined in a variety of different ways in the energy policy and economics literature. One common definition states that the rebound effect is the increase in demand for an energy service when the cost of the energy service is reduced due to efficiency improvements.[806] [807] [808] In

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[805] Allison Transmission's Responses to EPA's Hybrid Questions, November 6, 2014.

[806] Winebrake, J.J., Green, E.H., Comer, B., Corbett, J.J., Froman, S., 2012. *Estimating the direct rebound effect for on-road freight transportation.* Energy Policy 48, 252–259.

[807] Greene, D.L., Kahn, J.R., Gibson, R.C., 1999, ‘‘*Fuel economy rebound effect for U.S. household vehicles,*’’ The Energy Journal, 20.

[808] For a discussion of the wide range of definitions found in the literature, see Appendix D: Discrepancy in Rebound Effect Definitions, in EERA (2014), ‘‘Research to Inform Analysis of the Heavy-Duty vehicle Rebound Effect,’’ Excerpts of Draft Final Report of Phase 1 under EPA contract EP–C–

Continued

the context of heavy-duty vehicles (HDVs), this can be interpreted as an increase in HDV fuel consumption resulting from more intensive vehicle use in response to increased vehicle fuel efficiency.[809] Although much of this vehicle use increase is likely to take the form of increases in the number of miles vehicles are driven, it can also take the form of increases in the loaded weight at which vehicles operate or changes in traffic and road conditions vehicles encounter as operators alter their routes and schedules in response to improved fuel efficiency. Because this more intensive use consumes fuel and generates emissions, it reduces the fuel savings and avoided emissions that would otherwise be expected to result from the increases in fuel efficiency in this rulemaking.

In our analysis and discussion below, we focus on one widely-used metric to estimate the rebound effect associated with all types of more intensive vehicle use, the increase in vehicle miles traveled (VMT) that results from improved fuel efficiency. VMT can often provide a reasonable approximation for all types of more intensive vehicle use. For simplicity, we refer to this as ''the VMT rebound effect'' or ''the direct VMT rebound'' throughout this section, although we acknowledge that it is an approximation to the rebound effect associated with all types of more intensive vehicle use. The agencies use our VMT rebound estimates to generate VMT inputs that are then entered into the EPA MOVES national emissions inventory model and the Volpe Center's HD CAFE model. Both of these models use these inputs along with many others to generate projected emissions and fuel consumption changes resulting from each of the regulatory alternatives analyzed.

The following sections describe the factors affecting the magnitude of HDV VMT rebound; review the econometric and other evidence related to HDV VMT rebound; and summarize how we estimated the HDV rebound effect for this rulemaking.

(1) Factors Affecting the Magnitude of HDV VMT Rebound

The magnitude and timing of HDV VMT rebound are driven by the interaction of many different factors.[810] Fuel savings resulting from fuel efficiency standards may cause HDV operators and their customers to change their patterns of HDV use and fuel consumption in a variety of ways. As discussed in the RIA (Chapter 8), HDV VMT rebound estimates determined via other proxy elasticities vary, but in no case has there been an estimate that fully offsets the fuel saved due to efficiency improvements (*i.e.,* no rebound effect greater than or equal to 100 percent).[811]

If fuel cost savings are passed on to the HDV operators' customers (*e.g.,* logistics businesses, manufacturers, retailers, municipalities, utilities consumers, etc.), those customers might reorganize their logistics and distribution networks over time to take advantage of lower operating costs. For example, customers might order more frequent shipments or choose products that entail longer shipping distances, while freight carriers might divert some shipments to trucks from other shipping modes such as rail, barge or air. In addition, customers might choose to reduce their number of warehouses, reduce shipment rates or make smaller but more frequent shipments, all of which could lead to an increase in HDV VMT. Ultimately, fuel cost savings could ripple through the entire economy, thus increasing demand for goods and services shipped by trucks, and therefore increase HDV VMT due to increased gross domestic product (GDP).

Conversely, if fuel efficiency standards lead to net increases in the total costs of HDV operation because fuel cost savings do not fully offset the increase in HDV purchase prices and associated depreciation costs, then the price of HDV services could rise. This is likely to spur a decrease in HDV VMT, and perhaps a shift to alternative shipping modes. These effects could also ripple through the economy and affect GDP. Note, however, that we project fuel cost savings will offset technology costs in our analysis supporting the final standards.

It is also important to note that any increase in HDV VMT resulting from the final standards may be offset, to some extent, by a decrease in VMT by older HDVs. This may occur if lower fuel costs resulting from our standards cause multi-vehicle fleet operators to shift VMT to newer, more efficient HDVs in their fleet or cause operators with newer, more efficient HDVs to be more successful at winning contracts than operators with older HDVs.

Also, as discussed in Chapter 8.2 of the RIA, the magnitude of the rebound effect is likely to be influenced by the extent of any market failures that affect the demand for more fuel efficient HDVs, as well as by HDV operators' responses to their perception of the tradeoff between higher upfront HDV purchase costs versus lower but uncertain future expenditures on fuel.

(2) Recent Econometric and Other Evidence Related to HDV VMT Rebound

As discussed above, HDV VMT rebound is defined as the change in HDV VMT that occurs in response to an increase in HDV fuel efficiency. We are not aware of any studies that directly estimate this elasticity for the U.S. In the proposal, we discussed a number of econometric analyses of other related elasticities that could potentially be used as a proxy for measuring HDV VMT rebound, as well as several other analyses that may provide insight into the magnitude of HDV VMT rebound.[812] These studies produced a wide range of estimates for HDV VMT rebound, however, and we were unable to draw any strong conclusions about the magnitude of rebound based on this available literature.

We also discussed several challenges that researchers face in attempting to quantify the VMT rebound effect for HDVs,[813] including limited data on the HD sector and the difficulty of specifying mathematical models that reflect the complex set of factors that influence HD VMT. Given these limitations, the agencies requested comment on a number of aspects of the proposed VMT rebound analysis, including procedures for measuring the rebound effect and the studies discussed in the proposal. The agencies also committed to reviewing and considering revisions to VMT rebound estimates for

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13–025. (Docket ID: EPA–HQ–OAR–2014–0827). See also Greening, L.A., Greene, D.L., Difiglio, C., 2000, ''*Energy efficiency and consumption—the rebound effect—a survey,*'' Energy Policy, 28, 389–401.

[809] We discuss other potential rebound effects in Section E.3.b., such as the indirect and economy-wide rebound effects. Note also that there is more than one way to measure HDV energy services and vehicle use. The agencies' analyses use VMT as a measure (as discussed below); other potential measures include ton-miles, cube-miles, and fuel consumption.

[810] These factors are discussed more fully in a report to EPA from EERA, which illustrates in a series of diagrams the complex system of decisions and decision-makers that could influence the magnitude and timing of the rebound effect. See Sections 2.2.2, 2.2.3, 2.2.4, and 2.3 in EERA (2014), ''Research to Inform Analysis of the Heavy-Duty Vehicle Rebound Effect,'' Excerpts of Draft Final Report of Phase 1 under EPA contract EP–C–13–025 (EPA–HQ–OAR–2014–0827–0514).

[811] Elasticity is the measurement of how responsive an economic variable is to a change in another. For example: *Price elasticity of demand* is a measure used in economics to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price. More precisely, it gives the percentage change in quantity demanded in response to a one percent change in price.

[812] See 80 FR 40448–40452.

[813] See 80 FR 40448–40452.

the final rule based on submissions from public commenters and new research on the rebound effect.

This section reviews new econometric analyses that have been produced since the release of the proposal. All of these analyses study the change in HDV use (measured in VMT, ton-mile, or fuel consumption) in response to changes in fuel price ($/gallon) or fuel cost ($/mile or $/ton-mile). The studies presented below attempt to estimate these elasticities in the HDV sector using varying approaches and data sources.

Concurrent with the development of the proposal for this rule, EPA contracted with Energy and Environmental Research Associates (EERA) to analyze the HDV rebound effect for regulatory assessment purposes. Excerpts of EERA's initial report to EPA are included in the NPRM docket and contain detailed qualitative discussions of the rebound effect as well as data sources that could be used in quantitative analysis.[814] EERA also conducted follow-on quantitative analyses focused on estimating the impact of fuel prices on VMT and fuel consumption. We included a Working Paper in the NPRM docket that described much of this work.[815] Note that EERA's Working Paper was not available at the time the agencies conducted the analysis of the rebound effect for the proposal, but that the agencies agreed to consider this work and any other work in the analysis supporting the final rule.

At the time of publication of the NPRM, Winebrake et al. (2015) published two papers in Transportation Research Part D: Transport and Environment based on the EERA work mentioned above.[816] These two papers have been filed in each agency's docket and received public review and comment. In the first paper, the fuel price elasticities of VMT and fuel consumption for combination trucks are estimated with regression models. The combination trucks paper uses annual data for the period 1970–2012. VMT and fuel consumption are used as the dependent variables. The control variables include: A macroeconomic variable (*e.g.,* gross domestic product (GDP)), imports/exports, and fuel price, among other variables. In the second paper, the fuel price elasticity of VMT for single unit vehicles is estimated by using annual data for the period 1980–2012. The single unit vehicle paper uses similar control variables but includes additional variables related to lane miles and housing construction. VMT is the only dependent variable modeled in the single unit vehicle paper (*i.e.,* fuel consumption is not modeled).

The results in Winebrake et al. are that the null hypothesis—which states that the fuel price elasticity of VMT and the fuel price elasticity of fuel consumption are zero—cannot be rejected with statistical confidence. The papers hypothesize that low elasticities may be due to a range of possibilities including: (1) The common use of fuel surcharges; (2) adjustments in other operational costs such as labor; (3) possible principal-agent problems affecting driver behavior; and (4) the nature of freight transportation as an input to a larger supply chain system that is driven by other factors. These two papers suggest that previous regulatory analysis that uses a five percent rebound effect for combination trucks and a 15 percent rebound effect for single unit trucks may be overestimating the direct VMT rebound effect.

To the best of our knowledge, the Winebrake et al. paper represents the first peer-reviewed work in the last two decades, after Gately (1990),[817] that attempts to estimate quantitatively the impact of a change in fuel costs on HDV VMT in the U.S. context. A subsequent paper by Wadud, discussed in more detail below, states that there is ''only one creditable study'' on ''the responses of different [heavy duty] vehicle sectors to fuel price or income changes,'' specifically the Winebrake et al. combination truck work.

However, there is also other recent work that has not been peer reviewed, or that studies HD VMT rebound in other countries, that bears mention. Resources for the Future (RFF) filed a comment on the proposal with a Working Paper by Leard et al. (2015) to address HDV rebound effects.[818] [819] Leard et al.'s paper uses detailed truck-level micro-data from the Vehicle Inventory and Use Survey (VIUS) for six survey years (specifically, 1977, 1982, 1987, 1992, 1997, and 2002). The ''rebound effect'' in this paper is defined to be a combination of a ''VMT elasticity with respect to fuel costs per mile'' ($/mile); and a ''truck count elasticity with respect to fuel costs per mile.'' Fuel costs per mile are defined as fuel price ($/gal) divided by efficiency (mpg). Because the agencies do not estimate the directional impact of this rulemaking on vehicle sales, the portion of Leard et al.'s estimates associated with VMT rebound with respect to fuel costs per mile are the most useful point of comparison to the estimates in the proposal for this rulemaking.

Leard et al. report a VMT rebound effect result of 18.5 percent with respect to fuel costs per mile for combination trucks.[820] This finding suggests that previous estimates of combination truck rebound effects used in the proposed rule, a five percent rebound effect, may be underestimating the true rebound effect. Leard et al. also report a VMT rebound effect with respect to fuel costs per mile of 12.2 percent for single unit trucks.[821] This finding (like the findings of the Winebrake paper) suggests that the previous use of a 15 percent rebound effect for single unit vehicles in the proposed rule may be overestimating the true rebound effect. As noted, VIUS was discontinued in 2002, so the most recent data in this study is 2002, which is fourteen years old. The Leard et al. Working Paper has not yet been peer reviewed or published.

Recently, Wadud (2016) has estimated price elasticities of diesel demand in the U.K.[822] The paper aims to model diesel demand elasticities for different freight duty vehicle types in the U.K. Wadud uses a similar model specification as Winebrake et al. in the regression analysis. Wadud finds that diesel consumption in freight vehicles overall is quite inelastic. Diesel demand from articulated trucks and large goods vehicles (similar to combination trucks in the U.S.) does not respond to changes

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[814] EERA (2014), ''Research to Inform Analysis of the Heavy-Duty Vehicle Rebound Effect,'' Excerpts of Draft Final Report of Phase 1 under EPA contract EP–C–13–025, EPA–HQ–OAR–2014–0827–0514.

[815] EERA (2015), ''Working Paper on Fuel Price Elasticities for Heavy Duty Vehicles,'' Draft Final Report of Phase 2 under EPA contract EP–C–11–046, EPA–HQ–OAR–2014–0827–0515.

[816] Winebrake, J.J., et al., *Fuel price elasticities in the U.S. combination trucking sector.* Transportation Research Part D: Transport and Environment, 2015. 38: p. 166–177.

Winebrake, J.J., *et al., Fuel price elasticities for single unit truck operations in the United States.* Transportation Research Part D: Transport and Environment, 2015. 38: p. 178–187.

[817] Gately, D., 1990. *The U.S. demand for highway travel and motor fuel.* Energy J. 11, 59–74.

[818] Resources for the Future (RFF) comment, EPA–HQ–OAR–2014–0827–1200.

[819] Leard, B., et al., *Fuel Costs, Economic Activity, and the Rebound Effect for Heavy-Duty Trucks.* September 2015, Resources for the Future: RF DP 15–43, Washington, DC. EPA–HQ–OAR–2014–0827–1200–A1.

[820] Leard et al. report a total VMT rebound effect result of 29.7 percent for combination trucks, which is a sum of separate estimates associated with both VMT elasticity and truck count elasticity with respect to fuel costs per mile.

[821] For vocational trucks, Leard et al. report an overall 9.3 percent rebound value, which is a sum of separate estimates associated with both VMT elasticity and truck count elasticity with respect to fuel costs per mile.

[822] Wadud, Zia, *Diesel Demand in the Road Freight Sector in the UK: Estimates for Different Vehicle Types.* Applied Energy 165 (2016), p. 849–857.

in diesel prices. Demand in rigid trucks (similar to single unit trucks in the U.S.) responds to fuel price changes with a 15 percent elasticity. Wadud's work presents empirical results in the U.K., which might not be necessarily be appropriate to apply to the U.S.

(3) How the Agencies Estimated the HDV Rebound Effect for the Final Rule

(a) Values Used in the Phase 2 NPRM Analysis

At the time the agencies conducted their analysis of the proposed Phase 2 HD fuel efficiency and GHG emissions standards, the agencies determined that the evidence did not lend itself to any changes in the values used to estimate the VMT rebound effect in the HD Phase 1 rulemaking. The agencies used the rebound effects estimate of 15 percent for vocational vehicles five percent for combination tractors, and 10 percent for HD pickup trucks and vans from the HD Phase 1 rulemaking.

(b) How the Agencies Analyzed VMT Rebound in This Final Rulemaking

The emergence of new information as well as public comment are cause for updating the quantitative values used to estimate the VMT rebound effect from those estimated by the analysis conducted for the HD Phase 1 rulemaking. For vocational trucks, the Winebrake et al. study found no responsiveness of truck travel to diesel fuel prices, suggesting a VMT rebound of essentially zero. Leard et al. suggested a VMT rebound effect for vocational trucks of roughly 12 percent. For combination trucks, the Winebrake et al. study found a rebound effect of essentially zero percent. The Leard et al. study found a VMT elasticity rebound effect of roughly 18 percent for combination trucks. In addition to the RFF comments to which Leard et al. was included, EPA and NHTSA received ten other comments on HDV rebound during the comment period for the proposal, six of which were substantive. One of these commenters suggested that the agencies' rebound numbers ''appear reasonable.'' The five others commented that the rebound estimates for both combination and vocational vehicles used in the proposal were overestimated, and suggested using the Winebrake et al. estimates.

In revising the HD VMT rebound estimates, we give somewhat greater consideration to the findings of Winebrake et al. because it is peer-reviewed and published, whereas Leard et al. is a Working Paper. Based on this consideration and on the comments that we received in response to the proposal, the agencies have chosen to revise the VMT rebound estimate for vocational trucks down to five percent, and have elected to maintain the use of the five percent rebound effect for tractors. We note that while the Winebrake et al. work supports rebound estimates of zero percent for vocational vehicles and tractors, using a five percent value is conservative and leaves some consideration of uncertainty, as well as some consideration of the (un-peer reviewed and unpublished) findings of the Leard et al. study. The five percent value is in range of the two U.S. studies and generally addresses the issues raised by the commenters. We did not receive new data or comments on our estimated VMT rebound effect for heavy-duty pick-up trucks and vans. Therefore, we have elected to use the 10 percent value used for the proposal.

It should be noted that the rebound estimates we have selected for our analysis represent the VMT impact from the final standards with respect to changes in the fuel cost per mile driven. As described in the RIA (Chapter 8), the HDV rebound effect should ideally be a measure of the change in fuel consumed with respect to the change in *overall* operating costs due to a change in HDV fuel efficiency. Such a measure would incorporate all impacts from our rules, including those from incremental increases in vehicle prices that reflect costs for improving their fuel efficiency. Therefore, VMT rebound estimates with respect to fuel costs per mile must be ''scaled'' to apply to total operating costs, by dividing them by the fraction of total operating costs accounted for by fuel use.

In the NPRM, due to timing constraints, we used the same ''overall'' VMT rebound value for each of the alternatives. For the final rulemaking, we determined VMT rebound separately for each HDV category and for each alternative. The agencies made simplifying assumptions in the VMT rebound analysis for this final rulemaking, similar to the approach taken during HD Phase 1 final rules. For example, due to timing constraints, the agencies did not have the final technology package costs for each of the alternatives prior to the need to conduct the emission inventory analysis. Therefore, the agencies used the technology package costs developed for each of the NPRM alternatives. Chapter 8.3.3 in the RIA provides more details on our assessment of HDV VMT rebound. In addition, Chapter 7 of the RIA presents VMT rebound for each HDV sector that we estimated for the final program. These VMT impacts are reflected in the estimates of total fuel savings and reductions in emissions of GHG and other air pollutants presented in Section VII and VIII of this Preamble for all categories.

For the purposes of this final rulemaking, we have not taken into account any potential fuel savings or GHG emission reductions from the rail sector due to mode shift because estimates of this effect seem too speculative at this time. Similarly, we have not taken into account any fuel savings or GHG emissions reductions from the potential shift in VMT from older HDVs to newer, more efficient HDVs because we have found no evidence of this potential effect from fuel efficiency standards. The agencies requested comment on these assumptions in the NPRM, but did not receive any.

Note that while we focus on the VMT rebound effect in our analysis of these final rules, there are at least two other types of rebound effects discussed in the energy policy and economics literature. In addition to VMT rebound effects, there are ''indirect'' rebound effects, which refers to the purchase of other goods or services (that consume energy) with the costs savings from energy efficiency improvements; and ''economy-wide'' rebound effects, which refers to the increased demand for energy throughout the economy in response to the reduced market price of energy that happens as a result of energy efficiency improvements. One commenter pointed out that consumers may use their savings from lower fuel costs as a result of the direct rebound effect to buy more goods and services, which indirectly increases the use of energy (*i.e.,* the indirect rebound effect).[823] The commenter states that the indirect rebound effect represents a positive economic result for consumers, since consumer welfare increases, although it could result in increased energy use and GHG emissions. We agree with the commenter's observation that, to the extent that indirect rebound does occur, it could have both positive and negative impacts.

Another commenter suggested that the indirect or economy-wide rebound effect could be large enough so as to fully offset the fuel savings and GHG emissions benefits of the rule.[824] The commenter provides multiple estimates of the potential size of the indirect rebound effect. However, the unpublished methodology used to perform these estimates has not undergone peer review and, as explained in the response to comment

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[823] EPA–HQ–OAR–2014–0827–1336.

[824] EPA–HQ–OAR–2014–0827–1467.

document, the agencies find it to be dubious. Further, as discussed in detail in the proposal rule and our response to comment document, there are a number of other important questions not addressed by the commenter that must be examined before we can have enough confidence in these kinds of estimates to include them in our economic analysis.

As discussed in this rule, all of the fuel costs savings will not necessarily be passed through to the consumer in terms of cheaper goods and services. First, there may be market barriers that impede trucking companies from passing along the fuel cost savings from the rule in the form of lower rates. Second, there are upfront vehicle costs (and potentially transaction or transition costs associated with the adoption of new technologies) that would partially offset some of the fuel cost savings from our rule, thereby limiting the magnitude of the impact on prices of final goods and services. Also, it is not clear how the fuel savings from the rule would be utilized by trucking firms. For example, trucking firms may reinvest fuel savings in their own company; retain fuel savings as profits; pass fuel savings onto customers or others; or increase driver pay. Finally, it is not clear how the different pathways that fuel savings would be utilized would affect greenhouse gas emissions.

Research on indirect and economy-wide rebound effects is scant, and we have not identified any peer-reviewed research that attempts to quantify indirect or economy-wide rebound effects for HDVs. In particular, the agencies are not aware of any peer-reviewed approach which indicates that the magnitude of indirect or economy-wide rebound effects, if any, would be significant for this final rule.[825] Therefore, we rely on the analysis of vehicle miles traveled to estimate the rebound effect in this rule, as we did for the HD Phase 1 rule, where we attempted to quantify only rebound effects from our rule that impact HDV VMT.

In order to test the effect of alternative assumptions about the rebound effect, NHTSA examined the sensitivity of its estimates of benefits and costs of the proposed Phase 2 program for HD pickups and vans to alternative assumptions about the rebound effect. While the main analysis for pickups and vans assumes a 10 percent rebound effect, the sensitivity analysis estimates the benefits and costs of these standards under the assumptions of 5, 15, and 20 percent rebound effects. This sensitivity analysis can be found in Section IX.E.3 of the NPRM Preamble[826] and shows that (a) using a 5 percent value for the rebound effect reduced benefits and costs of the proposed standards by identical amounts, leaving net benefits unaffected; and (b) rebound effects of 15 percent and 20 percent increased costs and reduced benefits compared to their values in the main analysis, thus reducing net benefits of the proposed standards. Nevertheless, the proposed and now the final program have significant net benefits and these alternative values of the rebound effect would not have affected the agencies' selection of the final program stringency, as that selection is based on NHTSA's assessment of the maximum feasible fuel efficiency standards and EPA's selection of appropriate GHG standards to address energy security and the environment.

F. Impact on Class Shifting, Fleet Turnover, and Sales

The agencies considered two additional potential indirect effects which may lead to unintended consequences of the program to improve the fuel efficiency and reduce GHG emissions from HD trucks. The next sections cover the agencies' qualitative discussions on potential class shifting and fleet turnover effects.

(1) Class Shifting

Heavy-duty vehicles are typically configured and purchased to perform a function. For example, a concrete mixer truck is purchased to transport concrete, a combination tractor is purchased to move freight with the use of a trailer, and a Class 3 pickup truck could be purchased by a landscape company to pull a trailer carrying lawnmowers. The purchaser makes decisions based on many attributes of the vehicle, including the gross vehicle weight rating of the vehicle, which in part determines the amount of freight or equipment that can be carried. If the Phase 2 standards impact either the performance of the vehicle or the marginal cost of the vehicle relative to the other vehicle classes, then consumers may choose to purchase a different vehicle, resulting in the unintended consequence of increased fuel consumption and GHG emissions in-use.

The agencies, along with the NAS panel, found that there is little or no literature which evaluates class shifting between trucks.[827] In addition, the agencies did not receive comments specifically raising concerns about class shifting. NHTSA and EPA qualitatively evaluated the final rules in light of potential class shifting. The agencies looked at four potential cases of shifting: From light-duty pickup trucks to heavy-duty pickup trucks; from sleeper cabs to day cabs; from combination tractors to vocational vehicles; and within vocational vehicles.

Light-duty pickup trucks, those with a GVWR of less than 8,500 lbs, are currently regulated under the existing GHG/CAFE standards for light duty vehicles. The increased stringency of the light-duty 2017–2025 MY vehicle rule has led some to speculate that vehicle consumers may choose to purchase heavy-duty pickup trucks that are currently regulated under the HD Phase 1 program if the cost of the light-duty regulation is high relative to the cost to buy the larger heavy-duty pickup trucks. Since fuel consumption and GHG emissions rise significantly with vehicle mass, a shift from light-duty trucks to heavy-duty trucks would likely lead to higher fuel consumption and GHG emissions, an untended consequence of the regulations. Given the significant price premium of a heavy-duty truck (often five to ten thousand dollars more than a light-duty pickup), we believe that such a class shift would be unlikely whether or not this program exited. These final rules would continue to diminish any incentive for such a class shift because they would narrow the GHG and fuel efficiency performance gap between light-duty and heavy-duty pickup trucks. The regulations for the HD pickup trucks, and similarly for vans, are based on similar technologies and therefore reflect a similar expected increase in cost when compared to the light-duty GHG regulation. Hence, the combination of the two regulations provides little incentive for a shift from light-duty trucks to HD trucks. To the extent that this regulation of heavy-duty pickups and vans could conceivably encourage a class shift towards lighter pickups, this unintended consequence

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[825] The same entity responsible for these comments also sought reconsideration of the Phase 1 rule on the grounds that indirect rebound effects had not been considered by the agencies and could negate all of the benefits of the standards. This assertion rested on an unsupported affidavit lacking any peer review or other indicia of objectivity. This affidavit cited only one published study. The study cited did not deal with vehicle efficiency, has methodological limitations (many of them acknowledged), and otherwise was not pertinent. EPA and NHTSA thus declined to reconsider the Phase 1 rule based on these speculative assertions. See generally 77 FR 51703–51704, August 27, 2012 and 77 FR 51502–51503, August 24, 2012. The analysis in this entity's comments on this rulemaking rests largely on that same unsupported affidavit.

[826] 80 FR 40137.

[827] *See* 2010 NAS Report, page 152.

would in fact be expected to lead to lower fuel consumption and GHG emissions as the smaller light-duty pickups have significantly better fuel economy ratings than heavy-duty pickup trucks.

The projected cost increases for this action differ between Class 8 day cabs and Class 8 sleeper cabs, reflecting our conservative assumption for purposes of this analysis on shifting that compliance with these standards would lead truck consumers to specify sleeper cabs equipped with APUs or alternatives to APU while day cab consumers would not. Since Class 8 day cab and sleeper cab trucks perform essentially the same function when hauling a trailer, this raises the possibility that the additional cost for an APU or alternatives to APU equipped sleeper cab could lead to a shift from sleeper cab to day cab trucks. We do not believe that such an intended consequence would occur for the following reasons. The addition of a sleeper berth to a tractor cab is not a consumer-selectable attribute in quite the same way as other vehicle features. The sleeper cab provides a utility that long-distance trucking fleets need to conduct their operations—an on-board sleeping berth that lets a driver comply with federally-mandated rest periods, as required by the Department of Transportation Federal Motor Carrier Safety Administration's hours-of-service regulations. The cost of sleeper trucks is already higher than the cost of day cabs, yet the fleets that need this utility purchase them.[828] A day cab simply cannot provide this utility with a single driver. The need for this utility would not be changed even if the additional costs to reduce greenhouse gas emissions from sleeper cabs exceed those for reducing greenhouse gas emissions from day cabs.[829]

A trucking fleet could instead decide to put its drivers in hotels in lieu of using sleeper berths, and switch to day cabs. However, this is unlikely to occur in any great number, since the added cost for the hotel stays would far overwhelm differences in the marginal cost between day and sleeper cabs. Even if some fleets do opt to buy hotel rooms and switch to day cabs, they would be highly unlikely to purchase a day cab that was aerodynamically worse than the sleeper cab they replaced, since the need for features optimized for long-distance hauling would not have changed. So in practice, there would likely be little difference to the environment for any switching that might occur. Further, while our projected costs in the NPRM assumed the purchase of an APU for compliance for nearly all sleeper cabs, the updated analysis reflects additional flexibility in the final rules that would allow manufacturers to use several other alternatives to APUs that would be much less expensive. Thus, even though we are now projecting that APU costs will be somewhat higher than what we projected for the NPRM, manufacturers and consumers will not be required to use them. In fact, this regulatory structure would allow compliance using a near zero cost software utility that eliminates tractor idling after five minutes. Using this compliance approach, the cost difference between a Class 8 sleeper cab and day cab due to these regulations is small. We are proposing this alternative compliance approach reflecting that some sleeper cabs are used in team driving situations where one driver sleeps while the other drives. In that situation, an APU is unnecessary since the tractor is continually being driven when occupied. When it is parked, it would automatically eliminate any additional idling through the shutdown software. If trucking businesses choose this option, then costs based on purchase of APUs may overestimate the costs of this program to this sector.

Class shifting from combination tractors to vocational vehicles may occur if a customer deems the additional marginal cost of tractors due to the regulation to be greater than the utility provided by the tractor. The agencies initially considered this issue when deciding whether to include Class 7 tractors with the Class 8 tractors or regulate them as vocational vehicles. The agencies' evaluation of the combined vehicle weight rating of the Class 7 shows that if these vehicles were treated significantly differently from the Class 8 tractors, then they could be easily substituted for Class 8 tractors. Therefore, the agencies will continue to include both classes in the tractor category. The agencies believe that a shift from tractors to vocational vehicles would be limited because of the ability of tractors to pick up and drop off trailers at locations which cannot be done by vocational vehicles.

The agencies do not envision that the regulatory program would cause class shifting within the vocational vehicle class. As vocational vehicles include a wide variety of vehicle types, and serve a wide range of functions, the diversity in the vocational vehicle segment can be primarily attributed to the variety of customer needs for specialized vehicle bodies and added equipment, rather than to the chassis. The new standards are projected to lead to a small increase in the incremental cost per vehicle. However, these cost increases are consistent across the board for both vocational vehicles and the engines used in the vehicle (Table V–30 at Preamble Section V.C.(2)(e)). The agencies believe that the utility gained from the additional technology package would outweigh the additional cost for vocational vehicles.[830]

In conclusion, NHTSA and EPA believe that the regulatory structure for HD vehicles and engines would not significantly change the current competitive and market factors that determine purchaser preferences. Furthermore, even if a small amount of shifting would occur, any resulting GHG impacts would likely to be negligible because any vehicle class that sees an uptick in sales is also being regulated for GHG emission control and fuel efficiency. Therefore, the agencies did not include an impact of class shifting on the vehicle populations used to assess the benefits of the program.

(2) Fleet Turnover and Sales Effects

A regulation that affects the cost to purchase and/or operate trucks could affect whether a consumer decides to purchase a new truck and the timing of that purchase. The term pre-buy refers to the idea that truck purchases may occur earlier than otherwise planned to avoid the additional costs associated with a new regulatory requirement. Slower fleet turnover, or low-buys, may occur when owners opt to keep their existing truck rather than purchase a new truck due to the incremental cost of the regulation.

Several commenters raised the possibility of pre-buy for these standards. Allison Transmission, the National Automobile Dealers Association, the Owner-Operator Independent Drivers Association, and the Truck Renting and Leasing Association point toward pre-buy associated with standards from the 2000s for nitrogen oxides (NO_X) regulations as evidence of the likelihood

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[828] A baseline tractor price of a new day cab is $89,500 versus $113,000 for a new sleeper cab based on information gathered by ICF in the ''Investigation of Costs for Strategies to Reduce Greenhouse Gas Emissions for Heavy-Duty On-Road Vehicles,'' July 2010. Page 3. Docket Identification Number EPA–HQ–OAR–2014—0827.

[829] The average marginal cost difference between sleeper cabs and day cabs in the rule is roughly $2,500.

[830] The final rule projects the average per-vehicle costs associated with the 2027 MY standards to be generally less than five percent of the overall price of a new vehicle. The cost-effectiveness of these vocational vehicle standards in dollars per ton is similar to the cost effectiveness estimated for light-duty trucks in the 2017–2025 light duty greenhouse gas standards (Preamble section V.C.3).

of pre-buy for vehicle GHG and fuel efficiency standards. Daimler Trucks North America, the International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America, and the Truck and Engine Manufacturers Association express concern about pre-buy specifically in the context of NPRM Alternative 4, due to concerns that the time frame for technology development and adoption was too short. Daimler Trucks and the Environmental Defense Fund note that Phase 1 did not appear to result in pre-buy. Volvo Group notes that the phase-in approach of Phase 1 plus the flexibilities available eased the transition to new technologies, and that gradual market acceptance of new technologies will lead to less disruption than an accelerated program. The Recreational Vehicle Industry Association expressed concern that the standards will have a negative effect on recreational vehicle sales.

The 2010 NAS HD Report discussed the topics associated with medium- and heavy-duty vehicle fleet turnover. NAS noted that there is some empirical evidence of pre-buy behavior in response to the 2004 and 2007 heavy-duty engine emission standards, with larger impacts occurring in response to higher costs.[831] However, those regulations increased upfront costs to firms without any offsetting future cost savings from reduced fuel purchases. In summary, NAS stated that:

> . . . during periods of stable or growing demand in the freight sector, pre-buy behavior may have significant impact on purchase patterns, especially for larger fleets with better access to capital and financing. Under these same conditions, smaller operators may simply elect to keep their current equipment on the road longer, all the more likely given continued improvements in diesel engine durability over time. On the other hand, to the extent that fuel economy improvements can offset incremental purchase costs, these impacts will be lessened. Nevertheless, when it comes to efficiency investments, most heavy-duty fleet operators require relatively quick payback periods, on the order of two to three years.[832]

The regulations are projected to return fuel savings to the vehicle owners that offset the cost of the regulation within a few years. The effects of the regulation on purchasing behavior and sales will depend on the nature of the market failures and the extent to which firms consider the projected future fuel savings in their purchasing decisions.

If trucking firms or other buyers account for the rapid payback, they are unlikely to strategically accelerate or delay their purchase plans at additional cost in capital to avoid a regulation that will lower their overall operating costs. As discussed in Section IX.A., this scenario may occur if this program reduces uncertainty about fuel-saving technologies. More reliable information about ways to reduce fuel consumption allows truck purchasers to evaluate better the benefits and costs of additional fuel savings, primarily in the original vehicle market, but possibly in the resale market as well. In addition, these standards are expected to lead manufacturers to install more fuel-saving technologies and promote their purchase; the increased availability and promotion may encourage sales.

Other market failures may leave open the possibility of some pre-buy or delayed purchasing behavior. Firms may not consider the full value of the future fuel savings for several reasons. For instance, truck purchasers may not want to invest in fuel efficiency because of uncertainty about fuel prices. Another explanation is that the resale market may not fully recognize the value of fuel savings, due to lack of trust of new technologies or changes in the uses of the vehicles. Lack of coordination (also called split incentives—see Section IX.A) between truck purchasers (who may emphasize the up-front costs of the trucks) and truck operators, who like the fuel savings, can also lead to pre-buy or delayed purchasing behavior. If these market failures prevent firms from fully internalizing fuel savings when deciding on vehicle purchases, then pre-buy and delayed purchase could occur and could result in a slight decrease in the GHG benefits of the regulation.

Thus, whether pre-buy or delayed purchase is likely to play a significant role in the truck market depends on the specific behaviors of purchasers in that market. Without additional information about which scenario is more likely to be prevalent, the agencies are not projecting a change in fleet turnover characteristics due to this regulation.

Industry purchasing in relation to the advent of the Phase 1 standards offers at least some insight into the impacts of these standards. The Environmental Defense Fund observes that MY 2014 heavy-duty trucks had the highest sales since 2005. Any trends in sales are likely to be affected by macroeconomic conditions, which have been recovering since 2009–2010. The standards may have affected sales, but the size of that effect is likely to be swamped by the effects of the economic recovery. It is unlikely to be possible to separate the effects of the existing standards from other confounding factors.

G. Monetized GHG Impacts

(1) Monetized CO_2 Impacts—The Social Cost of Carbon (SC-CO_2)

We estimate the global social benefits of CO_2 emission reductions expected from the heavy-duty GHG and fuel efficiency standards using the social cost of carbon (SC-CO_2) estimates presented in the *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (May 2013, Revised July 2015) (''current SC-CO2 TSD'').[833] (The SC-CO_2 estimates are presented in Table IX–11). We refer to these estimates, which were developed by the U.S. government, as ''SC-CO_2 estimates.'' The SC-CO_2 is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year. It includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (*i.e.,* benefits of rulemakings that lead to an incremental reduction in cumulative global CO_2 emissions).

The SC-CO_2 estimates used in this analysis were developed over many

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[831] Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles; National Research Council; Transportation Research Board (2010). ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,'' (hereafter, ''NAS Report''). Washington, DC, the National Academies Press. Available electronically from the National Academies Press Web site at *http://www.nap.edu/catalog.php?record_id=12845.*, pp. 150–151, Docket EPA–HQ–OAR–2014–0827–0276.

[832] *See* NAS Report, Note 831, page 151, Docket EPA–HQ–OAR–2014–0827–0276.

[833] *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (May 2013, Revised July 2015), Interagency Working Group on Social Cost of Carbon, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury. Available at: *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.*

years, using the best science available, and with input from the public. Specifically, an interagency working group (IWG) that included EPA, DOT, and other executive branch agencies and offices used three integrated assessment models (IAMs) to develop the SC-CO_2 estimates and recommended four global values for use in regulatory analyses. The SC-CO_2 estimates were first released in February 2010 and updated in 2013 using new versions of each IAM. The 2013 update did not revisit the 2010 modeling decisions (*e.g.,* with regard to the discount rate, reference case socioeconomic and emission scenarios or equilibrium climate sensitivity). Rather, improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves and used for analyses in peer-reviewed publications. The 2010 SC-CO_2 Technical Support Document (2010 SC-CO_2 TSD) provides a complete discussion of the methods used to develop these estimates and the current SC-CO_2 TSD presents and discusses the update (including recent minor technical corrections to the estimates).[834]

The 2010 SC-CO_2 TSD noted a number of limitations to the SC-CO_2 analysis, including the incomplete way in which the IAMs capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Currently IAMs do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature due to a lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. Nonetheless, these estimates and the discussion of their limitations represent the best available information about the social benefits of CO_2 reductions to inform benefit-cost analysis; see RIA of this rule and the SC-CO_2 TSDs for additional details. The new versions of the models used to estimate the values presented below offer some improvements in these areas, although further work is warranted.

Accordingly, EPA and other agencies continue to engage in research on modeling and valuation of climate impacts with the goal to improve these estimates. The EPA and other federal agencies also continue to consider feedback on the SC-CO_2 estimates from stakeholders through a range of channels, including public comments on Agency rulemakings that use the SC-CO_2 in supporting analyses and through regular interactions with stakeholders and research analysts implementing the SC-CO_2 methodology used by the IWG. The SC-CO_2 comments received on this rulemaking covered the technical details of the modeling conducted to develop the SC-CO_2 estimates and some also provided constructive recommendations for potential opportunities to improve the SC-CO_2 estimates in future updates. EPA has carefully considered all of these comments and continues to conclude that the current estimates represent the best scientific information on the impacts of climate change available in a form appropriate for incorporating the damages from incremental CO_2 emissions changes into regulatory analysis. Therefore, EPA has presented the current SC-CO_2 estimates in this rulemaking. See Section 11.8 of the RTC document for a summary of and response to the SC-CO_2 comments submitted to this rulemaking. In addition, OMB sought public comment on the approach used to develop the SC-CO_2 estimates through a separate comment period and published a response to those comments in 2015.[835]

After careful evaluation of the full range of comments submitted to OMB, the IWG continues to recommend the use of the SC-CO_2 estimates in regulatory impact analysis. With the July 2015 release of the response to comments, the IWG announced plans to obtain expert independent advice from the National Academies of Sciences, Engineering and Medicine to ensure that the SC-CO_2 estimates continue to reflect the best available scientific and economic information on climate change. The Academies then convened a committee, ‘‘Assessing Approaches to Updating the Social Cost of Carbon,’’ (Committee) which is reviewing the state of the science on estimating the SC-CO_2, and will provide expert, independent advice on the merits of different technical approaches for modeling and highlight research priorities going forward. EPA will evaluate its approach based upon any feedback received from the Academies' panel.

To date, the Committee has released an interim report, which recommended against doing a near term update of the SC-CO_2 estimates. For future revisions, the Committee recommended the IWG move efforts towards a broader update of the climate system module consistent with the most recent, best available science, and also offered recommendations for how to enhance the discussion and presentation of uncertainty in the SC-CO_2 estimates. Specifically, the Committee recommended that ‘‘the IWG provide guidance in their technical support documents about how [SC-CO_2] uncertainty should be represented and discussed in individual regulatory impact analyses that use the [SC-CO_2]’’ and that the technical support document for each update of the estimates present a section discussing the uncertainty in the overall approach, in the models used, and uncertainty that may not be included in the estimates. At the time of this writing, the IWG is reviewing the interim report and considering the recommendations. EPA looks forward to working with the IWG to respond to the recommendations and will continue to follow IWG guidance on SC-CO_2.

The four global SC-CO_2 estimates are as follows: $13, $46, $68, and $140 per metric ton of CO_2 emissions in the year 2020 (2013$).[836] The first three values are based on the average SC-CO_2 from the three IAMs, at discount rates of 5, 3, and 2.5 percent, respectively. SC-CO_2 estimates for several discount rates are included because the literature shows that the SC-CO_2 is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context (where costs and benefits are incurred by different generations). The fourth value is the 95th percentile of the SC-CO_2 from all three models at a 3 percent discount rate. It is included to represent lower probability but higher outcomes from

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[834] Both the 2010 SC-CO_2 TSD and the current TSD are available at: *https://www.whitehouse.gov/omb/oira/social-cost-of-carbon.* The 2010 SC-CO_2 TSD also available in the docket: Docket ID EPA–HQ–OAR–2009–0472–114577, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, with participation by the Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (February 2010). Also available at: *http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.*

[835] See *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-response-to-comments-final-july-2015.pdf.*

[836] The current SC-CO_2 TSD presents the SC-CO_2 estimates in $2007. These estimates were adjusted to 2013$ using the GDP Implicit Price Deflator. Bureau of Economic Analysis, Table 1.1.9 Implicit Price Deflators for Gross Domestic Product; last revised on September 25, 2015.

climate change, which are captured further out in the tail of the SC-CO_2 distribution, and while less likely than those reflected by the average SC-CO_2 estimates, would be much more harmful to society and therefore, are relevant to policy makers. The SC-CO_2 increases over time because future emissions are expected to produce larger incremental damages as economies grow and physical and economic systems become more stressed in response to greater climate change. The SC-CO_2 values are presented in Table IX–11.

Applying the global SC-CO_2 estimates, shown in Table, to the estimated reductions in domestic CO_2 emissions for the program, yields estimates of the dollar value of the climate related benefits for each analysis year. These estimates are then discounted back to the analysis year using the same discount rate used to estimate the SC-CO_2. For internal consistency, the annual benefits are discounted back to net present value terms using the same discount rate as each SC-CO_2 estimate (*i.e.,* 5 percent, 3 percent, and 2.5 percent) rather than the discount rates of 3 percent and 7 percent used to derive the net present value of other streams of costs and benefits of the final rule.[837] The SC-CO_2 benefit estimates for each calendar year are shown in Table. The SC-CO_2 benefit estimates for each model year are shown in Table IX–13.

TABLE IX–11—SOCIAL COST OF CO_2, 2012–2050 [a]

[in 2013$ per Metric Ton]

Calendar year	5% Average	3% Average	2.5% Average	3%, 95th Percentile
2012	$12	$36	$58	$100
2015	12	40	62	120
2020	13	46	68	140
2025	15	51	75	150
2030	18	55	80	170
2035	20	60	86	180
2040	23	66	92	200
2045	25	70	98	220
2050	29	76	100	230

Note:

[a] The SC-CO_2 values are dollar-year and emissions-year specific and have been rounded to two significant digits. Unrounded numbers from the current SC-CO_2 TSD were used to calculate the CO_2 benefits.

TABLE IX–12—UPSTREAM AND DOWNSTREAM ANNUAL CO_2 BENEFITS FOR THE GIVEN SC-CO_2 VALUE [a] USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [b]

Calendar year	5% average	3% average	2.5% average	3% 95th percentile
2018	$7	$22	$33	$63
2019	13	46	68	130
2020	21	73	110	210
2021	80	280	420	840
2022	170	550	820	1,700
2023	250	850	1,300	2,600
2024	390	1,300	2,000	4,000
2025	560	1,800	2,700	5,500
2026	700	2,400	3,500	7,100
2027	950	3,000	4,400	9,100
2028	1,100	3,700	5,400	11,000
2029	1,300	4,300	6,400	13,000
2030	1,600	5,000	7,300	15,000
2035	2,700	8,100	11,000	25,000
2040	3,700	11,000	15,000	33,000
2050	5,500	15,000	20,000	45,000
NPV	24,000	110,000	180,000	340,000

Notes:

[a] The SC-CO_2 values are dollar-year and emissions-year specific.

[b] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

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[837] See more discussion on the appropriate discounting of climate benefits using SC-CO_2 in the 2010 SCC TSD. Other benefits and costs of proposed regulations unrelated to CO_2 emissions are discounted at the 3% and 7% rates specified in OMB guidance for regulatory analysis.

TABLE IX–13—UPSTREAM AND DOWNSTREAM DISCOUNTED MODEL YEAR LIFETIME CO_2 BENEFITS FOR THE GIVEN SC-CO_2 VALUE USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a] [b]

Model year	5% average	3% average	2.5% average	3% 95th percentile
2018	$38	$150	$230	$450
2019	36	140	220	430
2020	34	140	220	420
2021	560	2,300	3,600	7,000
2022	590	2,500	3,900	7,500
2023	610	2,600	4,000	7,800
2024	920	4,000	6,200	12,000
2025	940	4,100	6,400	12,000
2026	950	4,200	6,600	13,000
2027	1,200	5,400	8,500	16,000
2028	1,200	5,300	8,400	16,000
2029	1,200	5,300	8,400	16,000
Sum	8,200	36,000	57,000	110,000

Notes:

[a] The SC-CO_2 values are dollar-year and emissions-year specific.

[b] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(2) Monetized Non-CO_2 GHG Impacts

EPA calculated the global social benefits of CH_4 and N_2O emissions reductions expected from the final rulemaking using estimates of the social cost of methane (SC-CH_4) and the social cost of nitrous oxide (SC-N_2O). Similar to the SC-CO_2, the SC-CH_4 and SC-N_2O estimate the monetary value of impacts associated with marginal changes in CH_4 and N_2O emissions, respectively, in a given year. Each metric includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. The SC-CH_4 and SC-N_2O estimates applied in this analysis were developed by Marten et al. (2014) and are discussed in greater detail below. EPA is unaware of analogous estimates of HFC–134a and has therefore presented a sensitivity analysis, separate from the main benefit cost analysis, that approximates the benefits of HFC–134a reductions based on global warming potential (GWP) gas comparison metrics (''GWP approach''). Other unquantified non-CO_2 benefits are discussed in this section as well. Additional details are provided in the RIA of these rules.

(a) Monetized CH_4 and N_2O Impacts

As discussed in the proposed rulemaking, a challenge particularly relevant to the monetization of non-CO_2 GHG impacts is that the IWG did not estimate the social costs of non-CO_2 GHG emissions at the time the SC-CO_2 estimates were developed. While there are other estimates of the social cost of non-CO_2 GHGs in the peer review literature, none of those estimates are consistent with the SC-CO_2 estimates developed by the IWG and most are likely underestimates due to changes in the underlying science subsequent to their publication.[838]

However, in the time leading up to the proposal for this rulemaking, a paper by Marten et al. (2014) provided the first set of published SC-CH_4 and SC-N_2O estimates in the peer-reviewed literature that are consistent with the modeling assumptions the IWG used to develop the SC-CO_2 estimates.[839] Specifically, the estimation approach of Marten et al. (2014) used the same set of three IAMs, five socioeconomic-emissions scenarios, equilibrium climate sensitivity distribution, three constant discount rates, and aggregation approach used to develop the SC-CO_2 estimates. Marten et al. also used the same rationale as the IWG to develop global estimates of the SC-CH_4 and the SC-N_2O, given that CH_4 and N_2O are global pollutants.

The resulting SC-CH_4 and SC-N_2O estimates are presented in Table IX–14. More detailed discussion of their methodology, results and a comparison to other published estimates can be found in the RIA and in Marten et al. (2014).

TABLE IX–14—SOCIAL COST OF CH_4 AND N_2O, 2012–2050 [a]

[In 2013$ per metric ton] [Source: Marten et al., 2014 [b]]

Year	SC-CH_4				SC-N_2O			
	5% average	3% average	2.5% average	3% 95th percentile	5% average	3% average	2.5% average	3% 95th percentile
2012	$440	$1,000	$1,400	$2,800	$4,000	$14,000	$21,000	$36,000
2015	490	1,100	1,500	3,100	4,400	14,000	22,000	38,000
2020	590	1,300	1,800	3,500	5,200	16,000	24,000	43,000
2025	710	1,500	2,000	4,100	6,000	19,000	26,000	48,000
2030	830	1,800	2,200	4,600	6,900	21,000	30,000	54,000
2035	990	2,000	2,500	5,400	8,100	23,000	32,000	60,000

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[838] As discussed in the RIA, there is considerable variation among these published estimates in the models and input assumptions they employ. These studies differ in the emission perturbation year, employ a wide range of constant and variable discount rate specifications, and consider a range of baseline socioeconomic and emissions scenarios that have been developed over the last 20 years. See also Reilly and Richards, 1993; Schmalensee, 1993; Fankhauser, 1994; Marten and Newbold, 2012.

[839] Marten, A.L., E.A. Kopits, C.W. Griffiths, S.C. Newbold & A. Wolverton (2014). Incremental CH_4 and N_2O mitigation benefits consistent with the U.S. Government's SC-CO_2 estimates, *Climate Policy,* DOI: 10.1080/14693062.2014.912981.

TABLE IX–14—SOCIAL COST OF CH_4 AND N_2O, 2012–2050 [a]—Continued

[In 2013$ per metric ton] [Source: Marten et al., 2014 [b]]

Year	SC-CH_4				SC-N_2O			
	5% average	3% average	2.5% average	3% 95th percentile	5% average	3% average	2.5% average	3% 95th percentile
2040	1,100	2,200	2,900	6,000	9,200	25,000	35,000	66,000
2045	1,300	2,500	3,100	6,700	10,000	27,000	37,000	73,000
2050	1,400	2,700	3,400	7,400	12,000	30,000	41,000	79,000

Notes:

[a] The values are emissions-year specific and have been rounded to two significant digits. Unrounded numbers were used to calculate the GHG benefits.

[b] The estimates in this table have been adjusted to reflect the minor technical corrections to the SC-CO_2 estimates described above. See the Corrigendum to Marten et al. (2014), *http://www.tandfonline.com/doi/abs/10.1080/14693062.2015.1070550.*

In addition to requesting comment on these estimates in the proposed rulemaking, EPA noted that it had initiated a peer review of the application of the Marten et al (2014) non-CO_2 social cost estimates in regulatory analysis.[840] EPA also stated that, pending a favorable peer review, it planned to use the Marten et al (2014) estimates to monetize benefits of CH_4 and N_2O emission reduction in the main benefit-cost analysis of the final rule.

Since then, EPA received responses that supported use of the Marten et al. estimates. Three reviewers considered seven charge questions that covered issues such as the EPA's interpretation of the Marten et al. estimates, the consistency of the estimates with the SC-CO_2 estimates, the EPA's characterization of the limits of the GWP-approach to value non-CO_2 GHG impacts, and the appropriateness of using the Marten et al. estimates in regulatory impact analyses. The reviewers agreed with the EPA's interpretation of Marten et al.'s estimates, generally found the estimates to be consistent with the SC-CO_2 estimates, and concurred with the limitations of the GWP approach, finding directly modeled estimates to be more appropriate. While outside of the scope of the review, the reviewers briefly considered the limitations in the SC-CO_2 methodology (*e.g.,* those discussed earlier in this section) and noted that because the SC-CO_2 and SC-CH_4 and SC-N_2O methodologies are similar, the limitations also apply to the resulting SC-CH_4 and SC-N_2O estimates. Two of the reviewers concluded that use of the SC-CH_4 and SC-N_2O estimates developed by Marten et al. and published in the peer-reviewed literature is appropriate in RIAs, provided that the Agency discuss the limitations, similar to the discussion provided for SC-CO_2 and other economic analyses. All three reviewers encouraged continued improvements in the SC-CO_2 estimates and suggested that as those improvements are realized they should also be reflected in the SC-CH_4 and SC-N_2O estimates, with one reviewer suggesting the SC-CH_4 and SC-N_2O estimates lag this process. The EPA supports continued improvement in the SC-CO_2 estimates developed by the U.S. government and agrees that improvements in the SC-CO_2 estimates should also be reflected in the SC-CH_4 and SC-N_2O estimates. The fact that the reviewers agree that the SC-CH_4 and SC-N_2O estimates are generally consistent with the SC-CO_2 estimates that are recommended by OMB's guidance on valuing CO_2 emissions reductions, leads the EPA to conclude that use of the SC-CH_4 and SC-N_2O estimates is an analytical improvement over excluding CH_4 and N_2O emissions from the monetized portion of the benefit cost analysis.

The EPA also carefully considered the full range of public comments and associated technical issues on the Marten et al. estimates received in this rulemaking and determined that it would continue to use the estimates in the final rulemaking analysis. Based on the evaluation of the public comments on this rulemaking, the favorable peer review of the application of Marten et al. estimates, and past comments urging EPA to value non-CO_2 GHG impacts in its rulemakings, EPA concluded that the estimates represent the best scientific information on the impacts of climate change available in a form appropriate for incorporating the damages from incremental CH_4 and N_2O emissions changes into regulatory analysis and has included those benefits in the main benefits analysis. Please see RTC Section 11.8 for detailed responses to the comments on non-CO_2 GHG valuation.

The application of directly modeled estimates from Marten et al. (2014) to benefit-cost analysis of a regulatory action is analogous to the use of the SC-CO_2 estimates. Specifically, the SC-CH_4 and SC-N_2O estimates in Table IX–15 are used to monetize the benefits of changes in CH_4 and N_2O emissions expected as a result of the final rulemaking. Forecast changes in CH_4 and N_2O emissions in a given year resulting from the regulatory action are multiplied by the SC-CH_4 and SC-N_2O estimate for that year, respectively. To obtain a present value estimate, the monetized stream of future non-CO_2 benefits are discounted back to the analysis year using the same discount rate used to estimate the social cost of the non-CO_2 GHG emission changes.

The CH_4 and N_2O benefits based on Marten et al. (2014) are presented for each calendar year in Table IX–15.

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[840] For a copy of the peer review and the responses, see *https://cfpub.epa.gov/si/si_public_pra_view.cfm?dirEntryID=291976* (see ''SCCH4 EPA PEER REVIEW FILES.PDF'').

TABLE IX–15—ANNUAL UPSTREAM AND DOWNSTREAM NON-CO_2 GHG BENEFITS FOR THE GIVEN SC-NON-CO_2 VALUE USING METHOD B AND RELATIVE TO THE FLAT BASELINE, USING THE DIRECTLY MODELED APPROACH[a] [b]

[Millions of 2012$][c]

Calendar year	CH_4				N_2O			
	5% Average	3% Average	2.5% Average	3% 95th percentile	5% Average	3% Average	2.5% Average	3% 95th percentile
2018	$0	$1	$1	$2	$0	$0	$0	$0
2019	1	1	2	3	0	0	0	0
2020	1	2	3	5	0	0	0	0
2021	4	8	11	22	0	0	1	1
2022	7	16	21	43	0	1	1	2
2023	12	26	33	68	0	1	2	3
2024	19	40	52	110	1	2	3	5
2025	26	56	72	150	1	3	4	7
2026	34	72	92	190	1	3	5	9
2027	44	94	120	250	1	4	6	11
2028	54	120	150	300	2	5	7	13
2029	65	140	170	360	2	6	9	16
2030	76	160	200	420	2	7	10	19
2035	130	260	340	720	4	12	16	31
2040	180	360	460	980	6	16	22	41
2050	280	530	660	1,400	9	22	30	58
NPV	1,200	3,800	5,400	10,000	37	160	250	430

Notes:

[a] The SC-CH_4 and SC-N_2O values are dollar-year and emissions-year specific.

[b] Note that net present discounted values of reduced GHG emissions is are calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC-CH_4 and SC-N_2O at 5, 3, and 2.5 percent) is used to calculate net present value discounted values of SC-CH_4 and SC-N_2O for internal consistency. Refer to the 2010 SC-CO_2 TSD for more detail.

[c] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(b) *Sensitivity Analysis—HFC-134a Benefits Based on the GWP Approximation Approach*

While the rulemaking will result in reductions of HFC–134a, EPA is unaware of analogous estimates of the social cost of HFC–134a and has therefore used an alternative valuation approach and presented the results in this sensitivity analysis, separate from the main benefit cost analysis. Specifically, EPA has used the global warming potential (GWP) for HFC–134a to convert the emissions of this gas to CO_2 equivalents, which are then valued using the SC-CO_2 estimates. This approach, henceforth referred to as the "GWP approach," has been used in sensitivity analyses to estimate the non-CO_2 benefits in previous EPA rulemakings (see U.S. EPA 2012, 2013).[841] EPA has not presented these estimates in a main benefit-cost analysis due to the limitations associated with using the GWP approach to value changes in non-CO_2 GHG emissions, and considered the GWP approach as an interim method of analysis until social cost estimates for non-CO_2 GHGs, consistent with the SC-CO_2 estimates, were developed.

The GWP is a simple, transparent, and well-established metric for assessing the relative impacts of non-CO_2 emissions compared to CO_2 on a purely physical basis. However, as discussed both in the 2010 SC-CO_2 TSD and previous rulemakings (*e.g.,* U.S. EPA 2012, 2013), the GWP approximation approach to measuring non-CO_2 GHG benefits has several well-documented limitations. These metrics are not ideally suited for use in benefit-cost analyses to approximate the social cost of non-CO_2 GHGs because the approach would assume all subsequent linkages leading to damages are linear in radiative forcing, which would be inconsistent with the most recent scientific literature. Detailed discussion of limitations of the GWP approach can be found in the RIA.

EPA applies the GWP approach to estimate the benefits associated with reductions of HFCs in each calendar year. Under the GWP Approach, EPA converted HFC–134a to CO_2 equivalents using the AR4 100-year GWP for HFC–134a (1,430).[842] These CO_2-equivalent emission reductions are multiplied by the SC-CO_2 estimate corresponding to each year of emission reductions. As with the calculation of annual benefits of CO_2 emission reductions, the annual benefits of non-CO_2 emission reductions based on the GWP approach are discounted back to net present value terms using the same discount rate as each SC-CO_2 estimate. The estimated HFC–134a benefits using the GWP approach are presented in Table IX–16.

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[841] U.S. EPA. (2012). "Regulatory impact analysis supporting the 2012 U.S. Environmental Protection Agency final new source performance standards and amendments to the national emission standards for hazardous air pollutants for the oil and natural gas industry." Retrieved from *http://www3.epa.gov/ttn/ecas/regdata/RIAs/oil_natural_gas_final_neshap_nsps_ria.pdf.* U.S. EPA. (2013). "Regulatory impact analysis: Final rulemaking for 2017–2025 light-duty vehicle greenhouse gas emission standards and corporate average fuel economy standards." Retrieved from *http://www3.epa.gov/otaq/climate/documents/420r12016.pdf.*

[842] Source: Table 2.14 (Errata). Lifetimes, radiative efficiencies and direct (except for CH_4) GWPs relative to CO_2. IPCC Fourth Assessment Report "Climate Change 2007: Working Group I: The Physical Science Basis."

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Part II—Continued

Environmental Protection Agency

40 CFR Parts 9, 22, 85, et al.

Department of Transportation

National Highway Traffic Safety Administration

49 CFR Parts 523, 534, 535, et al.
Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2; Final Rule

Table IX–16—Annual Upstream and Downstream HFC-134a Benefits for the Given SC-CO_2 Value Using Method B and Relative to the Flat Baseline, Using the GWP Approach [a] [b]

[Millions of 2013$] [b]

Calendar year	HFC-134a			
	5% Average	3% Average	2.5% Average	3%, 95th Percentile
2018	$0	$0	$0	$0
2019	$0	$0	$0	$0
2020	$0	$0	$0	$0
2021	$0	$1	$1	$3
2022	$1	$2	$3	$5
2023	$1	$3	$4	$8
2024	$1	$4	$5	$11
2025	$1	$5	$7	$14
2026	$2	$6	$9	$18
2027	$2	$7	$10	$21
2028	$3	$8	$12	$25
2029	$3	$10	$14	$29
2030	$4	$11	$16	$33
2035	$5	$15	$22	$47
2040	$6	$18	$25	$54
2050	$9	$23	$31	$70
NPV	$44	$200	$320	$620

Notes:

[a] The SC-CO_2 values are dollar-year and emissions-year specific.

[b] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(c) Additional Non-CO_2 GHGs Co-Benefits

In determining the relative social costs of the different gases, the Marten et al. (2014) analysis accounts for differences in lifetime and radiative efficiency between the non-CO_2 GHGs and CO_2. The analysis also accounts for radiative forcing resulting from methane's effects on tropospheric ozone and stratospheric water vapor, and for at least some of the fertilization effects of elevated carbon dioxide concentrations. However, there exist several other differences between these gases that have not yet been captured in this analysis, for example the non-radiative effects of methane-driven elevated tropospheric ozone levels on human health, agriculture, and ecosystems, and the effects of carbon dioxide on ocean acidification. Inclusion of these additional non-radiative effects would potentially change both the absolute and relative value of the various gases.

Of these effects, the human health effect of elevated tropospheric ozone levels resulting from methane emissions is the closest to being monetized in a way that would be comparable to the SCC. Premature ozone-related cardiopulmonary deaths resulting from global increases in tropospheric ozone concentrations produced by the methane oxidation process have been the focus of a number of studies over the past decade (*e.g.,* West et al. 2006;[843] Anenberg et al. 2012;[844] Shindell et al. 2012[845]). Recently, a paper was published in the peer-reviewed scientific literature that presented a range of estimates of the monetized ozone-related mortality benefits of reducing methane emissions (Sarofim et al. 2015). For example, under their base case assumptions using a 3 percent discount rate, Sarofim et al. find global ozone-related mortality benefits of methane emissions reductions to be $790 per ton of methane in 2020, with 10.6 percent, or $80, of this amount resulting from mortality reductions in the United States. The methodology used in this study is consistent in some (but not all) aspects with the modeling underlying the SC-CO_2 and SC-CH_4 estimates discussed above, and required a number of additional assumptions such as baseline mortality rates and mortality response to ozone concentrations. While the EPA does consider the methane impacts on ozone to be important, there remain unresolved questions regarding several methodological choices involved in applying the Sarofim et al. (2015) approach in the context of an EPA benefits analysis, and therefore the EPA is not including a quantitative analysis of this effect in this rule at this time.

H. Monetized Non-GHG Health Impacts

This section discusses the economic benefits from reductions in health and environmental impacts resulting from non-GHG emission reductions that can be expected to occur as a result of the Phase 2 standards. CO_2 emissions are predominantly the byproduct of fossil fuel combustion processes that also produce criteria and hazardous air pollutant emissions. The vehicles that are subject to the Phase 2 standards are also significant sources of mobile source air pollution such as direct PM, NO_X, VOCs and air toxics. The standards will affect exhaust emissions of these pollutants from vehicles and will also affect emissions from upstream sources that occur during the refining and distribution of fuel. Changes in ambient concentrations of ozone, $PM_{2.5}$, and air toxics that will result from the Phase 2 standards are expected to affect human health by reducing premature deaths and other serious human health effects, as well as other important improvements in public health and

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[843] West JJ, Fiore AM, Horowitz LW, Mauzerall DL (2006) Global health benefits of mitigating ozone pollution with methane emission controls. Proc Natl Acad Sci USA 103 (11):3988–3993. doi:10.1073/pnas.0600201103

[844] Anenberg SC, Schwartz J, Shindell D, Amann M, Faluvegi G, Klimont Z, . . . , Vignati E (2012) Global air quality and health co-benefits of mitigating near-term climate change through methane and black carbon emission controls. Environ Health Perspect 120 (6):831. doi:10.1289/ehp.1104301.

[845] Shindell D, Kuylenstierna JCI, Vignati E, van Dingenen R, Amann M, Klimont Z, . . ., Fowler D (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security. Science 335 (6065):183–189. doi:10.1126/science.1210026.

welfare. Children especially benefit from reduced exposures to criteria and toxic pollutants, because they tend to be more sensitive to the effects of these respiratory pollutants. Ozone and particulate matter have been associated with increased incidence of asthma and other respiratory effects in children, and particulate matter has been associated with a decrease in lung maturation. Some minority groups and children living under the poverty line are even more vulnerable with higher prevalence of asthma.

It is important to quantify the health and environmental impacts associated with the standards because a failure to adequately consider ancillary impacts could lead to an incorrect assessment of their costs and benefits. Moreover, the health and other impacts of exposure to criteria air pollutants and airborne toxics tend to occur in the near term, while most effects from reduced climate change are likely to occur only over a time frame of several decades or longer.

Impacts such as emissions reductions, costs and benefits are presented in this analysis from two perspectives:

- A ''model year lifetime analysis'' (MY), which shows impacts of the program that occur over the lifetime of the vehicles produced during the model years subject to the Phase 2 standards (MYs 2018 through 2029).,
- A ''calendar year analysis'' (CY), which shows annual costs and benefits of the Phase 2 standards for each year from 2018 through 2050. We assume the standard in the last model year subject to the standards applies to all subsequent MY fleets developed in the future.

In previous light-duty and heavy-duty GHG rulemakings, EPA has quantified and monetized non-GHG health impacts using two different methods. For the MY analysis, EPA applies PM-related ''benefits per-ton'' values to the stream of lifetime estimated emission reductions as a reduced-form approach to estimating the $PM_{2.5}$-related benefits of the rule.[846] [847] For the CY analysis, EPA typically conducts full-scale photochemical air quality modeling to quantify and monetize the $PM_{2.5}$- and ozone-related health impacts of a single representative future year. EPA then assumes these benefits are repeated in subsequent future years when criteria pollutant emission reductions are equal to or greater than those modeled in the representative future year.

This two-pronged approach to estimating non-GHG impacts is precipitated by the length of time needed to prepare the necessary emissions inventories and the processing time associated with full-scale photochemical air quality modeling for a *single* representative future year. The timing requirements (along with other resource limitations) preclude EPA from being able to do the more detailed photochemical modeling for every year that we include in our benefit and cost estimates, and require EPA to make air quality modeling input decisions early in the analytical process. As a result, it was necessary to use emissions from the proposed program to conduct the air quality modeling.

The chief limitation when using air quality inventories based on emissions from the proposal in the CY modeling analysis is that they can diverge from the estimated emissions of the final rulemaking. How much the emissions might diverge and how that difference would impact the air quality modeling and health benefit results is difficult to anticipate. For the FRM, EPA concluded that when comparing the proposal and final rule inventories, the differences were enough to justify the move of the typical CY benefits analysis (based on air quality modeling) from the primary estimate of costs and benefits to a supplemental analysis in an appendix to the RIA (See RIA Appendix 8.A).[848] While we believe this supplemental analysis is still illustrative of the standard's potential benefits, EPA has instead chosen to characterize the CY benefits in a manner consistent with the MY lifetime analysis. That is, we apply the PM-related ''benefits per-ton'' values to the CY final rule emission reductions to estimate the PM-related benefits of the final rule.

This section presents the benefits-per-ton values used to monetize the benefits from reducing population exposure to PM associated with the standards. EPA bases its analyses on peer-reviewed studies of air quality and health and welfare effects and peer-reviewed studies of the monetary values of public health and welfare improvements, and is generally consistent with benefits analyses performed for the analysis of the final Tier 3 Vehicle Rule,[849] the final 2012 p.m. NAAQS Revision,[850] and the final 2017–2025 Light Duty Vehicle GHG Rule.[851]

EPA is also requiring that rebuilt engines installed in new incomplete vehicles (*i.e.,* ''glider kit'' vehicles) meet the emission standards applicable in the year of assembly of the new vehicle, including all applicable standards for criteria pollutants (Section XIII.B). For the final rule, EPA has updated its analysis of the environmental impacts of these glider kit vehicles (see Section XIII.B.1). These standards will decrease PM and NO_X emissions dramatically, leading to substantial public health-related benefits. Although we only present these benefits as a sensitivity analysis in Section XIII.B, it is clear that removing even a fraction of glider kit vehicles from the road will yield substantial health-related benefits that are not captured by the primary estimate of monetized non-GHG health impacts described in this section.

(1) Economic Value of Reductions in Particulate Matter

As described in Section VIII, the standards will reduce emissions of several criteria and toxic pollutants and their precursors. In this analysis, EPA only estimates the economic value of the human health benefits associated with the resulting reductions in $PM_{2.5}$ exposure. Due to analytical limitations with the benefit per ton method, this analysis does not estimate benefits resulting from reductions in population exposure to other criteria pollutants such as ozone.[852] Furthermore, the

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[846] Fann, N., Baker, K.R., and Fulcher, C.M. (2012). *Characterizing the PM $_{2.5}$-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S.*, Environment International, 49, 241–151, published online September 28, 2012.

[847] See also: *http://www3.epa.gov/airquality/benmap/sabpt.html.* The current values available on the Web page have been updated since the publication of the Fann et al., 2012 paper. For more information regarding the updated values, see: *http://www3.epa.gov/airquality/benmap/models/Source_Apportionment_BPT_TSD_1_31_13.pdf* (accessed September 9, 2014).

[848] Chapter 5 of the RIA has more detail on the differences between the air quality and final inventories.

[849] U.S. Environmental Protection Agency. (2014). *Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule: Regulatory Impact Analysis,* Assessment and Standards Division, Office of Transportation and Air Quality, EPA–420–R–14–005, March 2014. Available on the internet: *http://www3.epa.gov/otaq/documents/tier3/420r14005.pdf.*

[850] U.S. Environmental Protection Agency. (2012). *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter,* Health and Environmental Impacts Division, Office of Air Quality Planning and Standards, EPA–452–R–12–005, December 2012. Available on the internet: *http://www3.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf.*

[851] U.S. Environmental Protection Agency (U.S. EPA). (2012). *Regulatory Impact Analysis: Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards,* Assessment and Standards Division, Office of Transportation and Air Quality, EPA–420–R–12–016, August 2012. Available on the Internet at: *http://www3.epa.gov/otaq/climate/documents/420r12016.pdf.*

[852] The air quality modeling that underlies the PM-related benefit per ton values also produced estimates of ozone levels attributable to each sector. However, the complex non-linear chemistry governing ozone formation prevented EPA from developing a complementary array of ozone benefit

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benefits per-ton method, like all air quality impact analyses, does not monetize all of the potential health and welfare effects associated with reduced concentrations of $PM_{2.5}$.

This analysis uses estimates of the benefits from reducing the incidence of the specific $PM_{2.5}$-related health impacts described below. These estimates, which are expressed per ton of $PM_{2.5}$-related emissions eliminated by the final program, represent the monetized value of human health benefits (including reductions in both premature mortality and premature morbidity) from reducing each ton of directly emitted $PM_{2.5}$ or its precursors (SO_2 and NO_X), from a specified source. Ideally, the human health benefits would be estimated based on changes in ambient $PM_{2.5}$ as determined by full-scale air quality modeling. However, the length of time needed to prepare the necessary emissions inventories, in addition to the processing time associated with the modeling itself, has precluded us from performing air quality modeling that reflects the emissions and air quality impacts associated with the final program.

EPA received comment regarding the omission of ozone-related benefits from the non-GHG benefits analysis included in the proposal. EPA agrees that total benefits are underestimated when ozone-related benefits are not included in the primary analysis. However, for reasons described in the introduction to this section, PM- and ozone-related health benefits based on air quality modeling for the CY analysis are not included in the primary estimate of costs and benefits. Instead, they can be found as a supplemental analysis to the RIA in Appendix 8A.

The PM-related dollar-per-ton benefit estimates used in this analysis are provided in Table IX–17. As the table indicates, these values differ among pollutants, and also depend on their original source, because emissions from different sources can result in different degrees of population exposure and resulting health impacts. In the summary of costs and benefits, Section IX.K of this Preamble, EPA presents the monetized value of PM-related improvements associated with the final program.

TABLE IX–17—PM-RELATED BENEFITS-PER-TON VALUES

[Thousands, 2013$] [a]

Year [c]	On-road mobile sources			Upstream sources [d]		
	Direct $PM_{2.5}$	SO_2	NO_X	Direct $PM_{2.5}$	SO_2	NO_X
Estimated Using a 3 Percent Discount Rate [b]						
2016	$380–$870	$20–$46	$7.8–$18	$330–$760	$71–$160	$6.9–$16
2020	410–920	22–50	8.2–18	350–800	76–170	7.5–17
2025	450–1,000	25–56	9.0–20	400–890	84–190	8.2–18
2030	490–1,100	28–62	9.7–22	430–960	92–200	8.9–20
Estimated Using a 7 Percent Discount Rate [b]						
2016	$340–$780	$18–$42	$7.1–$16	$300–$680	$64–$140	$6.3–$14
2020	370–830	20–45	7.5–17	320–730	68–150	6.7–15
2025	410–920	22–50	8.1–18	350–800	76–170	7.4–17
2030	440–990	25–56	8.8–20	380–870	82–180	8.0–18

Notes:

[a] The benefit-per-ton estimates presented in this table are based on a range of premature mortality estimates derived from the ACS study (Krewski et al., 2009) and the Six-Cities study (Lepeule et al., 2012). See Chapter VIII of the RIA for a description of these studies.

[b] The benefit-per-ton estimates presented in this table assume either a 3 percent or 7 percent discount rate in the valuation of premature mortality to account for a twenty-year segmented premature mortality cessation lag.

[c] Benefit-per-ton values were estimated for the years 2016, 2020, 2025 and 2030. We hold values constant for intervening years (*e.g.,* the 2016 values are assumed to apply to years 2017–2019; 2020 values for years 2021–2024; 2030 values for years 2031 and beyond).

[d] We assume for the purpose of this analysis that total "upstream emissions" are most appropriately monetized using the refinery sector benefit per-ton values. The majority of upstream emission reductions associated with the final rule are related to domestic onsite refinery emissions and domestic crude production. While total upstream emissions also include storage and transport sources, as well as sources upstream from the refinery, we have chosen to simply apply the refinery values.

The benefit-per-ton technique has been used in previous analyses, including EPA's 2017–2025 Light-Duty Vehicle Greenhouse Gas Rule,[853] the Reciprocating Internal Combustion Engine rules,[854] [855] and the Residential Wood Heaters NSPS.[856] Table IX–18 shows the quantified $PM_{2.5}$-related co-benefits captured in those benefit per-ton estimates, as well as unquantified effects the benefit per-ton estimates are unable to capture.

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per ton values. This limitation notwithstanding, we anticipate that the ozone-related benefits associated with reducing emissions of NO_X and VOC are substantial. Refer to RIA Appendix 8.A for the ozone benefits results from the supplemental CY benefits analysis.

[853] U.S. Environmental Protection Agency (U.S. EPA). (2012). *Regulatory Impact Analysis: Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards,* Assessment and Standards Division, Office of Transportation and Air Quality, EPA–420–R–12–016, August 2012. Available on the Internet at: *http://www3.epa.gov/otaq/climate/documents/420r12016.pdf.*

[854] U.S. Environmental Protection Agency (U.S. EPA). (2013). *Regulatory Impact Analysis for the Reconsideration of the Existing Stationary Compression Ignition (CI) Engines NESHAP,* Office of Air Quality Planning and Standards, Research Triangle Park, NC. January. EPA–452/R–13–001. Available at *http://www3.epa.gov/ttnecas1/regdata/RIAs/RICE_NESHAPreconsideration_Compression_Ignition_Engines_RIA_final2013_EPA.pdf.*

[855] U.S. Environmental Protection Agency (U.S. EPA). (2013). *Regulatory Impact Analysis for Reconsideration of Existing Stationary Spark Ignition (SI) RICE NESHAP,* Office of Air Quality Planning and Standards, Research Triangle Park, NC. January. EPA–452/R–13–002. Available at *http://www3.epa.gov/ttnecas1/regdata/RIAs/NESHAP_RICE_Spark_Ignition_RIA_finalreconsideration2013_EPA.pdf.*

[856] U.S. Environmental Protection Agency (U.S. EPA). (2015). *Regulatory Impact Analysis for Residential Wood Heaters NSPS Revision.* Office of Air Quality Planning and Standards, Research Triangle Park, NC. February. EPA–452/R–15–001. Available at *http://www2.epa.gov/sites/production/files/2015-02/documents/20150204-residential-wood-heaters-ria.pdf.*

TABLE IX–18—HUMAN HEALTH AND WELFARE EFFECTS OF $PM_{2.5}$

Pollutant/ effect	Quantified and monetized in primary estimates	Unquantified effects changes in:
$PM_{2.5}$	Adult premature mortality	Chronic and subchronic bronchitis cases.
	Acute bronchitis	Strokes and cerebrovascular disease.
	Hospital Admissions: Respiratory and cardiovascular	Low birth weight.
	Emergency room visits for asthma	Pulmonary function.
	Nonfatal heart attacks (myocardial infarction)	Chronic respiratory diseases other than chronic bronchitis.
	Lower and upper respiratory illness	Non-asthma respiratory emergency room visits.
	Minor restricted-activity days	Visibility.
	Work loss days	Household soiling.
	Asthma exacerbations (asthmatic population).	
	Infant mortality.	

A more detailed description of the benefit-per-ton estimates is provided in Chapter 8 of the RIA that accompanies this rulemaking. Readers interested in reviewing the complete methodology for creating the benefit-per-ton estimates used in this analysis can consult EPA’s “Technical Support Document: Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors.”[857] Readers can also refer to Fann et al. (2012)[858] for a detailed description of the benefit-per-ton methodology.

As Table IX–17 indicates, EPA projects that the per-ton values for reducing emissions of non-GHG pollutants from both vehicle use and upstream sources such as fuel refineries will increase over time.[859] These projected increases reflect rising income levels, which increase affected individuals’ willingness to pay for reduced exposure to health threats from air pollution.[860] They also reflect future population growth and increased life expectancy, which expands the size of the population exposed to air pollution in both urban and rural areas, especially among older age groups with the highest mortality risk.[861]

(2) Unquantified Health and Environmental Impacts

One commenter supported the inclusion of all quantifiable impacts of reductions in non-GHG pollutants. Specifically, they suggested the inclusion of ecosystem benefits from reduced non-GHG pollutants including those to crops as well as consideration of the impacts on toxic air contaminants such as diesel PM.

In addition to the PM-related co-pollutant health impacts EPA quantifies in this analysis, EPA acknowledges that there are a number of other health and human welfare endpoints that we are not able to quantify or monetize because of current limitations in the methods or available data. These impacts are associated with emissions of air toxics (including benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, naphthalene and ethanol), ambient ozone, and ambient $PM_{2.5}$ exposures. Chapter 8 of the RIA lists these unquantified health and environmental impacts. While there will be impacts associated with air toxic pollutant emission changes that result from the final standard, EPA will not attempt to monetize those impacts. This is primarily because currently available tools and methods to assess air toxics risk from mobile sources at the national scale are not adequate for extrapolation to incidence estimations or benefits assessment. The best suite of tools and methods currently available for assessment at the national scale are those used in the National-Scale Air Toxics Assessment (NATA). EPA’s Science Advisory Board specifically commented in their review of the 1996 NATA that these tools were not yet ready for use in a national-scale benefits analysis, because they did not consider the full distribution of exposure and risk, or address sub-chronic health effects.[862] While EPA has since improved the tools, there remain critical limitations for estimating incidence and assessing benefits of reducing mobile source air toxics.[863] EPA continues to work to address these limitations; however, EPA does not have the methods and tools available for national-scale application in time for the analysis of the final rules.[864]

I. Energy Security Impacts

The Phase 2 standards are designed to require improvements in the fuel efficiency of medium- and heavy-duty vehicles and, thereby, reduce fuel consumption and GHG emissions. In turn, the Phase 2 standards help to reduce U.S. petroleum imports. A reduction of U.S. petroleum imports reduces both financial and strategic risks caused by potential sudden disruptions in the supply of imported petroleum to the U.S., thus increasing

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[857] For more information regarding the updated values, see: *http://www3.epa.gov/airquality/benmap/models/Source_Apportionment_BPT_TSD_1_31_13.pdf* (accessed September 9, 2014).

[858] Fann, N., Baker, K.R., and Fulcher, C.M. (2012). *Characterizing the $PM_{2.5}$-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S.,* Environment International, 49, 241–151, published online September 28, 2012.

[859] As we discuss in the emissions chapter of the RIA (Chapter V), the rule will yield emission reductions from upstream refining and fuel distribution due to decreased petroleum consumption.

[860] The issue is discussed in more detail in the 2012 p.m. NAAQS RIA. See U.S. Environmental Protection Agency. (2012). *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter,* Health and Environmental Impacts Division, Office of Air Quality Planning and Standards, EPA–452–R–12–005, December 2012. Available on the internet: *http://www3.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf.*

[861] For more information about EPA’s population projections, please refer to the following: *http://www3.epa.gov/air/benmap/models/BenMAPManualAppendicesAugust2010.pdf* (See Appendix K).

[862] Science Advisory Board. 2001. NATA—Evaluating the National-Scale Air Toxics Assessment for 1996—an SAB Advisory. *http://www3.epa.gov/ttn/atw/sab/sabrev.html.*

[863] Examples include gaps in toxicological data, uncertainties in extrapolating results from high-dose animal experiments to estimate human effects at lower does, limited ambient and personal exposure monitoring data, and insufficient economic research to support valuation of the health impacts often associated with exposure to individual air toxics. See Gwinn et al., 2011. Meeting Report: Estimating the Benefits of Reducing Hazardous Air Pollutants—Summary of 2009 Workshop and Future Considerations. Environ Health Perspectives, Jan 2011; 119(1): 125–130.

[864] In April, 2009, EPA hosted a workshop on estimating the benefits of reducing hazardous air pollutants. This workshop built upon the work accomplished in the June 2000 in an earlier (2000) Science Advisory Board/EPA Workshop on the Benefits of Reductions in Exposure to Hazardous Air Pollutants, which generated thoughtful discussion on approaches to estimating human health benefits from reductions in air toxics exposure, but no consensus was reached on methods that could be implemented in the near term for a broad selection of air toxics. Please visit *http://epa.gov/air/toxicair/2009workshop.html* for more information about the workshop and its associated materials.

U.S. energy security. This section summarizes the agency's estimates of U.S. oil import reductions and energy security benefits of the Phase 2 final standards. Additional discussion of this issue can be found in Chapter 8.8 of the RIA.

(1) Implications of Reduced Petroleum Use on U.S. Imports

U.S. energy security is generally considered as the continued availability of energy sources at an acceptable price. Most discussion of U.S. energy security revolves around the topic of the economic costs of U.S. dependence on oil imports. While the U.S. has reduced its consumption and increased its production of oil in recent years, it still relies on oil from potentially unstable sources. In addition, oil exporters with a large share of global production have the ability to raise the price of oil by exerting the monopoly power associated with a cartel, the Organization of Petroleum Exporting Countries (OPEC), to restrict oil supply relative to demand. These factors contribute to the vulnerability of the U.S. economy to episodic oil supply shocks and price spikes.

In 2014, U.S. expenditures for imports of crude oil and petroleum products, net of revenues for exports, were $178 billion and expenditures on both imported oil and domestic petroleum and refined products totaled $469 billion (in 2013$) (see Figure IX–1).[865] Recently, as a result of strong growth in domestic oil production mainly from tight shale formations, U.S. production of oil has increased while U.S. oil imports have decreased. For example, from 2012 to 2015, domestic oil production increased by 44 percent while net oil imports and products decreased by 38 percent. While U.S. oil import costs have declined since 2011, total oil expenditures (domestic and imported) remained near historical highs through 2014. Post-2015 oil expenditures are projected (AEO 2015) to remain between double and triple the inflation-adjusted levels experienced by the U.S. from 1986 to 2002.C

Focusing on changes in oil import levels as a source of vulnerability has been standard practice in assessing energy security in the past, but given current market trends both from domestic and international levels, adding changes in consumption of petroleum to this assessment may provide better information about U.S. energy security. The major mechanism through which the economy sustains harm due to fluctuations in the (world) energy market is through price, which itself is leveraged through both imports and consumption. However, the United States, may be increasingly insulated from the physical effects of overseas oil disruptions, though the price impacts of an oil disruption anywhere will continue to be transmitted to U.S. markets. As of 2015, Canada accounted for 63 percent of U.S. net oil imports of crude oil and petroleum products. The implications of the U.S. becoming a significant petroleum producer have yet to be discerned in the literature, but it can be anticipated that this will have some impact on energy security.

In 2010, just over 40 percent of world oil supply came from OPEC nations. The AEO 2015 projects that this share will stay high; dipping slightly from 37 percent by 2020 and then rising gradually to over 40 percent by 2035 and thereafter. Approximately 30 percent of global supply is from Middle East and North African countries alone, a share that is also expected to grow. Measured in terms of the share of world oil resources or the share of global oil export supply, rather than oil production, the concentration of global petroleum resources in OPEC nations is even larger. As another measure of concentration, of the 137 countries/principalities that export either crude or refined products, the top 12 have recently accounted for over 55 percent of exports.[866] Eight of these countries are members of OPEC, and a ninth is Russia.[867] In a market where even a 1–2 percent supply loss can raise prices noticeably, and where a 10 percent supply loss could lead to an unprecedented price shock, this regional concentration is of concern.[868] Historically, the countries of the Middle East have been the source of eight of the ten major world oil disruptions,[869] with the ninth originating in Venezuela, an OPEC country, and the tenth being Hurricanes Katrina and Rita.

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[865] See EIA Annual Energy Review, various editions. For data 2011–2013, and projected data: EIA Annual Energy Outlook (AEO) 2014 (Reference Case). See Table 11, file ''aeotab_11.xls.''

[866] Based on data from the CIA, combining various recent years, *https://www.cia.gov/library/publications/the-world-factbook/rankorder/2242rank.html.*

[867] The other three are Norway, Canada, and the EU, an exporter of product.

[868] For example, the 2005 Hurricanes Katrina/Rita and the 2011 Libyan conflict both led to a 1.8 percent reduction in global crude supply. While the price impact of the latter is not easily distinguished given the rapidly rising post-recession prices, the former event was associated with a 10–15 percent world oil price increase. There are a range of smaller events with smaller but noticeable impacts. Somewhat larger events, such as the 2002/3 Venezuelan Strike and the War in Iraq, corresponded to about a 2.9 percent sustained loss of supply, and were associated with a 28 percent world oil price increase.

Compiled from EIA oil price data, IEA2012 [IEA Response System for Oil Supply Emergencies (*http://www.iea.org/publications/freepublications/publication/EPPD_Brochure_English_2012_02.pdf*)

See table on P. 11.and Hamilton 2011 ''Historical Oil Shocks,''(*http://econweb.ucsd.edu/~jhamilto/oil_history.pdf*) in *Routledge Handbook of Major Events in Economic History*, pp. 239–265, edited by Randall E. Parker and Robert Whaples, New York: Routledge Taylor and Francis Group, 2013). Available in bookstores.

[869] IEA 2011 ''IEA Response System for Oil Supply Emergencies.''

[870] For historical data: EIA Annual Energy Review, various editions. For data 2011–2013, and projected data: EIA Annual Energy Outlook (AEO) 2014 (Reference Case). See Table 11, file ''aeotab_11.xls.''

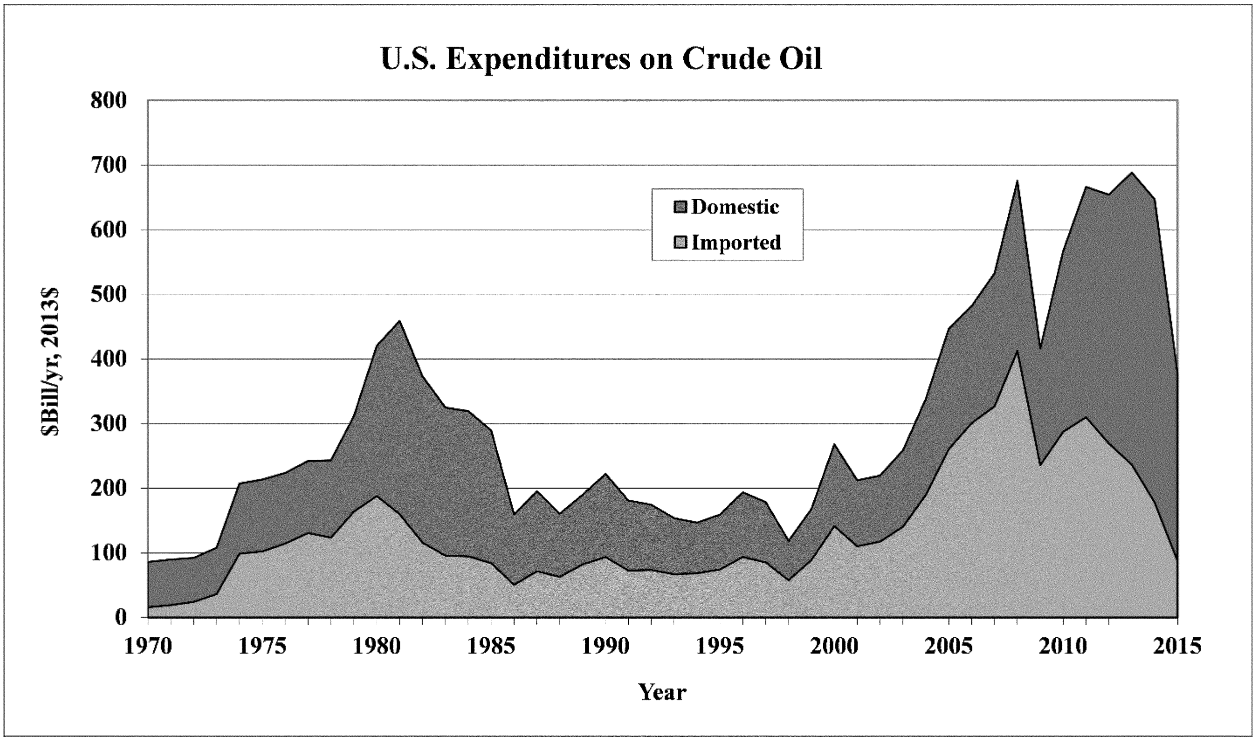

Figure IX-1 U.S. Expenditures on Crude Oil from 1970 through 2015[870]

The agencies used EPA's MOVES model to estimate the reductions in U.S. fuel consumption due to these final rules for vocational vehicles and tractors. For HD pickups and vans, the agencies used both DOT's CAFE model and EPA's MOVES model to estimate the fuel consumption impacts. (Detailed explanations of the MOVES and CAFE models can be found in Chapter 5 of the RIA. See IX.C of the Preamble for estimates of reduced fuel consumption from these final rules). Based on a detailed analysis of differences in U.S. fuel consumption, petroleum imports, and imports of petroleum products, the agencies estimate that approximately 90 percent of the reduction in fuel consumption resulting from adopting improved GHG emission and fuel efficiency standards is likely to be reflected in reduced U.S. imports of crude oil and net imported petroleum products.[871] Thus, on balance, each gallon of fuel saved as a consequence of the HD GHG and fuel efficiency standards is anticipated to reduce total U.S. imports of petroleum by 0.90 gallons. Based upon the fuel savings estimated by the MOVES/CAFE models and the 90 percent oil import factor, the reduction in U.S. oil imports and exports from these final rules are estimated for the years 2020, 2025, 2030, 2040, and 2050 (in millions of barrels per day (MMBD)) in Table IX–19 below. For comparison purposes, Table IX–19 also shows U.S. imports of crude oil in 2020, 2025, 2030 and 2040 as projected by DOE in the Annual Energy Outlook 2015 Reference Case. U.S. Gross Domestic Product (GDP) is projected to grow by roughly 48 percent over the same time frame (*e.g.,* from 2020 to 2040) in the AEO 2015 projections.

TABLE IX–19—PROJECTED U.S. IMPORTS AND EXPORTS OF OIL AND U.S. OIL IMPORT REDUCTIONS RESULTING FROM THE FINAL PHASE 2 PROGRAM IN 2020, 2025, 2030, 2040 AND 2050 USING METHOD B AND RELATIVE TO A FLAT BASELINE

[Millions of barrels per day (MMBD)] [a]

Year	U.S. oil exports	U.S. oil imports	U.S. net product imports *	U.S. net crude & product imports	U.S. oil import reductions from final HD Rules
2020	0.63	6.14	−2.80	2.71	0.007
2025	0.63	6.72	−3.24	2.85	0.162
2030	0.63	7.07	−3.56	2.88	0.405
2040	0.63	8.21	−4.26	3.32	0.721

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[871] We looked at changes in U.S. crude oil imports and net petroleum products in the AEO 2015 Reference Case in comparison the Low (*i.e.,* Economic Growth) Demand Case to undertake this analysis. See the spreadsheet "Impact of Fuel Demand on Imports AEO2015.xlsx." We also considered a paper entitled "Effect of a U.S. Demand Reduction on Imports and Domestic Supply Levels" by Leiby, P., 4/16/2013. This paper suggests that "Given a particular reduction in oil demand stemming from a policy or significant technology change, the fraction of oil use savings that shows up as reduced U.S. imports, rather than reduced U.S. supply, is actually quite close to 90 percent, and probably close to 95 percent."

TABLE IX–19—PROJECTED U.S. IMPORTS AND EXPORTS OF OIL AND U.S. OIL IMPORT REDUCTIONS RESULTING FROM THE FINAL PHASE 2 PROGRAM IN 2020, 2025, 2030, 2040 AND 2050 USING METHOD B AND RELATIVE TO A FLAT BASELINE—Continued

[Millions of barrels per day (MMBD)] [a]

Year	U.S. oil exports	U.S. oil imports	U.S. net product imports *	U.S. net crude & product imports	U.S. oil import reductions from final HD Rules
2050	(**)	(**)	(**)	(**)	0.861

Notes:
* Negative U.S. Net Product Imports imply positive exports.
** The AEO 2015 only projects energy market and economic trends through 2040.

(2) Energy Security Implications

In order to understand the energy security implications of reducing U.S. oil imports, EPA has worked with Oak Ridge National Laboratory (ORNL), which has developed approaches for evaluating the social costs and energy security implications of oil use. The energy security estimates provided below are based upon a methodology developed in a peer-reviewed study entitled, ''*The Energy Security Benefits of Reduced Oil Use, 2006–2015*'', completed in March 2008. This ORNL study is an updated version of the approach used for estimating the energy security benefits of U.S. oil import reductions developed in a 1997 ORNL Report.[872] For EPA and NHTSA rulemakings, the ORNL methodology is updated periodically to account for forecasts of future energy market and economic trends reported in the U.S. Energy Information Administration's Annual Energy Outlook.

When conducting this analysis, ORNL considered the full cost of importing petroleum into the U.S. The full economic cost is defined to include two components in addition to the purchase price of petroleum itself. These are: (1) The higher costs for oil imports resulting from the effect of U.S. demand on the world oil price (*i.e.,* the ''demand'' or ''monopsony'' costs); and (2) the risk of reductions in U.S. economic output and disruption to the U.S. economy caused by sudden disruptions in the supply of imported oil to the U.S. (i.e., macroeconomic disruption/adjustment costs).

The literature on energy security for the last two decades has routinely combined the monopsony and the macroeconomic disruption components when calculating the total value of the energy security premium. However, in the context of using a global value for the Social Cost of Carbon (SCC) the question arises: how should the energy security premium be used when some benefits from these rules, such as the benefits of reducing greenhouse gas emissions, are calculated from a global perspective? Monopsony benefits represent avoided payments by U.S. consumers to oil producers that result from a decrease in the world oil price as the U.S. decreases its demand for oil. Although there is clearly an overall benefit to the U.S. when considered from a domestic perspective, the decrease in price due to decreased demand in the U.S. also represents a loss to oil producing countries, one of which is the U.S. Given the redistributive nature of this monopsony effect from a global perspective, it is excluded in the energy security benefits calculations for these final rules.

In contrast, the other portion of the energy security premium, the avoided U.S. macroeconomic disruption and adjustment cost that arises from reductions in U.S. petroleum imports, does not have offsetting impacts outside of the U.S., and, thus, is included in the energy security benefits estimated for these final rules. To summarize, the agencies have included only the avoided macroeconomic disruption portion of the energy security benefits to estimate the monetary value of the total energy security benefits of these final rules.

For this rulemaking, ORNL updated the energy security premiums by incorporating the most recent oil price forecast and energy market trends, particularly regional oil supplies and demands, from the AEO 2015 into its model.[873] ORNL developed energy security premium estimates for a number of different years. Table IX–20 provides estimates for energy security premiums for the years 2020, 2025, 2030 and 2040,[874] as well as a breakdown of the components of the energy security premiums for each year. The components of the energy security premiums and their values are discussed below.

TABLE IX–20—ENERGY SECURITY PREMIUMS IN 2020, 2025, 2030 AND 2040

[2013$/Barrel] *

Year (range)	Monopsony (range)	Avoided macroeconomic disruption/adjustment costs (range)	Total mid-point (range)
2020	$2.21 ($0.65–$3.59)	$5.48 ($2.51–$8.92)	$7.69 ($4.54–$11.14)
2025	$2.59 ($0.76–$4.14)	$6.30 ($2.92–$10.22)	$8.89 ($5.22–$12.83)
2030	$2.83 (0.83–$4.56)	$7.26 ($3.40–$11.73)	$10.09 ($5.90–$14.59)

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[872] Leiby, Paul N., Donald W. Jones, T. Randall Curlee, and Russell Lee, *Oil Imports: An Assessment of Benefits and Costs,* ORNL–6851, Oak Ridge National Laboratory, November, 1997.

[873] Leiby, P., Factors Influencing Estimate of Energy Security Premium for Heavy-Duty Phase 2 Final Rule, 11/1/2014, Oak Ridge National Laboratory.

[874] AEO 2015 forecasts energy market trends and values only to 2040. The post-2040 energy security premium values are assumed to be equal to the 2040 estimate.

TABLE IX–20—ENERGY SECURITY PREMIUMS IN 2020, 2025, 2030 AND 2040—Continued

[2013$/Barrel] *

Year (range)	Monopsony (range)	Avoided macroeconomic disruption/adjustment costs (range)	Total mid-point (range)
2040	$4.09 ($1.19–$6.67)	$9.61 ($4.54–$15.39)	$13.69 ($8.12–$19.64)

Note:
* Top values in each cell are the midpoints, the values in parentheses are the 90 percent confidence intervals.

(a) Effect of Oil Use on the Long-Run Oil Price

The first component of the full economic costs of importing petroleum into the U.S. follows from the effect of U.S. import demand on the world oil price over the long-run. Because the U.S. is a sufficiently large purchaser of global oil supplies, its purchases can affect the world oil price. This monopsony power means that increases in U.S. petroleum demand can cause the world price of crude oil to rise, and conversely, that reduced U.S. petroleum demand can reduce the world price of crude oil. Thus, one benefit of decreasing U.S. oil purchases, due to improvements in the fuel efficiency of medium- and heavy-duty vehicles, is the potential decrease in the crude oil price paid for all crude oil purchased.

There is disagreement in the literature about the magnitude of the monopsony component, and its relevance for policy analysis. Brown and Huntington (2013)[875] for example, argue that the United States' refusal to exercise its market power to reduce the world oil price does not represent a proper externality, and that the monopsony component should not be considered in calculations of the energy security externality. However, they also note in their earlier discussion paper (Brown and Huntington 2010)[876] that this is a departure from the traditional energy security literature, which includes sustained wealth transfers associated with stable but higher-price oil markets. On the other hand, Greene (2010)[877] and others in prior literature (*e.g.,* Toman 1993)[878] have emphasized that the monopsony cost component is policy-relevant because the world oil market is non-competitive and strongly influenced by cartelized and government-controlled supply decisions. Thus, while sometimes couched as an externality, Greene notes that the monopsony component is best viewed as stemming from a completely different market failure than an externality (Ledyard 2008),[879] yet still implying marginal social costs to importers.

Recently, the Council on Foreign Relations (*i.e.,* ''the Council'') (2015) released a discussion paper that assesses NHTSA's analysis of the benefits and costs of CAFE in a lower-oil-price world.[880] In this paper, the Council notes that while NHTSA cites the monopsony effect of the CAFE standards for 2017–2025, NHTSA does not include it when calculating the cost-benefit calculation for the rule. The Council argues that the monopsony benefit should be included in the CAFE cost-benefit analysis and that including the monopsony benefit is more consistent with the legislators' intent in mandating CAFE standards in the first place.

The recent National Academy of Science (NAS 2015) Report, ''Cost, Effectiveness and the Deployment of Fuel Economy Technologies for Light-Duty Vehicles,''[881] suggests that the agencies' logic about not accounting for monopsony benefits is inaccurate. According to the NAS, the fallacy lies in treating the two problems, oil dependence and climate change, similarly. According to the NAS, ''Like national defense, it [oil dependence] is inherently adversarial (*i.e.,* oil consumers against producers using monopoly power to raise prices). The problem of climate change is inherently global and requires global action. If each nation considered only the benefits to itself in determining what actions to take to mitigate climate change, an adequate solution could not be achieved. Likewise, if the U.S. considers the economic harm its reduced petroleum use will do to monopolistic oil producers it will not adequately address its oil dependence problem. Thus, if the United States is to solve both of these problems it must take full account of the costs and benefits of each, using the appropriate scope for each problem.'' At this point in time, we are continuing to exclude monopsony premiums for the cost benefit analysis of these final rules, but we will be taking comment on this issue in a near term future rulemaking.

There is also a question about the ability of gradual, long-term reductions, such as those resulting from these final rules, to reduce the world oil price in the presence of OPEC's monopoly power. OPEC is currently the world's marginal petroleum supplier, and could conceivably respond to gradual reductions in U.S. demand with gradual reductions in supply over the course of several years as the fuel savings resulting from these rules grow. However, if OPEC opts for a long-term strategy to preserve its market share, rather than maintain a particular price level (as they have done recently in response to increasing U.S. petroleum production), reduced demand will create downward pressure on the global price. The Oak Ridge analysis assumes that OPEC does respond to demand reductions over the long run, but there is still a price effect in the model. Under the mid-case behavioral assumption used in the premium calculations, OPEC responds by gradually reducing supply to maintain *market share* (consistent with the long-term self-interested strategy suggested by Gately (2004, 2007)).[882]

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[875] Brown, Stephen P.A. and Hillard G. Huntington. 2013. *Assessing the U.S. Oil Security Premium.* Energy Economics, vol. 38, pp 118–127.

[876] Reassessing the Oil Security Premium. RFF Discussion Paper Series, (RFF DP 10–05). doi: RFF DP 10–05

[877] Greene, D. L. 2010. *Measuring energy security: Can the United States achieve oil independence*?, Energy Policy, 38(4), 1614–1621. doi:10.1016/j.enpol.2009.01.041.

[878] Toman, M., 1993, The economics of energy security: theory, evidence and policy, Chapter 25, Handbook of Natural Resources and Energy Economics, Volume 3, pp. 1167–1218.

[879] Ledyard, John O. ''Market Failure.'' The New Palgrave Dictionary of Economics. Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan, 2008.

[880] Council on Foreign Relations, ''Automobile Fuel Economy Standards in a Lower-Oil-Price World,'' Sivarm & Levi, November 2015.

[881] Transitions to Alternative Vehicles and Fuels,'' Committee on Transitions to Alternative Vehicles and Fuels, National Research Council, 2013.

[882] Gately, Dermot, 2004. ''*OPEC's Incentives for Faster Output Growth,*'' The Energy Journal, 25

Continued

(b) Macroeconomic Disruption Adjustment Costs

The second component of the oil import premium, ‘‘avoided macroeconomic disruption/adjustment costs,’’ arises from the effect of oil imports on the expected cost of supply disruptions and accompanying price increases. A sudden increase in oil prices triggered by a disruption in world oil supplies has two main effects: (1) It increases the costs of oil imports in the short-run and (2) it can lead to macroeconomic contraction, dislocation and Gross Domestic Product (GDP) losses. For example, ORNL estimates the combined value of these two factors to be $6.30/barrel (2013$) when U.S. oil imports are reduced in 2025, with a range from $2.92/barrel to $10.22/barrel of imported oil reduced.

Since future disruptions in foreign oil supplies are an uncertain prospect, each of the disruption cost components must be weighted by the probability that the supply of petroleum to the U.S. will actually be disrupted. Thus, the ‘‘expected value’’ of these costs—the product of the probability that a supply disruption will occur and the sum of costs from reduced economic output and the economy's abrupt adjustment to sharply higher petroleum prices—is the relevant measure of their magnitude. Further, when assessing the energy security value of a policy to reduce oil use, it is only the change in the expected costs of disruption that results from the policy that is relevant. The expected costs of disruption may change from lowering the normal (*i.e.,* pre-disruption) level of domestic petroleum use and imports, from any induced alteration in the likelihood or size of disruption, or from altering the short-run flexibility (*e.g.,* elasticity) of petroleum use.

By late 2015/early 2016, world oil prices were sharply lower than in 2014. Future prices remain uncertain, but sustained markedly lower oil prices can have mixed implications for U.S. energy security. Under lower prices U.S. expenditures on oil consumption are lower, and they are a less prominent component of the U.S. economy. This would lessen the issue of imported oil as an energy security problem for the U.S. On the other hand, sustained lower oil prices encourage greater oil consumption, and reduce the competitiveness of new U.S. oil supplies and alternative fuels. The AEO 2015 low oil price outlook, for example, projects that by 2030 total U.S. petroleum supply would be 10 percent lower and imports would be 78 percent higher than the AEO Reference Case. Under the low-price case, 2030 prices are 35 percent lower, so that import expenditures are 16 percent higher.

A second potential proposed energy security effect of lower oil prices is increased instability of supply, due to greater global reliance on fewer suppling nations,[883] and because lower prices may increase economic and geopolitical instability in some supplier nations.[884] [885] [886] The International Monetary Fund reported that low oil prices are creating substantial economic tension in the Middle East oil producers on top of the economic costs of ongoing conflicts, and noted the risk that Middle East countries including Saudi Arabia could run out of financial assets without substantial change in policy.[887] The concern raised is that oil revenues are essential for some exporting nations to fund domestic programs and avoid domestic unrest.

The Competitive Enterprise Institute (CEI) and others argue that there are little, if any, energy security benefits associated with these rules. In large part CEI argues that oil supplies are plentiful and that current oil prices are low so that reduced consumption of petroleum products due to these rules would have no effect on energy security. However, the discussion of current low oil prices (‘‘lowest Labor Day gasoline prices in a decade’’) does not assure the absence of future oil supply shocks or price shocks, or even speak to their reduced likelihood. CEI points out that the current low oil prices have been observed before as recently as a decade ago, as they have in more than one instance before that. For example, oil prices were even lower in 1999. But in the intervening periods, oil supply and price shocks have continued to recur, and the recent price record only amplifies oil's high historical price volatility.

Also, sharply lower world oil prices do not clearly imply greater energy security for the U.S. Current low world oil prices may reduce the U.S.'s fracking industry's tight oil production (as CEI points out), or other sources of oil supplies around the world. Some have hypothesized that reduction in oil production outside of OPEC may be the objective of some OPEC producers. With low oil prices, U.S.' oil import share over time might be larger, increasing the U.S.' dependence on imported oil.

Securing America's Future Energy (SAFE), Operation Free and the Investor Network on Climate Risk agree that these rules do improve America's energy security. SAFE goes on to state that several policy options should be included in these rules to further enhance energy security. The agencies agree that these rules enhances America's energy security, but do not have information to evaluate the policy options that SAFE proposes.

The recent economics literature on whether oil shocks are the threat to economic stability that they once were is mixed. Some of the current literature asserts that the macroeconomic component of the energy security externality is small. For example, the National Research Council (2009) argued that the non-environmental externalities associated with dependence on foreign oil are small, and potentially trivial.[888] Analyses by Nordhaus (2007) and Blanchard and Gali (2010) question the impact of more recent oil price shocks on the economy.[889] They were motivated by

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(2):75–96; Gately, Dermot, 2007. ‘‘*What Oil Export Levels Should We Expect From OPEC?*’’, The Energy Journal, 28(2):151–173.

[883] Fatih Birol, Executive Director of the International Energy Agency, warns that prolonged lower oil prices would trigger energy security concerns by increasing reliance on a small number of low-cost producers ‘‘or risk a sharp rebound in price if investment falls short.’’ ‘‘It would be a grave mistake to index our attention to energy security to changes in the oil price,’’ Birol said. ‘‘Now is not the time to relax. Quite the opposite: a period of low oil prices is the moment to reinforce our capacity to deal with future energy security threats.’’ Hussain, Y. (2015). ‘‘Grave mistake’’ to be complacent on energy security, International Energy Agency warns. *Financial Post,* (November 10). Retrieved from *http://business.financialpost.com/news/energy/grave-mistake-to-be-complacent-on-energy-security-international-energy-agency-warns.*

[884] Batovic, A. (2015). *Low oil prices fuel political and economic instability. Global Risk Insights,* 18–19. Retrieved from *http://globalriskinsights.com/2015/09/low-oil-prices-fuel-political-and-economic-instability/.*

[885] Monaldi, F. (2015). The Impact of the Decline in Oil Prices on the Economics, Politics and Oil Industry of Venezuela. *Columbia Center on Global Energy Policy Discussion Papers,* (September). Retrieved from *http://energypolicy.columbia.edu/sites/default/files/energy/Impact* of the Decline in Oil Prices on Venezuela, September 2015.pdf.

[886] Even, S., & Guzansky, Y. (2015). *Falling oil prices and Saudi stability—Opinion. Jerusalem Post,* (September 30). Retrieved from *http://www.jpost.com/Opinion/Falling-oil-prices-and-Saudi-stability-419534.*

[887] International Monetary Fund (IMF). (2015). *IMF Regional Economic Outlook—Middle East and Central Asia. Regional Economic Outlook* (Vol. 33). Tomkiw, L. (2015). Oil Rich Saudi Arabia Running Out Of Assets? IMF Report Says It's Possible In Next 5 Years. *International Business Times, October 21,* 19–22. Retrieved from *http://www.ibtimes.com/oil-rich-saudi-arabia-running-out-assets-imf-report-says-its-possible-next-5-years-215017.*

[888] National Research Council, 2009. Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. National Academy of Science, Washington, DC.

[889] See, William Nordhaus, ‘‘*Who's Afraid of a Big Bad Oil Shock?*’’, available at *http://aida.econ.yale.edu/~nordhaus/homepage/Big_Bad_Oil_Shock_Meeting.pdf,* and Olivier Blanchard and Jordi Gali, ‘‘*The macroeconomic Effects of Oil price Shocks: Why are the 2000s so different from the*

attempts to explain why the economy actually expanded immediately after the last shocks, and why there was no evidence of higher energy prices being passed on through higher wage inflation. Using different methodologies, they conclude that the economy has largely gotten over its concern with dramatic swings in oil prices.

One reason, according to Nordhaus, is that monetary policy has become more accommodating to the price impacts of oil shocks. Another is that consumers have simply decided that such movements are temporary, and have noted that price impacts are not passed on as inflation in other parts of the economy. He also notes that real changes to productivity due to oil price increases are incredibly modest,[890] and that the general direction of the economy matters a great deal regarding how the economy responds to a shock. Estimates of the impact of a price shock on aggregate demand are insignificantly different from zero.

Blanchard and Gali (2010) contend that improvements in monetary policy (as noted above), more flexible labor markets, and lessening of energy intensity in the economy, combined with an absence of concurrent shocks, all contributed to lessen the impact of oil shocks after 1980. They find ''. . . the effects of oil price shocks have changed over time, with steadily smaller effects on prices and wages, as well as on output and employment.''[891] In a comment at the chapter's end, this work is summarized as follows: ''The message of this chapter is thus optimistic in that it suggests a transformation in U.S. institutions has inoculated the economy against the responses that we saw in the past.''

At the same time, the implications of the ''Shale Oil Revolution'' are now being felt in the international markets, with current prices at four year lows. Analysts generally attribute this result in part to the significant increase in supply resulting from U.S. production, which has put liquid petroleum production roughly on par with Saudi Arabia. The price decline is also attributed to the sustained reductions in U.S. consumption and global demand growth from fuel efficiency policies and previously high oil prices. The resulting decrease in foreign imports, down to about one-third of domestic consumption (from 60 percent in 2005, for example[892]), effectively permits U.S. supply to act as a buffer against artificial or other supply restrictions (the latter due to conflict or a natural disaster, for example).

However, other papers suggest that oil shocks, particularly sudden supply shocks, remain a concern. Both Blanchard and Gali's and Nordhaus work were based on data and analysis through 2006, ending with a period of strong global economic growth and growing global oil demand. The Nordhaus work particularly stressed the effects of the price increase from 2002–2006 that were comparatively gradual (about half the growth rate of the 1973 event and one-third that of the 1990 event). The Nordhaus study emphasizes the robustness of the U.S. economy during a time period through 2006. This time period was just before rapid further increases in the price of oil and other commodities with oil prices more-than-doubling to over $130/barrel by mid-2008, only to drop after the onset of the largest recession since the Great Depression.

Hamilton (2012) reviewed the empirical literature on oil shocks and suggested that the results are mixed, noting that some work (*e.g.* Rasmussen and Roitman (2011) finds less evidence for economic effects of oil shocks, or declining effects of shocks (Blanchard and Gali 2010), while other work continues to find evidence regarding the economic importance of oil shocks. For example, Baumeister and Peersman (2011) found that an oil price increase had a decreasing effect over time. But they note that with a declining price-elasticity of demand that a given physical oil disruption would have a bigger effect on price and a similar effect on output as in the earlier data.[893] Hamilton observes that ''a negative effect of oil prices on real output has also been reported for a number of other countries, particularly when nonlinear functional forms have been employed''. Alternatively, rather than a declining effect, Ramey and Vine (2010)[894] found ''remarkable stability in the response of aggregate real variables to oil shocks once we account for the extra costs imposed on the economy in the 1970s by price controls and a complex system of entitlements that led to some rationing and shortages.''

Some of the recent literature on oil price shocks has emphasized that economic impacts depend on the nature of the oil shock, with differences between price increases caused by sudden supply loss and those caused by rapidly growing demand. Most recent analyses of oil price shocks have confirmed that ''demand-driven'' oil price shocks have greater effects on oil prices and tend to have positive effects on the economy while ''supply-driven'' oil shocks still have negative economic impacts (Baumeister, Peersman and Van Robays (2010)).[895] A recent paper by Kilian and Vigfusson (2014),[896] for example, assigned a more prominent role to the effects of price increases that are unusual, in the sense of being beyond range of recent experience. Kilian and Vigfusson also conclude that the difference in response to oil shocks may well stem from the different effects of demand- and supply-based price increases: ''One explanation is that oil price shocks are associated with a range of oil demand and oil supply shocks, some of which stimulate the U.S. economy in the short run and some of which slow down U.S. growth (see Kilian (2009)). How recessionary the response to an oil price shock is thus depends on the average composition of oil demand and oil supply shocks over the sample period.''

The general conclusion that oil supply-driven shocks reduce economic output is also reached in a recently published paper by Cashin et al. (2014)[897] for 38 countries from 1979–2011. ''The results indicate that the economic consequences of a supply-driven oil-price shock are very different from those of an oil-demand shock

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1970s?'', pp. 373–421, in *The International Dimensions of Monetary Policy,* Jordi Gali and Mark Gertler, editors, University of Chicago Press, February 2010, available at *http://www.nber.org/chapters/c0517.pdf.*

[890] In fact, ''. . . energy-price changes have no effect on multifactor productivity and very little effect on labor productivity.'' Page 19. He calculates the productivity effect of a doubling of oil prices as a decrease of 0.11 percent for one year and 0.04 percent a year for ten years. Page 5. (The doubling reflects the historical experience of the post-war shocks, as described in Table 7.1 in Blanchard and Gali, p. 380).

[891] Blanchard and Gali, p. 414.

[892] See, Oil price Drops on Oversupply, *http://www.oil-price.net/en/articles/oil-price-drops-on-oversupply.php*, 10/6/2014.

[893] Hamilton, J. D. (2012). *Oil Prices, Exhaustible Resources, and Economic Growth.* In Handbook of Energy and Climate Change. Retrieved from *http://econweb.ucsd.edu/~jhamilto/handbook_climate.pdf.*

[894] Ramey, V. and Vine, D., 2010, ''Oil, Automobiles, and the U.S. Economy: How Much have Things Really Changed?'' National Bureau of Economic Research Working Papers, WP 16067. Retrieved from *http://www.nber.org/papers/w16067.pdf* [EPA–HQ–OAR–2014–0827–0601].

[895] Baumeister, C., Peersman, G., Van Robays, I., 2010, ''The Economic Consequences of Oil Shocks: Differences across Countries and Time'', Workshop and Conference on Inflation Challenges in the Era of Relative Price Shocks.

[896] Kilian, L., Vigfusson, R.J., 2014, ''The Role of Oil Price Shocks in Causing U.S. Recessions'', Board of Governors of the Federal Reserve System. International Finance Discussion Papers.

[897] Cashin, P., Mohaddes, K., Raissi, Maziar, and Raissi, M., 2014, ''The differential effects of oil demand and supply shocks on the global economy''. Energy Economics.

driven by global economic activity, and vary for oil-importing countries compared to energy exporters,'' and ''oil importers [including the U.S.] typically face a long-lived fall in economic activity in response to a supply-driven surge in oil prices'' but almost all countries see an increase in real output for an oil-demand disturbance. Note that the energy security premium calculation in this analysis is based on price shocks from potential future supply events only.

Finally, despite continuing uncertainty about oil market behavior and outcomes and the sensitivity of the U.S. economy to oil shocks, it is generally agreed that it is beneficial to reduce petroleum fuel consumption from an energy security standpoint. It is not just imports alone, but both imports and consumption of petroleum from all sources and their role in economic activity, that may expose the U.S. to risk from price shocks in the world oil price. Reducing fuel consumption reduces the amount of domestic economic activity associated with a commodity whose price depends on volatile international markets.

(c) Cost of Existing U.S. Energy Security Policies

The last often-identified component of the full economic costs of U.S. oil imports are the costs to the U.S. taxpayers of existing U.S. energy security policies. The two primary examples are maintaining the Strategic Petroleum Reserve (SPR) and maintaining a military presence to help secure a stable oil supply from potentially vulnerable regions of the world. The SPR is the largest stockpile of government-owned emergency crude oil in the world. Established in the aftermath of the 1973/1974 oil embargo, the SPR provides the U.S. with a response option should a disruption in commercial oil supplies threaten the U.S. economy. It also allows the U.S. to meet part of its International Energy Agency obligation to maintain emergency oil stocks, and it provides a national defense fuel reserve. While the costs for building and maintaining the SPR are more clearly related to U.S. oil use and imports, historically these costs have not varied in response to changes in U.S. oil import levels. Thus, while the effect of the SPR in moderating price shocks is factored into the ORNL analysis, the cost of maintaining the SPR is excluded.

U.S. military costs are excluded from the analysis performed by ORNL because their attribution to particular missions or activities is difficult, and because it is not clear that these outlays would decline in response to incremental reductions in U.S. oil imports. Most military forces serve a broad range of security and foreign policy objectives. The agencies also recognize that attempts to attribute some share of U.S. military costs to oil imports are further challenged by the need to estimate how those costs might vary with incremental variations in U.S. oil imports.

In the proposal to these rules, the agencies solicited comments on quantifying the military benefits from reduced U.S. imports of oil. The California Air Resources Board (CARB) notes that the National Research Council (NRC)[898] attempted to estimate the military costs associated with U.S. imports and consumption of petroleum. The NRC cited estimates of the national defense costs of oil dependence from the literature that range from less than $5 to $50 billion per year or more. Assuming a range of approximate range of $10 to $50 billion per year, the NRC divided national defense costs by a projected U.S. consumption rate of approximately 6.4 billion barrels per year (EIA, 2012). This procedure yielded a range of average national defense cost of $1.50–$8.00 per barrel (rounded to the nearest $0.50), with a mid-point of $5/barrel (in 2009$). The agencies acknowledge this NRC study, but have not included the estimates as part of the cost-benefit analysis for these rules.

(3) Energy Security Benefits of This Program

Using the ORNL ''oil premium'' methodology, updating world oil price values and energy trends using AEO 2015 and using the estimated fuel savings from these final rules estimated from the MOVES/CAFE models, the agencies have calculated the annual energy security benefits of these final rules through 2050.[899] Since the agencies are taking a global perspective with respect to valuing greenhouse gas benefits from the rules, only the avoided macroeconomic adjustment/disruption portion of the energy security premium is used in the energy security benefits estimates present below. These results are shown below in Table IX–21. The agencies have also calculated the net present value at 3 percent and 7 percent discount rates of model year lifetime benefits associated with energy security; these values are presented in Table IX–22.

TABLE IX–21—ANNUAL U.S. ENERGY SECURITY BENEFITS OF THE FINAL PROGRAM AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO A FLAT BASELINE FOR FINAL HDV RULES

[In Millions of 2013$] [a]

Year	Benefits (2013$)
2018	$4
2019	9
2020	14
2021	55
2022	109
2023	171
2024	268
2025	372
2026	482
2027	627
2028	775
2029	923
2030	1,074
2035	1,847
2040	2,533
2050	3,025
NPV, 3%	24,716
NPV, 7%	10,050

TABLE IX–22—DISCOUNTED MODEL YEAR LIFETIME ENERGY SECURITY BENEFITS DUE TO THE FINAL PROGRAM AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO A FLAT BASELINE FOR FINAL HDV RULES

[Millions of 2013$] [a]

Calendar year	3% Discount rate	7% Discount rate
2018	$30	$21
2019	29	20
2020	28	18
2021	485	294
2022	520	304
2023	552	311
2024	849	461
2025	886	464
2026	917	463
2027	1,183	577
2028	1,182	555
2029	1,184	536
Sum	7,844	4,026

J. Other Impacts

(1) Costs of Noise, Congestion and Crashes Associated With Additional (Rebound) Driving

Although it provides benefits to drivers as described above, increased vehicle use associated with the rebound effect also contributes to increased

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[898] National Research Council, ''Transitions to alternative vehicles and fuels,'' 2013.

[899] In order to determine the energy security benefits beyond 2040, we use the 2040 energy security premium multiplied by the estimate fuel savings from the final rule. Since the AEO 2015 only goes to 2040, we only calculate energy security premiums to 2040.

traffic congestion, motor vehicle crashes, and highway noise. Depending on how the additional travel is distributed over the day and where it takes place, additional vehicle use can contribute to traffic congestion and delays by increasing the number of vehicles using facilities that are already heavily traveled. These added delays impose higher costs on drivers and other vehicle occupants in the form of increased travel time and operating expenses. At the same time, this additional travel also increases costs associated with traffic crashes and vehicle noise.

The agencies estimate these costs using the same methodology as used in the two light-duty and the HD Phase 1 rule analyses, which relies on estimates of congestion, crash, and noise costs imposed by automobiles and light trucks developed by the Federal Highway Administration to estimate these increased external costs caused by added driving.[900] We provide the details behind the estimates in Chapter 8.7 of the RIA. Table IX–23 presents the estimated annual impacts associated with crash, congestion and noise along with net present values at both 3 percent and 7 percent discount rates. Table IX–24 presents the estimated discounted model year lifetime impacts associated with crashes, congestion and noise. The methodology used in this final rule is the same as that used in the proposal, except that costs were updated to 2013 dollars.

TABLE IX–23—ANNUAL COSTS ASSOCIATED WITH CRASHES, CONGESTION AND NOISE AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Calendar year	Costs of crashes, congestion, and noise
2018	$0
2019	0
2020	0
2021	99
2022	139
2023	178
2024	216
2025	252
2026	285
2027	317
2028	345
2029	372
2030	396
2035	487
2040	541
2050	604
NPV, 3%	6,755
NPV, 7%	3,070

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–24—DISCOUNTED MODEL YEAR LIFETIME COSTS OF CRASHES, CONGESTION AND NOISE AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Calendar year	3% discount rate	7% Discount rate
2018	$124	$80
2019	140	89
2020	158	100
2021	343	215
2022	333	201
2023	323	187
2024	319	178
2025	313	168
2026	305	158
2027	297	148
2028	289	139
2029	283	131
Sum	3,227	1,793

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(2) Benefits Associated With Reduced Refueling Time

By reducing the frequency with which drivers typically refuel their vehicles and by extending the upper limit of the range that can be traveled before requiring refueling (*i.e.,* future fuel tank sizes remain constant), savings will be realized associated with less time spent refueling vehicles. Alternatively, refill intervals may remain the same (*i.e.,* future fuel tank sizes get smaller), resulting in the same number of refills as today but less time spent per refill because there will be less fuel to refill. The agencies have estimated this impact using the former approach—by assuming that future tank sizes remain constant.

The savings in refueling time are calculated as the total amount of time the driver of a typical truck in each class will save each year as a consequence of pumping less fuel into the vehicle's tank. The calculation does not include any reduction in time spent searching for a fueling station or other time spent at the station; it is assumed that time savings occur only when truck operators are actually refueling their vehicles.

The calculation uses the reduced number of gallons consumed by truck type and divides that value by the tank volume and refill amount to get the number of refills, then multiplies that by the time per refill to determine the number of hours saved in a given year. The calculation then applies DOT-recommended values of travel time savings to convert the resulting time savings to their economic value, including a 1.2 percent growth rate in those time savings going forward.[901] The input metrics used in the analysis are presented in greater detail in RIA Chapter 9.7. The annual benefits associated with reduced refueling time are shown in Table IX–25 along with net present values at both 3 percent and 7 percent discount rates. The discounted model year lifetime benefits are shown in Table IX–26. The methodology used in this final rule is the same as that used in the proposal, except that costs have been updated to 2013 dollars.

TABLE IX–25—ANNUAL REFUELING BENEFITS AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Calendar year	Refueling benefits
2018	$1
2019	3
2020	5
2021	27
2022	56
2023	91
2024	144
2025	202
2026	264
2027	342
2028	420
2029	495
2030	570
2035	895
2040	1,141

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[900] These estimates were developed by FHWA for use in its 1997 Federal Highway Cost Allocation Study; *http://www.fhwa.dot.gov/policy/hcas/final/index.htm* (last accessed July 8, 2012).

[901] U.S. Department of Transportation, Valuation of Travel Guidance, July 9, 2014, at page 14.

TABLE IX–25—ANNUAL REFUELING BENEFITS AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE—Continued

[Millions of 2013$] [a]

Calendar year	Refueling benefits
2050	1,497
NPV, 3%	11,985
NPV, 7%	4,925

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–26—DISCOUNTED MODEL YEAR LIFETIME REFUELING BENEFITS USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Model year	3% discount rate	7% discount rate
2018	$9	$7
2019	9	6
2020	8	6
2021	218	135
2022	255	152
2023	290	166
2024	428	236
2025	461	245
2026	491	251
2027	609	300
2028	601	285
2029	594	272
Sum	3,976	2,061

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(3) Benefits of Increased Travel Associated With Rebound Driving

The increase in travel associated with the rebound effect produces additional benefits to vehicle owners and operators, which reflect the value of the added (or more desirable) social and economic opportunities that become accessible with additional travel. The analysis estimates the economic benefits from increased rebound-effect driving as the sum of fuel expenditures incurred plus the consumer surplus from the additional accessibility it provides. As evidenced by the fact that vehicles make more frequent or longer trips when the cost of driving declines, the benefits from this added travel exceed added expenditures for the fuel consumed. The amount by which the benefits from this increased driving exceed its increased fuel costs measures the net benefits from the additional travel, usually referred to as increased consumer surplus.

The agencies' analysis estimates the economic value of the increased consumer surplus provided by added driving using the conventional approximation, which is one half of the product of the decline in vehicle operating costs per vehicle-mile and the resulting increase in the annual number of miles driven. Because it depends on the extent of improvement in fuel economy, the value of benefits from increased vehicle use changes by model year and varies among alternative standards. Under even those alternatives that will impose the highest standards, however, the magnitude of the consumer surplus from additional vehicle use represents a small fraction of this benefit.

The annual benefits associated with increased travel are shown in Table IX–27 along with net present values at both 3 percent and 7 percent discount rates. The discounted model year lifetime benefits are shown in Table IX–28. The methodology used in this final rule is the same as that used in the proposal, except that costs have been updated to 2013 dollars.

TABLE IX–27—ANNUAL VALUE OF INCREASED TRAVEL AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Calendar year	Benefits of increased travel
2018	$0
2019	0
2020	0
2021	298
2022	417
2023	534
2024	648
2025	759
2026	866
2027	967
2028	1,064
2029	1,157
2030	1,247
2035	1,660
2040	2,043
2050	2,284
NPV, 3%	23,357
NPV, 7%	10,343

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE IX–28—DISCOUNTED MODEL YEAR LIFETIME VALUE OF INCREASED TRAVEL AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Millions of 2013$] [a]

Calendar year	3% discount rate	7% discount rate
2018	$452	$285
2019	511	319
2020	580	358
2021	1,054	647
2022	1,038	613
2023	1,020	580
2024	1,001	549
2025	994	525
2026	982	500
2027	951	466
2028	942	445
2029	937	427
Sum	10,462	5,715

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

K. Summary of Benefits and Costs

This section presents the costs, benefits, and other economic impacts of the Phase 2 standards. It is important to note that NHTSA's fuel consumption standards and EPA's GHG standards will both be in effect, and will jointly lead to increased fuel efficiency and reductions in GHG and non-GHG emissions. The individual categories of benefits and costs presented in the tables below are defined more fully and presented in more detail in Chapter 8 of the RIA. These include:

- The vehicle program costs (costs of complying with the vehicle CO_a; and fuel consumption standards),
- changes in fuel expenditures associated with reduced fuel use by more efficient vehicles and increased fuel use associated with the ''rebound'' effect, both of which result from the program,
- the global economic value of reductions in GHGs,
- the economic value of reductions in non-GHG pollutants,
- costs associated with increases in noise, congestion, and crashes resulting from increased vehicle use,
- savings in drivers' time from less frequent refueling,
- benefits of increased vehicle use associated with the ''rebound'' effect, and
- the economic value of improvements in U.S. energy security impacts.

For a discussion of the cost of ownership and the agencies' payback analysis of vehicles covered by this rule, please see Section IX.M.

The agencies conducted two analyses using two analytical methods referred to as Method A and Method B. For an explanation of these methods, please see Section I.D. And as discussed in Section X.A.1, the agencies present estimates of benefits and costs that are measured against two different assumptions about improvements in fuel efficiency that might occur in the absence of the Phase 2 standards. The first case (Alternative 1a) uses a baseline that projects very little improvement in new vehicles in the absence of new Phase 2 standards, and the second (Alternative 1b) uses a more dynamic baseline that projects more significant improvements in vehicle fuel efficiency.

Table IX–29 shows benefits and costs for these standards from the perspective of a program designed to improve the nation's energy security and conserve energy by improving fuel efficiency. From this viewpoint, technology costs occur when the vehicle is purchased. Fuel savings are counted as benefits that occur over the lifetimes of the vehicles produced during the model years subject to the Phase 2 standards as they consume less fuel. The table shows that benefits far outweigh the costs, and the final program is anticipated to result in large net benefits to the U.S economy.

TABLE IX–29—LIFETIME BENEFITS & COSTS OF THE FINAL PROGRAM FOR MODEL YEARS 2018–2029 VEHICLES USING ANALYSIS METHOD A

[Billions of 2013$ discounted at 3% and 7%]

Category	Baseline 1a		Baseline 1b	
	3%	7%	3%	7%
Vehicle Program: Technology and Indirect Costs, Normal Profit on Additional Investments	24.4	16.6	23.7	16.1
Additional Routine Maintenance	1.7	0.9	1.7	0.9
Congestion, Crashes, Fatalities and Noise from Increased Vehicle Use[a]	3.2	1.9	3.1	1.8
Total Costs	29.3	19.4	28.5	18.8
Fuel Savings (valued at pre-tax prices)	163.0	87.0	149.1	79.7
Savings from Less Frequent Refueling	3.2	1.7	3.0	1.6
Economic Benefits from Additional Vehicle Use	5.5	3.5	5.4	3.4
Reduced Climate Damages from GHG Emissions[b]	36.0		33.0	
Reduced Health Damages from Non-GHG Emissions	30.0	16.1	27.1	14.6
Increased U.S. Energy Security	7.9	4.2	7.3	3.9
Total Benefits	246	149	225	136
Net Benefits	216	129	197	117

Notes:

[a] "Congestion, Crashes, Fatalities and Noise from Increased Vehicle Use" includes NHTSA's monetized value of estimated reductions in the incidence of highway fatalities associated with mass reduction in HD pickup and vans, but this does not include these reductions from tractor-trailers or vocational vehicles. This likely results in a conservative overestimate of these costs.

[b] Benefits and net benefits use the 3 percent average global SC-CO_2, SC-CH_4, and SC-N_2O value applied to CO_2, CH_4, and N_2O emissions, respectively; GHG reductions also include HFC reductions, and include benefits to other nations as well as the U.S. See RIA Chapter 8.5 and Preamble Section IX.G for further discussion.

Table IX–30 through Table IX–32 report benefits and cost from the perspective of reducing GHG. Table IX–30 shows the annual impacts and net benefits of the final program for selected future years, together with the net present values of cumulative annual impacts from 2018 through 2050, discounted at 3 percent and 7 percent rates.

Table IX–31 and Table IX–32 show the discounted lifetime costs and benefits for each model year affected by the Phase 2 standards at 3 percent and 7 percent discount rates, respectively.

TABLE IX–30—ANNUAL BENEFITS & COSTS OF THE FINAL PROGRAM AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Billions of 2013$][a]

	2018	2021	2024	2030	2035	2040	2050	NPV, 3%	NPV, 7%
Vehicle program	−$0.2	−$2.5	−$4.2	−$5.2	−$5.7	−$6.3	−$7.3	−$87.8	−$41.9
Maintenance	0.0	0.0	−0.1	−0.2	−0.2	−0.2	−0.2	−3.2	−1.5
Pre-tax fuel	0.1	1.3	6.1	23.4	38.9	53.1	63.4	523.3	213.8
Energy security	0.0	0.1	0.3	1.1	1.8	2.5	3.0	24.7	10.1
Crashes/Congestion/Noise	0.0	−0.1	−0.2	−0.4	−0.5	−0.5	−0.6	−6.8	−3.1
Refueling impacts	0.0	0.0	0.1	0.6	0.9	1.1	1.5	12.0	4.9
Travel value	0.0	0.3	0.6	1.2	1.7	2.0	2.3	23.4	10.3
Non-GHG impacts	0.0 to 0.0	0.2 to 0.5	0.7 to 1.8	2.7 to 6.8	4.1 to 10.1	5.0 to 12.5	6.0 to 15.0	58.8 to 132.0	22.1 to 49.7
GHG:[b c]									
SC-GHG; 5% Avg	0.0	0.1	0.4	1.7	2.8	3.9	5.8	25.1	25.1
SC-GHG; 3% Avg	0.0	0.3	1.4	5.2	8.4	11.1	15.2	115.4	115.4
SC-GHG; 2.5% Avg	0.0	0.4	2.0	7.5	11.9	15.5	20.9	183.1	183.1
SC-GHG; 3% 95th	0.1	0.9	4.1	15.6	25.5	33.6	46.6	351.0	351.0

TABLE IX–30—ANNUAL BENEFITS & COSTS OF THE FINAL PROGRAM AND NET PRESENT VALUES AT 3% AND 7% DISCOUNT RATES USING METHOD B AND RELATIVE TO THE FLAT BASELINE—Continued

[Billions of 2013$] [a]

	2018	2021	2024	2030	2035	2040	2050	NPV, 3%	NPV, 7%
Net benefits:									
SC-GHG; 5% Avg	−0.1	−0.6	4.3	26.7	46.6	64.3	78.2	606.2	253.8
SC-GHG; 3% Avg	−0.1	−0.4	5.2	30.2	52.2	71.4	87.6	696.4	344.0
SC-GHG; 2.5% Avg	−0.1	−0.3	5.9	32.6	55.7	75.8	93.3	764.2	411.8
SC-GHG; 3% 95th	0.0	0.2	8.0	40.7	69.4	94.0	119.0	932.1	579.7

Notes:

[a] Positive values denote decreased social costs (benefits); negative values denote increased social costs. For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] GHG benefit estimates include reductions in CO_2, CH_4, and N_2O but do not include the HFC reductions, as discussed in Section IX.G. Net present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC-CO_2, SC-CH_4, and SC-N_2O, each discounted at rates of 5, 3, 2.5 percent) is used to calculate net present value of SC-CO_2, SC-CH_4, and SC-N_2O, respectively, for internal consistency. Refer to the SC-CO_2 TSD for more detail.

[c] Section IX.G notes that SC-GHGs increases over time. For the years 2012–2050, the SC-CO_2 estimates range as follows: For Average SC-CO_2 at 5%: $12–$28; for Average SC-CO_2 at 3%: $37–$77; for Average SC-CO_2 at 2.5%: $58–$105; and for 95th percentile SC-CO_2 at 3%: $105–$237. For the years 2012–2050, the SC-CH_4 estimates range as follows: For Average SC-CH_4 at 5%: $440–$1,400; for Average SC-CH_4 at 3%: $1,000–$2,700; for Average SC-CH_4 at 2.5%: $1,400–$3,400; and for 95th percentile SC-CH_4 at 3%: $2,800–$7,400. For the years 2012–2050, the SC-N_2O estimates range as follows: For Average SC-N_2O at 5%: $4,000–$12,000; for Average SC-N_2O at 3%: $14,000–$30,000; for Average SC-N_2O at 2.5%: $21,000–$41,000; and for 95th percentile SC-N_2O at 3%: $36,000–$79,000. Section IX.G also presents these SC-GHG estimates.

TABLE IX–31—DISCOUNTED MODEL YEAR LIFETIME BENEFITS & COSTS OF THE FINAL PROGRAM USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Billions of 2013$ discounted at 3%] [a]

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Sum
Vehicle program	−$0.2	−$0.2	−$0.2	−$2.1	−$2.0	−$2.1	−$3.1	−$3.0	−$3.0	−$3.6	−$3.5	−$3.4	−$26.5
Maintenance	−0.01	−0.01	−0.01	−0.15	−0.16	−0.16	−0.18	−0.18	−0.17	−0.30	−0.29	−0.29	−1.9
Pre-tax fuel	0.7	0.7	0.6	10.7	11.4	12.0	18.5	19.1	19.7	25.3	25.2	25.1	169.1
Energy security	0.0	0.0	0.0	0.5	0.5	0.6	0.8	0.9	0.9	1.2	1.2	1.2	7.8
Crashes/Congestion/Noise	−0.1	−0.1	−0.2	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−3.2
Refueling	0.0	0.0	0.0	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.6	4.0
Travel value	0.5	0.5	0.6	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9	10.5
Non-GHG	0.1 to 0.3	0.1 to 0.2	0.1 to 0.2	1.4 to 3.2	1.4 to 3.2	1.5 to 3.3	2.3 to 5.2	2.3 to 5.3	2.2 to 4.8	2.8 to 6.2	2.7 to 6.1	2.7 to 6.0	19.6 to 44.1
GHG: [b c]													
SC-GHG; 5% Avg	0.0	0.0	0.0	0.6	0.6	0.6	1.0	1.0	1.0	1.3	1.2	1.2	8.6
SC-GHG; 3% Avg	0.2	0.1	0.1	2.4	2.6	2.7	4.1	4.2	4.3	5.5	5.5	5.5	37.2
SC-GHG; 2.5% Avg	0.2	0.2	0.2	3.7	4.0	4.2	6.4	6.6	6.8	8.7	8.6	8.6	58.3
SC-GHG; 3% 95th	0.5	0.4	0.4	7.2	7.7	8.0	12.3	12.7	13.1	16.8	16.7	16.6	112.5
Net benefits:													
SC-GHG; 5% Avg	1.1	1.1	1.1	12.8	13.7	14.3	21.8	22.7	23.1	29.6	29.5	29.5	200.2
SC-GHG; 3% Avg	1.2	1.2	1.2	14.6	15.6	16.3	24.9	26.0	26.4	33.9	33.8	33.7	228.8
SC-GHG; 2.5% Avg	1.3	1.3	1.3	16.0	17.1	17.8	27.2	28.4	28.9	37.0	36.9	36.9	249.9
SC-GHG; 3% 95th	1.5	1.5	1.5	19.5	20.8	21.7	33.2	34.5	35.2	45.1	44.9	44.9	304.1

Notes:

[a] Positive values denote decreased social costs (benefits); negative values denote increased social costs. For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.c

[b] GHG benefit estimates include reductions in CO_2, CH_4, and N_2O but do not include the HFC reductions, as discussed in Section IX.G. Net present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC-CO_2, SC-CH_4, and SC-N_2O, each discounted at rates of 5, 3, 2.5 percent) is used to calculate net present value of SC-CO_2, SC-CH_4, and SC-N_2O, respectively, for internal consistency. Refer to the SC-CO_2 TSD for more detail.

[c] Section IX.G notes that SC-GHG increases over time. For the years 2012–2050, the SC-CO_2 estimates range as follows: For Average SC-CO_2 at 5%: $12–$28; for Average SC-CO_2 at 3%: $37–$77; for Average SC-CO_2 at 2.5%: $58–$105; and for 95th percentile SC-CO_2 at 3%: $105–$237. For the years 2012–2050, the SC-CH_4 estimates range as follows: For Average SC-CH_4 at 5%: $440–$1,400; for Average SC-CH_4 at 3%: $1,000–$2,700; for Average SC-CH_4 at 2.5%: $1,400–$3,400; and for 95th percentile SC-CH_4 at 3%: $2,800–$7,400. For the years 2012–2050, the SC-N_2O estimates range as follows: For Average SC-N_2O at 5%: $4,000–$12,000; for Average SC-N_2O at 3%: $14,000–$30,000; for Average SC-N_2O at 2.5%: $21,000–$41,000; and for 95th percentile SC-N_2O at 3%: $36,000–$79,000. Section IX.G also presents these SC-GHG estimates.

TABLE IX–32—DISCOUNTED MODEL YEAR LIFETIME BENEFITS & COSTS OF THE FINAL PROGRAM USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[Billions of 2013$ discounted at 7%] [a b]

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Sum
Vehicle program	−$0.2	−$0.2	−$0.2	−$1.6	−$1.5	−$1.5	−$2.2	−$2.0	−$1.9	−$2.2	−$2.1	−$2.0	−$17.6
Maintenance	0.00	0.00	0.00	−0.10	−0.09	−0.09	−0.10	−0.10	−0.09	−0.15	−0.14	−0.13	−1.0
Pre-tax fuel	0.5	0.4	0.4	6.6	6.7	6.8	10.1	10.1	10.0	12.4	11.9	11.4	87.2
Energy security	0.0	0.0	0.0	0.3	0.3	0.3	0.5	0.5	0.5	0.6	0.6	0.5	4.0
Crashes/Congestion/Noise	−0.1	−0.1	−0.1	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.1	−0.1	−0.1	−1.8
Refueling	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	2.1
Travel value	0.3	0.3	0.4	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4	0.4	5.7
Non-GHG	0.1 to 0.2	0.1 to 0.1	0.1 to 0.1	0.8 to 1.8	0.8 to 1.7	0.8 to 1.7	1.1 to 2.6	1.1 to 2.5	1.0 to 2.2	1.2 to 2.7	1.2 to 2.6	1.1 to 2.5	9.2 to 20.8
GHG: [b c]													
SC-GHG; 5% Avg	0.0	0.0	0.0	0.6	0.6	0.6	1.0	1.0	1.0	1.3	1.2	1.2	8.6
SC-GHG; 3% Avg	0.2	0.1	0.1	2.4	2.6	2.7	4.1	4.2	4.3	5.5	5.5	5.5	37.2
SC-GHG; 2.5% Avg	0.2	0.2	0.2	3.7	4.0	4.2	6.4	6.6	6.8	8.7	8.6	8.6	58.3
SC-GHG; 3% 95th	0.5	0.4	0.4	7.2	7.7	8.0	12.3	12.7	13.1	16.8	16.7	16.6	112.5
Net benefits:													
SC-GHG; 5% Avg	0.7	0.7	0.6	7.6	7.9	7.9	11.7	11.8	11.6	14.4	13.9	13.5	102.3
SC-GHG; 3% Avg	0.8	0.8	0.8	9.4	9.8	10.0	14.8	15.1	15.0	18.7	18.2	17.7	130.9
SC-GHG; 2.5% Avg	0.9	0.9	0.8	10.7	11.2	11.4	17.1	17.4	17.4	21.9	21.3	20.9	151.9
SC-GHG; 3% 95th	1.1	1.1	1.0	14.2	14.9	15.3	23.0	23.6	23.7	29.9	29.3	28.9	206.1

Notes:

[a] Positive values denote decreased social costs (benefits); negative values denote increased social costs. For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] GHG benefit estimates include reductions in CO_2, CH_4, and N_2O but do not include the HFC reductions, as discussed in Section IX.G. Net present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC-CO_2, SC-CH_4, and SC-N_2O, each discounted at rates of 5, 3, 2.5 percent) is used to calculate net present value of SC-CO_2, SC-CH_4, and SC-N_2O, respectively, for internal consistency. Refer to the SC-CO_2 TSD for more detail.

[c] Section IX.G notes that SC-GHG increases over time. For the years 2012–2050, the SC-CO_2 estimates range as follows: For Average SC-CO_2 at 5%: $12–$28; for Average SC-CO_2 at 3%: $37–$77; for Average SC-CO_2 at 2.5%: $58–$105; and for 95th percentile SCCO_2 at 3%: $105–$237. For the years 2012–2050, the SC-CH_4 estimates range as follows: For Average SC-CH_4 at 5%: $440–$1,400; for Average SC-CH_4 at 3%: $1,000–$2,700; for Average SC-CH_4 at 2.5%: $1,400–$3,400; and for 95th percentile SC-CH_4 at 3%: $2,800–$7,400. For the years 2012–2050, the SC-N_2O estimates range as follows: For Average SC-N_2O at 5%: $4,000–$12,000; for Average SC-N_2O at 3%: $14,000–$30,000; for Average SC-N_2O at 2.5%: $21,000–$41,000; and for 95th percentile SC-N_2O at 3%: $36,000–$79,000. Section IX.G also presents these SC-GHG estimates.

L. Employment Impacts

Executive Order 13563 (January 18, 2011) directs federal agencies to consider regulatory impacts on, among other criteria, job creation.[902] According to the Executive Order ''Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science.'' Analysis of employment impacts of a regulation is not part of a standard benefit-cost analysis (except to the extent that labor costs contribute to costs). Employment impacts of federal rules are of general interest, however, and have been particularly so, historically, in the auto sector during periods of challenging labor market conditions. For this reason, we are describing the connections of these standards to employment in the regulated sector, the motor vehicle manufacturing sector, as well as the motor vehicle body and trailer and motor vehicle parts manufacturing sectors.[903]

The overall effect of the final rules on motor vehicle sector employment depends on the relative magnitude of output and substitution effects, described below. Because we do not have quantitative estimates of the output effect, and only a partial estimate of the substitution effect, we cannot reach a quantitative estimate of the overall employment effects of the final rules on motor vehicle sector employment or even whether the total effect will be positive or negative.

According to the U.S. Bureau of Labor Statistics, in 2015, about 910,000 people in the U.S. were employed in the Motor Vehicle and Parts Manufacturing Sector (NAICS 3361, 3362, and 3363),[904] the directly regulated sector. The employment effects of these final rules are expected to expand beyond the regulated sector. Though some of the parts used to achieve these standards are likely to be built by motor vehicle manufacturers (including trailer manufacturers) themselves, the motor vehicle parts manufacturing sector also plays a significant role in providing those parts, and will also be affected by changes in vehicle sales. Changes in truck sales, discussed in Section IX.F.(2), could also affect employment for truck and trailer vendors. As discussed in Section IX.C., this final rule is expected to reduce the amount of fuel these vehicles use, and thus affect the petroleum refinery and supply industries as well. Finally, since the net reduction in cost associated with these final rules is expected to lead to lower transportation and shipping costs, in a competitive market a substantial portion of those cost savings will be passed along to consumers, who then will have additional discretionary income (how much of the cost is passed along to consumers depends on market structure and the relative price elasticities). The final rules are not expected to have any notable inflationary or recessionary effect.

The employment effects of environmental regulation are difficult to disentangle from other economic changes and business decisions that affect employment, over time and across regions and industries. In light of these difficulties, we lean on economic theory to provide a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments. Neoclassical microeconomic theory describes how profit-maximizing firms adjust their use of productive inputs in response to changes in their economic conditions.[905] Berman and Bui (2001, pp. 274–75) model two components that drive changes in firm-level labor demand: Output effects and substitution effects.[906] Regulation can affect the profit-maximizing quantity of output by changing the marginal cost of production. If regulation causes marginal cost to increase, it will place upward pressure on output prices, leading to a decrease in the quantity demanded, and resulting in a decrease in production. The output effect describes how, holding labor intensity constant, a decrease in production causes a decrease in labor demand. As noted by Berman and Bui, although many assume that regulation increases marginal cost, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that lowers marginal production costs, or it may induce use of technologies that may prove popular with buyers or provide positive network externalities (see Section IX.A. for discussion of this effect). In such a case, output could increase.

The substitution effect describes how, holding output constant, regulation affects labor intensity of production. Although increased environmental regulation may increase use of pollution control equipment and energy to operate that equipment, the impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) model the substitution effect as the effect of regulation on pollution control equipment and expenditures required

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[902] Available at *http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf*.

[903] The employment analysis in this RIA is part of EPA's ongoing effort to ''conduct continuing evaluations of potential loss or shifts of employment which may result from the administration or enforcement of [the Act]'' pursuant to CAA section 321(a).

[904] U.S. Department of Labor, Bureau of Labor Statistics. ''Automotive Industry; Employment, Earnings, and Hours.'' *http://www.bls.gov/iag/tgs/iagauto.htm*, accessed 4/20/16.

[905] See Layard, P.R.G., and A. A. Walters (1978), Microeconomic Theory (McGraw-Hill, Inc.), Chapter 9 (Docket ID EPA–HQ–OAR–2014–0827–0070), a standard microeconomic theory textbook treatment, for a discussion.

[906] Berman, E. and L. T. M. Bui (2001). ''Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.'' Journal of Public Economics 79(2): 265–295 (Docket EPA–HQ–OAR–2014–0827–0074). The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih (2002). ''Jobs versus the Environment: An Industry-Level Perspective.'' Journal of Environmental Economics and Management 43: 412–436, Docket EPA–HQ–OAR–2014–0827–0088) use a similar model, but they break the employment effect into three parts: (1) A demand effect; (2) a cost effect; and (3) a factor-shift effect.

by the regulation and the corresponding change in labor intensity of production.

In summary, as output and substitution effects may be positive or negative, theory alone cannot predict the direction of the net effect of regulation on labor demand at the level of the regulated firm. Operating within the bounds of standard economic theory, empirical estimation of net employment effects on regulated firms is possible when data and methods of sufficient detail and quality are available. The literature, however, illustrates difficulties with empirical estimation. For example, studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods do not permit estimation of net effects.

The conceptual framework described thus far focused on regulatory effects on plant-level decisions within a regulated industry. Employment impacts at an individual plant do not necessarily represent impacts for the sector as a whole. The approach must be modified when applied at the industry level. At the industry level, labor demand is more responsive if: (1) The price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of total production costs.[907] For example, if all firms in an industry are faced with the same regulatory compliance costs and product demand is inelastic, then industry output may not change much, and output of individual firms may change slightly.[908] In this case, the output effect may be small, while the substitution effect depends on input substitutability. Suppose, for example, that new equipment for fuel efficiency improvements requires labor to install and operate. In this case, the substitution effect may be positive, and with a small output effect, the total effect may be positive. As with potential effects for an individual firm, theory cannot determine the sign or magnitude of industry-level regulatory effects on labor demand. Determining these signs and magnitudes requires additional sector-specific empirical study. For environmental rules, much of the data needed for these empirical studies is not publicly available, would require significant time and resources in order to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical RIA.

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes in other related sectors. For example, these standards are expected to increase demand for fuel-saving technologies. This increased demand may increase revenue and employment in the firms providing these technologies. At the same time, the regulated industry is purchasing the equipment, and these costs may impact labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

If the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment.[909] Instead, labor would primarily be reallocated from one productive use to another, and net national employment effects from environmental regulation would be small and transitory (*e.g.,* as workers move from one job to another).[910] The International Union, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW) commented that, when the 900,000 workers in the auto sector are combined with ‘‘jobs from other sectors that are dependent on the industry,’’ the industry ‘‘is responsible for 7.25 million jobs nationwide, or about 3.8 percent of private-sector employment.’’ The agencies consider the 900,000 motor-vehicle-sector jobs to be in the industry directly affected by these standards; for the reasons discussed here, the overall state of the U.S. economy is likely to have a much more significant effect on the people employed in other sectors than these standards.

Affected sectors may experience transitory effects as workers change jobs. Some workers may retrain or relocate in anticipation of new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. These adjustment costs can lead to local labor disruptions. Although the net change in the national workforce is expected to be small, localized reductions in employment may adversely impact individuals and communities just as localized increases may have positive impacts.

If the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease.[911] An important research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in assessing large-scale regulatory impacts on employment.[912]

Environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may impact labor productivity or employees’ ability to work.[913] While the theoretical framework for analyzing labor supply effects is analogous to that for labor demand, it is more difficult to study empirically. There is a small emerging literature described in the next section that uses detailed labor and environmental data to assess these impacts.

To summarize, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector and elsewhere. Labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into output and substitution effects which may be either negative or positive. Estimation of net employment effects for regulated sectors is possible when data of sufficient detail and quality are

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[907] See Ehrenberg, Ronald G., and Robert S. Smith (2000), Modern Labor Economics: Theory and Public Policy (Addison Wesley Longman, Inc.), p. 108, Docket EPA–HQ–OAR–2014–0827–0077.

[908] This discussion draws from Berman, E. and L. T. M. Bui (2001). ‘‘Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.’’ Journal of Public Economics 79(2): 265–295 (Docket EPA–HQ–OAR–2014–0827), p. 293, Docket EPA–HQ–OAR–2014–0827–0074.

[909] Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed. The unemployment rate at full employment is not zero.

[910] Arrow et al. (1996). ‘‘Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles.’’ American Enterprise Institute, the Annapolis Center, and Resources for the Future, Docket EPA–HQ–OAR–2014–0827–0073. See discussion on bottom of p. 6. In practice, distributional impacts on individual workers can be important, as discussed later in this section.

[911] Schmalensee, Richard, and Robert N. Stavins. ‘‘A Guide to Economic and Policy Analysis of EPA’s Transport Rule.’’ White paper commissioned by Excelon Corporation, March 2011, Docket EPA–HQ–OAR–2014–0827–0071.

[912] Klaiber, H. Allen, and V. Kerry Smith (2012). ‘‘Developing General Equilibrium Benefit Analyses for Social Programs: An Introduction and Example.’’ *Journal of Benefit-Cost Analysis* 3(2), Docket EPA–HQ–OAR–2014–0827–0086.

[913] E.g. Graff Zivin, J., and M. Neidell (2012). ‘‘The Impact of Pollution on Worker Productivity.’’ *American Economic Review* 102: 3652–3673, Docket EPA–HQ–OAR–2014–0827–0092.

available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the empirical literature.

Achates Power, the American Council for an Energy-Efficient Economy, BlueGreen Alliance, Ceres, Environmental Defense Fund (EDF), Natural Resources Defense Council, and JD Gilroy expressed support for the standards' potential to increase employment in the vehicle manufacturing industry. They argued that the standards will drive new jobs, reward organizations that innovate with respect to fuel efficiency, and help maintain the U.S. position as a leader in industries related to truck manufacturing and fuel efficiency technology. Brian Mannix points out the difficulty associated with generating complete employment forecasts that include all direct and indirect effects. He concludes that the agencies are correct to be careful about estimating a definitive forecast.

Comments from the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW) urge EPA and NHTSA to ensure that the standards avoid market disruptions or ''pre-buy/no-buy'' boom and bust cycles. UAW suggests that in the past, market disruptions caused by pre-buy in anticipation of the 2007 and 2010 NO_X and PM standards contributed to the layoff of 10,000 UAW workers in 2009, though these layoffs were also partly driven by the Great Recession. As pointed out in the comments from EDF, fuel economy standards are fundamentally different from the past standards, because increases in costs for new technology are offset by fuel savings that accrue to the buyer. As a result these standards are less likely to cause disruptions to vehicle purchasing trends. Moreover, as discussed in Section IX.F.(2) above, there is no evidence to date that the HD GHG/fuel consumption rules have resulted in pre-buy/no-buys.

NAFA Fleet Management Association expressed concern that the standards would make it more difficult to hire qualified drivers and technicians, and would require additional employee training. As discussed in Section IX.A., the effects of the standards on hiring and retention of drivers and technicians are not well understood. The agencies expect that normal market forces should help to alleviate any labor shortages, whether or not they are associated with the standards. The Recreational Vehicle (RV) Industry Association expresses concern that buyers RVs do not consider fuel expenditures when purchasing vehicles; as a result, increased up-front costs of the vehicle might reduce their sales. The RV industry was disproportionately hurt during the Great Recession and has only recently experienced a recovery.[914] [915] However, one of the main drivers of the turn-around appears to be low gas prices,[916] which suggests that RV buyers may put some weight on fuel savings in their buying decisions; if so, the reduction in expected fuel costs may mitigate at least some of the effect of higher up-front prices.

(1) Current State of Knowledge Based on the Peer-Reviewed Literature

In the labor economics literature there is an extensive body of peer-reviewed empirical work analyzing various aspects of labor demand, relying on the above theoretical framework.[917] This work focuses primarily on the effects of employment policies, *e.g.* labor taxes, minimum wage, etc.[918] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is very limited. Several empirical studies [919] suggest that net employment impacts may be zero or slightly positive but small even in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones.[920] However, since these latter studies compare more regulated to less regulated counties, they overstate the net national impact of regulation to the extent that regulation causes plants to locate in one area of the country rather than another. List et al. (2003) [921] find some evidence that this type of geographic relocation may be occurring. Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

Analytic challenges make it very difficult to accurately produce net employment estimates for the whole economy that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have very little sectoral detail and usually assume that the economy is at full employment. EPA is currently in the process of seeking input from an independent expert panel on modeling economy-wide impacts, including employment effects. For more information, see: *https://federalregister.gov/a/2014–02471*.

(2) Employment Impacts in the Motor Vehicle and Parts Manufacturing Sector

This section describes changes in employment in the motor vehicle, trailer, and parts (hence, motor vehicle) manufacturing sectors due to these final rules. We focus on the motor vehicle manufacturing sector because it is directly regulated, and because it is likely to bear a substantial share of

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[914] Quiggle, Ben. ''RV sales projected to be stronger in 2016 thanks to low gas prices, steady economy,'' *The Elkhart Truth,* March 6, 2016. *http://www.elkharttruth.com/news/business/2016/03/03/RV-sales-projected-to-be-stronger-in-2016-thanks-to-low-gas-prices-steady-economy.html*, accessed 3/28/2016, Docket EPA–HQ–OAR–2014-0827.

[915] Morris, Frank. ''Ready For A Road Trip? RVs Are Rolling Back Into Fashion,'' *Morning Edition on NPR,* March 28, 2016. *http://www.npr.org/2016/03/28/468172578/ready-for-a-road-trip-rvs-are-rolling-back-into-fashion*, accessed 3/28/2016, Docket EPA–HQ–OAR–2014–0827.

[916] Quiggle, Ben. ''RV sales projected to be stronger in 2016 thanks to low gas prices, steady economy,'' *The Elkhart Truth,* March 6, 2016. *http://www.elkharttruth.com/news/business/2016/03/03/RV-sales-projected-to-be-stronger-in-2016-thanks-to-low-gas-prices-steady-economy.html*, accessed 3/28/2016, Docket EPA–HQ–OAR–2014–0827.

[917] See Hamermesh (1993), Labor Demand (Princeton, NJ: Princeton University Press), Chapter 2 (Docket EPA–HQ–OAR–2014–0827–0082) for a detailed treatment.

[918] See Ehrenberg, Ronald G., and Robert S. Smith (2000), Modern Labor Economics: Theory and Public Policy (Addison Wesley Longman, Inc.), Chapter 4 (Docket EPA–HQ–OAR–2014–0827–0077), for a concise overview.

[919] Berman, E. and L. T. M. Bui (2001). ''Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.'' Journal of Public Economics 79(2): 265–295 (Docket EPA–HQ–OAR2014–0827–0074). Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. ''Jobs Versus the Environment: An Industry-Level Perspective.'' Journal of Environmental Economics and Management 43 (2002): 412–436, Docket EPA–HQ–OAR–2014–0827–0088; Gray et al. (2014), ''Do EPA Regulations Affect Labor Demand? Evidence from the Pulp and Paper Industry,'' *Journal of Environmental Economics and Management* 68: 188–202, Docket EPA–HQ–OAR–2014–0827–0080; and Ferris, Shadbegian and Wolverton (2014), ''The Effect of Environmental Regulation on Power Sector Employment: Phase I of the Title IV SO_2 Trading Program,'' *Journal of the Association of Environmental and Resource Economists* 1: 521–553, Docket EPA–HQ–OAR–2014–0827–0078.

[920] Greenstone, M. (2002). ''The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures,'' Journal of Political Economy 110(6): 1175–1219 (Docket EPA–HQ–OAR–2014–0827–0081); Walker, Reed. (2011). ''Environmental Regulation and Labor Reallocation.'' American Economic Review: Papers and Proceedings 101(3): 442–447 (Docket EPA–HQ–OAR–2014–0827–0091).

[921] List, J. A., D. L. Millimet, P. G. Fredriksson, and W. W. McHone (2003). ''Effects of Environmental Regulations on Manufacturing Plant Births: Evidence from a Propensity Score Matching Estimator.'' The Review of Economics and Statistics 85(4): 944–952 (Docket EPA–HQ–OAR2014–0827–0087).

changes in employment due to these final rules. We include discussion of effects on the parts manufacturing sector, because the motor vehicle manufacturing sector can either produce parts internally or buy them from an external supplier, and we do not have estimates of the likely breakdown of effort between the two sectors.

We follow the theoretical structure of Berman and Bui[922] of the impacts of regulation in employment in the regulated sectors. In Berman and Bui's (2001, p. 274–75) theoretical model, as described above, the change in a firm's labor demand arising from a change in regulation is decomposed into two main components: Output and substitution effects.[923] As the output and substitution effects may be both positive, both negative, or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms.

Following the Berman and Bui framework for the impacts of regulation on employment in the regulated sector, we consider two effects for the motor vehicle sector: The output effect and the substitution effect.

(a) The Output Effect

If truck or trailer sales increase, then more people will be required to assemble trucks, trailers, and their components. If truck or trailer sales decrease, employment associated with these activities will decrease. The effects of this final rulemaking on HD vehicle sales thus depend on the perceived desirability of the new vehicles. On one hand, this final rulemaking will increase truck and trailer costs; by itself, this effect would reduce truck and trailer sales. In addition, while decreases in truck performance would also decrease sales, this program is not expected to have any negative effect on truck performance. On the other hand, this final rulemaking will reduce the fuel costs of operating the trucks; by itself, this effect would increase truck sales, especially if potential buyers have an expectation of higher fuel prices. The agencies have not made an estimate of the potential change in truck or trailer sales. However, as discussed in IX.E., the agencies have estimated an increase in vehicle miles traveled (*i.e.,* VMT rebound) due to the reduced operating costs of trucks meeting these standards. Since increased VMT is most likely to be met with more drivers and more trucks, our projection of VMT rebound is suggestive of an increase in vehicle sales and truck driver employment (recognizing that these increases may be partially offset by a decrease in manufacturing and sales for equipment of other modes of transportation such as rail cars or barges).

(b) The Substitution Effect

The output effect, above, measures the effect due to new truck and trailer sales only. The substitution effect includes the impacts due to the changes in technologies needed for vehicles to meet these standards, separate from the effect on output (that is, as though holding output constant). This effect includes both changes in employment due to incorporation of abatement technologies and overall changes in the labor intensity of manufacturing. We present estimates for this effect to provide a sense of the order of magnitude of expected impacts on employment, which we expect to be small in the automotive sector, and to repeat that regulations may have positive as well as negative effects on employment.

One way to estimate this effect, given the cost estimates for complying with the final rule, is to use the ratio of workers to each $1 million of expenditures in that sector. The use of these ratios has both advantages and limitations. It is often possible to estimate these ratios for quite specific sectors of the economy: For instance, it is possible to estimate the average number of workers in the motor vehicle body and trailer manufacturing sector per $1 million spent in the sector, rather than use the ratio from another, more aggregated sector, such as motor vehicle manufacturing. As a result, it is not necessary to extrapolate employment ratios from possibly unrelated sectors. On the other hand, these estimates are averages for the sectors, covering all the activities in those sectors; they may not be representative of the labor required when expenditures are required on specific activities, or when manufacturing processes change sufficiently that labor intensity changes. For instance, the ratio for the motor vehicle manufacturing sector represents the ratio for all vehicle manufacturing, not just for emissions reductions associated with compliance activities. In addition, these estimates do not include changes in sectors that supply these sectors, such as steel or electronics producers. They thus may best be viewed as the effects on employment in the motor vehicle sector due to the changes in expenditures in that sector, rather than as an assessment of all employment changes due to these changes in expenditures. In addition, this approach estimates the effects of increased expenditures while holding constant the labor intensity of manufacturing; it does not take into account changes in labor intensity due to changes in the nature of production. This latter effect could either increase or decrease the employment impacts estimated here.[924]

Some of the costs of these final rules will be spent directly in the motor vehicle manufacturing sector, but it is also likely that some of the costs will be spent in the motor vehicle body and trailer and motor vehicle parts manufacturing sectors. The analysis here draws on estimates of workers per $1 million of expenditures for each of these sectors.

There are several public sources for estimates of employment per $1 million expenditures. The U.S. Bureau of Labor Statistics (BLS) provides its Employment Requirements Matrix (ERM),[925] which provides direct estimates of the employment per $1 million in sales of goods in 202 sectors. The values considered here are for Motor Vehicle Manufacturing (NAICS 3361), Motor Vehicle Body and Trailer Manufacturing (NAICS 3362), and Motor Vehicle Parts Manufacturing (NAICS 3363) for 2014.

The Census Bureau provides the Annual Survey of Manufacturers[926] (ASM), a subset of the Economic Census (EC), based on a sample of establishments; though the EC itself is more complete, it is conducted only every 5 years, while the ASM is annual. Both include more sectoral detail than the BLS ERM: For instance, while the ERM includes the Motor Vehicle

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[922] Berman, E. and L. T. M. Bui (2001). ''Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.'' *Journal of Public Economics 79*(2): 265–295 (Docket EPA–HQ–OAR2014–0827–0074).

[923] The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (2002) use a similar model, but they break the employment effect into three parts: (1) The demand effect; (2) the cost effect; and (3) the factor-shift effect. See Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. ''Jobs Versus the Environment: An Industry-Level Perspective.'' Journal of Environmental Economics and Management 43 (2002): 412–436 (Docket EPA–HQ–OAR–2014–0827–0088).

[924] As noted above, Morgenstern et al. (2002) separate the effect of holding output constant into two effects: The cost effect, which holds labor intensity constant, and the factor shift effect, which estimates those changes in labor intensity.

[925] *http://www.bls.gov/emp/ep_data_emp_requirements.htm*; see ''HD Substitution Effect Employment Impacts,'' Docket EPA–HQ–OAR–2014–0827.

[926] *http://www.census.gov/manufacturing/asm/index.html*; see ''HD Substitution Effect Employment Impacts,'' Docket EPA–HQ–OAR–2014–0827.

Manufacturing sector, the ASM and EC have detail at the 6-digit NAICS code level (*e.g.,* light truck and utility vehicle manufacturing). While the ERM provides direct estimates of employees/ $1 million in expenditures, the ASM and EC separately provide number of employees and value of shipments; the direct employment estimates here are the ratio of those values. The values reported are for Motor Vehicle Manufacturing (NAICS 3361), Light Truck and Utility Vehicle Manufacturing (NAICS 336112), Heavy Duty Truck Manufacturing (NAICS 33612), Motor Vehicle Body and Trailer manufacturing (NAICS 3362), and Motor Vehicle Parts Manufacturing (NAICS 3363).

RIA Chapter 8.11.2.2 provides the details on the values of workers per $1 million in expenditures in 2014 (2012 for EC) for the sectors mentioned above. In 2013$, these range from 0.4 workers per $1 million for Motor Vehicle Manufacturing in the ERM as well as for Light Truck & Utility Vehicle Manufacturing in the ASM, to 3.5 workers per $1 million in expenditures for Motor Vehicle Body and Trailer Manufacturing in the EC. These values are then adjusted to remove the employment effects of imports through use of a ratio of domestic production to domestic sales of 0.78.[927]

Over time, the amount of labor needed in the motor vehicle industry has changed: Automation and improved methods have led to significant productivity increases. The BLS ERM, for instance, provided estimates that, in 1997, 1.09 workers in the Motor Vehicle Manufacturing sector were needed per $1 million, but only 0.39 workers by 2014 (in 2013$).[928] Because the ERM is available annually for 1997–2014, we used these data to estimate productivity improvements over time. We then used these productivity estimates to project the ERM through 2027, and to adjust the ASM values for 2014 and the EC values for 2012. RIA Chapter 8.11.2 provides detail on these calculations.

Finally, to simplify the presentation and give a range of estimates, we compared the projected employment among the 3 sectors for the ERM, EC, and ASM, and we provide only the maximum and minimum employment effects estimated across the ERM, EC, and ASM. We provide the range rather than a point estimate because of the inherent difficulties in estimating employment impacts; the range gives an estimate of the expected magnitude. The ERM estimates in the Motor Vehicle Manufacturing Sector are consistently the minimum values. The ASM estimates in the Motor Vehicle Body and Trailer Manufacturing Sector are the maximum values for all years but 2027, when the ASM values for Motor Vehicle Parts Manufacturing provide the maximum values.

Section IX.B. of the Preamble discusses the vehicle cost estimates developed for these final rules. The final step in estimating employment impacts is to multiply costs (in $ millions) by workers per $1 million in costs, to estimate employment impacts in the regulated and parts manufacturing sectors. Increased costs of vehicles and parts will, by itself, and holding labor intensity constant, be expected to increase employment between 2018 and 2027 between zero and 4.5 thousand jobs each year.

While we estimate employment impacts, measured in job-years, beginning with program implementation, some of these employment gains may occur earlier as motor vehicle manufacturers and parts suppliers hire staff in anticipation of compliance with the standards. A job-year is a way to calculate the amount of work needed to complete a specific task. For example, a job-year is one year of work for one person.

TABLE IX–33—EMPLOYMENT EFFECTS DUE TO INCREASED COSTS OF VEHICLES AND PARTS (SUBSTITUTION EFFECT), IN JOB-YEARS

Year	Costs (millions of 2013$)	Minimum employment due to substitution effect (ERM estimates, expenditures in the Motor Vehicles Mfg sector)	Maximum employment due to substitution effect (ASM estimates, expenditures in the Body and Trailer Mfg sector[a])
2018	227	0	400
2019	215	0	400
2020	220	0	300
2021	2,270	300	3,100
2022	2,243	300	2,900
2023	2,485	300	2,900
2024	3,890	400	4,200
2025	4,146	400	4,100
2026	4,203	400	3,800
2027	5,219	500	4,500

Note:
[a] For 2027, the maximum employment effects are associated with the ASM's Motor Vehicle Parts Manufacturing sector.

(c) Summary of Employment Effects in the Motor Vehicle Sector

The overall effect of these final rules on motor vehicle sector employment depends on the relative magnitude of the output effect and the substitution effect. Because we do not have quantitative estimates of the output effect, and only a partial estimate of the substitution effect, we cannot reach a quantitative estimate of the overall employment effects of these final rules on motor vehicle sector employment or even whether the total effect will be positive or negative.

These standards are not expected to provide incentives for manufacturers to shift employment between domestic and

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[927] To estimate the proportion of domestic production affected by the change in sales, we use data from Ward's Automotive Group for total truck production in the U.S. compared to total truck sales in the U.S. For the period 2006–2015, the proportion is 78 percent (HD Substitution Effect Employment Impacts, Docket EPA–HQ–OAR–2014–0827), ranging from 68 percent (2009) to 83 percent (2012) over that time.

[928] *http://www.bls.gov/emp/ep_data_emp_requirements.htm*; see ''HD Substitution Effect Employment Impacts,'' Docket EPA–HQ–OAR–2014–0827. This analysis used data for sectors 80 (Motor Vehicle Manufacturing), 81 (Motor Vehicle Body and Trailer Manufacturing), and 82 (Motor Vehicle Parts Manufacturing) from ''Chain-weighted (2009 dollars) real domestic employment requirements tables.''

foreign production. This is because these standards will apply to vehicles sold in the U.S. regardless of where they are produced. If foreign manufacturers already have increased expertise in satisfying the requirements of the standards, there may be some initial incentive for foreign production, but the opportunity for domestic manufacturers to sell in other markets might increase. To the extent that the requirements of these final rules might lead to installation and use of technologies that other countries may seek now or in the future, developing this capacity for domestic production now may provide some additional ability to serve those markets.

(3) Employment Impacts in Other Affected Sectors

(a) Transport and Shipping Sectors

Although not directly regulated by these final rules, employment effects in the transport and shipping sector are likely to result from these regulations. If the overall cost of shipping a ton of freight decreases because of increased fuel efficiency (taking into account the increase in upfront purchasing costs), in a perfectly competitive industry some of these costs savings, depending on the relative elasticities of supply and demand, will be passed along to customers. Consumer Federation of America expects reduced shipping costs to be passed along to customers. With lower prices, demand for shipping would lead to an increase in demand for truck shipping services (consistent with the VMT rebound effect analysis) and therefore an increase in employment in the truck shipping sector. In addition, if the relative cost of shipping freight via trucks becomes cheaper than shipping by other modes (*e.g.,* rail or barge), then employment in the truck transport industry is likely to increase. If the trucking industry is more labor intensive than other modes, we would expect this effect to lead to an overall increase in employment in the transport and shipping sectors.[929] [930] Such a shift would, however, be at the expense of employment in the sectors that are losing business to trucking. The first effect—a gain due to lower shipping costs—is likely to lead to a net increase in employment. The second effect, due to mode-shifting, may increase employment in trucking, but decrease employment in other shipping sectors (*e.g.,* rail or barge), with the net effects dependent on the labor-intensity of the sectors and the volumes.

(b) Fuel Suppliers

In addition to the effects on the trucking industry and related truck parts sector, these final rules will result in reductions in fuel use that lower GHG emissions. Fuel saving, principally reductions in liquid fuels such as diesel and gasoline, will affect employment in the fuel suppliers industry sectors, principally the Petroleum Refinery sector.

Section IX.C. of this Preamble provides estimates of the effects of these standards on expected fuel consumption. While reduced fuel consumption represents savings for purchasers of fuel, it also represents a loss in value of output for the petroleum refinery industry, which will result in reduced sectoral employment. Because this sector is material-intensive, the employment effect is not expected to be large.[931]

(c) Fuel Savings

As a result of this final rulemaking, it is anticipated that trucking firms will experience fuel savings. Fuel savings lower the costs of transportation goods and services. In a competitive market, some of the fuel savings that initially accrue to trucking firms are likely to be passed along as lower transportation costs that, in turn, could result in lower prices for final goods and services. Some commenters provide estimates of per-household fuel savings ranging from $150 per year by 2030 (Clean Fuels Ohio, Edison Solar, a mass comment campaign sponsored by Pew Charitable Trusts, Quasar Energy Group), to $400 in 2035 (Environmental Defense Fund); they view these savings as providing benefits to the wider economy. The National Ready Mixed Concrete Association emphasizes concerns about the costs that the standards will impose. Although the agencies do not endorse the particular values provided in the comments, we agree that the standards will provide net benefits to the U.S.; as shown in Section IX.K., the benefits exceed the costs by a wide margin. As noted above, the Consumer Federation of America expects consumers to recover these fuel savings via the costs of goods and services relying on HD vehicles. The agencies note that some of the savings might also be retained by firms for investments or for distributions to firm owners. Again, how much accrues to customers versus firm owners will depend on the relative elasticities of supply and demand. Regardless, the savings will accrue to some segment of consumers: Either owners of trucking firms or the general public, and the effect will be increased spending by consumers in other sectors of the economy, creating jobs in a diverse set of sectors, including retail and service industries.

As described in Section IX.C.(2), the retail value of fuel savings from this final rulemaking is projected to be $15.8 billion (2013$) in 2027, according to Table IX–6. If all those savings are spent, the fuel savings will stimulate increased employment in the economy through those expenditures. If the fuel savings accrue primarily to firm owners, they may either reinvest the money or take it as profit. Reinvesting the money in firm operations could increase employment directly. If they take the money as profit, to the extent that these owners are wealthier than the general public, they may spend less of the savings, and the resulting employment impacts would be smaller than if the savings went to the public. Thus, while fuel savings are expected to decrease employment in the refinery sector, they are expected to increase employment through increased consumer expenditures.

(4) Summary of Employment Impacts

The primary employment effects of these rules are expected to be found throughout several key sectors: Truck and engine manufacturers, the trucking industry, truck parts manufacturing, fuel production, and consumers. These rules initially takes effect in model year 2018; the unemployment rate at that time is unknowable. In an economy with full employment, the primary employment effect of a rulemaking is likely to be to move employment from one sector to another, rather than to increase or decrease employment. For that reason, we focus our partial quantitative analysis on employment in the regulated sector, to examine the impacts on that sector directly. We discuss the likely direction of other impacts in the regulated sector as well as in other directly related sectors, but we do not quantify those impacts, because they are more difficult to quantify with reasonable accuracy, particularly so far into the future.

For the regulated sector, we have not quantified the output effect. The

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[929] American Transportation Research Institute, ''An Analysis of the Operational Costs of Trucking: 2011 Update.'' *See http://www.atri-online.org/research/results/Op_Costs_2011_Update_one_page_summary.pdf,* Docket EPA–HQ–OAR–2014–0827–512.

[930] Association of American Railroads, ''All Inclusive Index and Rail Adjustment Factor.'' June 3, 2011. *See http://www.aar.org/~/media/aar/RailCostIndexes/AAR-RCAF-2011-Q3.ashx,* Docket EPA–HQ–OAR–2014–0827–0065.

[931] In the 2014 BLS ERM cited above, the Petroleum and Coal Products Manufacturing sector has a ratio of workers per $1 million of 0.215, lower than all but two of the 181 sectors with non-zero employment per $1 million.

substitution effect is associated with potential increased employment between zero and 4.5 thousand jobs per year between 2018 and 2027, depending on the share of employment impacts in the affected sectors (Motor Vehicle Manufacturing, Motor Vehicle Body and Trailer Manufacturing, and Motor Vehicle Parts Manufacturing). These estimates do not include potential changes, either greater or less, in labor intensity of production. As mentioned above, some of these job gains may occur earlier as auto manufacturers and parts suppliers hire staff to prepare to comply with the standard.

Lower prices for shipping are expected to lead to an increase in demand for truck shipping services and, therefore, an increase in employment in that sector, though this effect may be offset somewhat by changes in employment in other shipping sectors. Reduced fuel production implies less employment in the fuel provision sectors. Finally, any net cost savings are expected to be passed along to some segment of consumers: Either the general public or the owners of trucking firms, who are expected then to increase employment through their expenditures. Under conditions of full employment, any changes in employment levels in the regulated sector due to this program are mostly expected to be offset by changes in employment in other sectors.

M. Cost of Ownership and Payback Analysis

This section examines the economic impacts of the Phase 2 standards from the perspective of buyers, operators, and subsequent owners of new HD vehicles at the level of individual purchasers of different types of vehicles. In each case, the analysis assumes that HD vehicle manufacturers are able to recover their costs for improving fuel efficiency—including direct technology outlays, indirect costs, and normal profits on any additional capital investments—by charging higher prices to HD vehicle buyers.

Table IX–34 reports aggregate benefits and costs to buyers and operators of new HD vehicles for the final program using Method A. The table reports economic impacts on buyers using only the 7 percent discount rate, since that rate is intended to represent the opportunity cost of capital that HD vehicle buyers and users must divert from other investment opportunities to purchase more costly vehicles. As it shows, fuel savings and the other benefits from increased fuel efficiency—savings from less frequent refueling and benefits from additional truck use—far outweigh the higher costs to buyers of new HD vehicles. As a consequence, buyers, operators, and subsequent owners of HD vehicles subject to the Phase 2 standards are together projected to experience large economic gains under the final program. It should be noted that, because the original buyers may not hold the vehicles for their lifetimes, and because those who own or operate the vehicles may not pay for the fuel, these benefits and costs do not necessarily represent benefits and costs to identifiable individuals.

As Table IX–34 shows, the agencies have estimated the increased costs for maintenance of the new technologies that HD vehicle manufacturers will employ to decrease fuel consumption, and these costs are included together with those for purchasing more fuel-efficient vehicles. Manufacturers' efforts to comply with the Phase 2 standards could also result in changes to vehicle performance and capacity for certain vehicles. For example, reducing the mass of HD vehicles in order to improve fuel efficiency could be used to improve their load-carrying capabilities, while some engine technologies and aerodynamic modifications could reduce payload capacity.

TABLE IX–34—MY 2018–2029 LIFETIME AGGREGATE IMPACTS OF THE FINAL PROGRAM ON ALL HD VEHICLE BUYERS AND OPERATORS USING METHOD A

[Billions of 2013$, Discounted at 7%] [a]

	Baseline 1a	Baseline 1b
Vehicle costs	16.6	16.1
Maintenance costs	0.9	0.9
Total costs to HD vehicle buyers	17.5	17.0
Fuel savings [b] (valued at retail prices)	97.7	89.5
Refueling benefits	1.7	1.6
Increased travel benefits	3.5	3.4
Total benefits to HD vehicle buyers/operators	103	94.5
Net benefits to HD vehicle buyers/operators [c]	85.4	77.5

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the less dynamic baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

[b] Fuel savings includes fuel consumed during additional rebound driving.

[c] Net benefits shown do not include benefits associated with carbon or other co-pollutant emission reductions, crash/congestion/noise impacts, energy security, etc.

It is also useful to examine the cost of purchasing and owning a new vehicle that complies with the Phase 2 standards and its payback period—the point at which cumulative savings from lower fuel expenditures outpace increased vehicle costs. For example, a new MY 2027 tractor is estimated to cost roughly $13,550 more (on average, or roughly 13 to 14 percent of a typical $100,000 reference case tractor) due to the addition of new GHG reducing/fuel consumption improving technology. This new technology will result in lower fuel consumption and, therefore, reduced fuel expenditures. But how many months or years will pass before the reduced fuel expenditures will surpass the increased upfront costs?

Table IX–35 presents the discounted annual increased vehicle costs and fuel savings associated with owning a new MY 2027 HD pickup or van using both 3 percent and 7 percent discount rates. Table IX–36 and Table IX–37 show the same information for a MY 2027 vocational vehicle and a tractor/trailer, respectively. These comparisons include sales taxes, excise taxes (for vocational and tractor/trailer) and increased insurance expenditures on the higher value vehicles, as well as maintenance costs throughout the lifetimes of affected vehicles.

The fuel expenditure column uses retail fuel prices specific to gasoline and diesel fuel as projected in AEO2015.[932] This payback analysis does not include other impacts, such as reduced refueling events, the value of driving potential rebound miles, or noise, congestion and crashes. We use retail fuel prices and exclude these other private and social impacts because the analysis is intended to focus on those factors that are most important to buyers when considering a new vehicle purchase, and to include only those factors that have clear dollar impacts on HD vehicle buyers.

As shown, payback will occur in the 3rd year of ownership for HD pickups and vans (the first year where cumulative net costs turn negative), in the 4th year for vocational vehicles and early in the 2nd year for tractor/trailers. Note that each table reflects the average vehicle and reflects proper weighting of fuel consumption/costs (gasoline vs. diesel).

TABLE IX–35—DISCOUNTED ANNUAL INCREMENTAL EXPENDITURES FOR A MY 2027 HD PICKUP OR VAN USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[2013$] [a]

Age in years	3% Discount rate				7% Discount rate			
	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net
1	−$1,451	−$4	$550	−$905	−$1,424	−$4	$540	−$888
2	−25	−4	539	−395	−24	−3	509	−406
3	−24	−3	527	105	−21	−3	479	49
4	−22	−3	515	595	−19	−3	451	477
5	−21	−3	492	1,064	−17	−3	415	872
6	−19	−3	469	1,511	−16	−2	381	1,235
7	−18	−3	446	1,936	−14	−2	348	1,567
8	−17	−2	423	2,340	−13	−2	318	1,870

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] Includes new technology costs, insurance costs and sales taxes.

[c] Maintenance costs.

[d] Uses AEO2015 retail fuel prices.

TABLE IX–36—DISCOUNTED ANNUAL INCREMENTAL EXPENDITURES FOR A MY 2027 VOCATIONAL VEHICLE USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[2013$] [a]

Age in years	3% Discount rate				7% Discount rate			
	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net
1	−$3,147	−$25	$1,022	−$2,151	−$3,088	−$25	$1,003	−$2,110
2	−49	−24	1,004	−1,220	−46	−23	948	−1,231
3	−46	−24	987	−303	−42	−21	898	−397
4	−43	−23	970	602	−38	−20	849	394
5	−40	−21	909	1,450	−34	−18	766	1,109
6	−38	−19	850	2,243	−31	−15	689	1,752
7	−35	−17	796	2,987	−27	−14	622	2,333
8	−33	−16	743	3,681	−25	−12	558	2,854

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] Includes new technology costs, insurance costs, excise and sales taxes.

[c] Maintenance costs.

[d] Uses AEO2015 retail fuel prices.

TABLE IX–37—DISCOUNTED ANNUAL INCREMENTAL EXPENDITURES FOR A MY 2027 TRACTOR/TRAILER USING METHOD B AND RELATIVE TO THE FLAT BASELINE

[2013$] [a]

Age in years	3% Discount rate				7% Discount rate			
	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net
1	−$16,022	−$169	$15,310	−$880	−$15,719	−$166	$15,021	−$864
2	−251	−163	15,095	13,801	−237	−154	14,256	13,002
3	−235	−158	14,872	28,280	−214	−144	13,521	26,166

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[932] U.S. Energy Information Administration, Annual Energy Outlook 2015; Report Number DOE/EIA–0383(2015), April 2015.

TABLE IX–37—DISCOUNTED ANNUAL INCREMENTAL EXPENDITURES FOR A MY 2027 TRACTOR/TRAILER USING METHOD B AND RELATIVE TO THE FLAT BASELINE—Continued

[2013$] [a]

Age in years	3% Discount rate				7% Discount rate			
	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net	Vehicle [b]	Maint [c]	Fuel [d]	Cumulative net
4	−220	−153	14,637	42,545	−192	−134	12,809	38,649
5	−206	−140	13,683	55,882	−173	−118	11,527	49,885
6	−192	−127	12,730	68,292	−156	−103	10,323	59,950
7	−179	−116	11,880	79,878	−140	−90	9,274	68,993
8	−166	−105	11,025	90,630	−125	−79	8,285	77,074

Notes:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

[b] Includes new technology costs, insurance costs, excise and sales taxes.

[c] Maintenance costs.

[d] Uses AEO2015 retail fuel prices.

N. Safety Impacts

(1) Summary of Supporting HD Vehicle Safety Research

As discussed in the Notice of Proposed Rulemaking, NHTSA and EPA considered the potential safety impact of technologies that improve Medium – and Heavy-Duty vehicle fuel efficiency and GHG emissions when determining potential regulatory alternatives. The safety assessment of the technologies in this rule was informed by two comprehensive NAS reports, an extensive analysis of safety effects of HD pickups and vans using estimates from the DOT report on the effect of mass reduction and vehicle size on safety, and focused agency-sponsored safety testing and research. The following section provides a concise summary of the literature and work considered by the agencies in development of this final rule.

(a) National Academy of Sciences Medium and Heavy Duty Phase 1 and Phase 2 Reports

As required by EISA, the National Research Council has been conducting continuing studies of the technologies and approaches for reducing the fuel consumption of medium- and heavy-duty vehicles. The first was a report issued in 2010, ‘‘Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles’’ (‘‘NAS Report’’). The second was a report issued in 2014, ‘‘Reducing the Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two-First Report’’ (‘‘NAS HD Phase 2 First Report’’). While the reports primarily focused on reducing vehicle fuel consumption and emissions through technology application, and examined potential regulatory frameworks, both reports contain findings and recommendations related to safety. In developing this rule, the agencies carefully considered the reports’ findings related to safety.

In particular, NAS indicated that idle reduction strategies can also accommodate for the safety of the driver in both hot and cold weather conditions. The agencies considered this potential approach for application of idle reduction technologies by allowing for override provisions, as defined in 40 CFR 1037.660(b), where operator safety is a primary consideration. Override is allowed if the external ambient temperature reaches a level below which or above which the cabin temperature cannot be maintained within reasonable heat or cold exposure threshold limit values for the health and safety of the operator (not merely comfort).

NAS also reported extensively on the emergence of natural gas (NG) as a viable fuel option for commercial vehicles, but alluded to the existence of uncertainties regarding its safety. The committee found that while the public crash databases do not contain information on vehicle fuel type, the information, at the time of the report, indicates that the crash-related safety risk for NG storage on vehicles does not appear to be appreciably different from diesel fuel risks. The committee also found that while there are two existing SAE-recommended practice standards for NG-powered HD vehicles, the industry could benefit from best practice directives to minimize crash risks for NG fuel tanks, such as on shielding to prevent punctures during crashes. As a final point, NAS stated that manufacturers and operators have a great incentive to prevent possible NG leakage from a vehicle fuel system because it will be a significant safety concern and reduce vehicle range. No recommendations were made for additional Federal safety regulations for these vehicles. In response, the agencies reviewed and discussed the existing NG vehicle standards and best practices cited by NAS in Section XI of the NPRM.

In the NAS Committee’s Phase 1 report, the Committee indicated that aerodynamic fairings detaching from trucks on the road could be a potential safety issue. However, the Phase 2 interim report stated that ‘‘Anecdotal information gained during the observations of on-road trailers indicates a few skirts badly damaged or missing from one side. The skirt manufacturers report no safety concerns (such as side skirts falling off) and little maintenance needed.’’

The NAS report also identified the link between tire inflation and condition and vehicle stopping distance and handling, which impacts overall safety. The committee found that tire pressure monitoring systems and automatic tire inflation systems are being adopted by fleets at an increasing rate. However, the committee noted that there are no standards for performance, display, and system validation. The committee recommended that NHTSA issue a white paper on the minimum performance of tire pressure systems from a safety perspective.

The agencies considered the safety findings in both NAS reports in developing this rule and conducted additional research on safety to further examine information and findings of the reports.

(b) DOT CAFE Model Heavy-Duty Pickup and Van Safety Analysis

This analysis considered the potential crash safety effects on the technologies manufacturers may apply to HD pickups and vans to meet each of the regulatory alternatives evaluated in the NPRM. NHTSA research has shown that vehicle mass reduction affects overall societal fatalities associated with crashes and, most relevant to this rule, that mass reduction in heavier light- and medium-duty vehicles has an overall beneficial effect on societal fatalities. Reducing the mass of a heavier vehicle involved in a multiple vehicle crash reduces the likelihood of fatalities among the occupants of the other vehicle(s). In addition to the effects of mass reduction, the analysis anticipates that these standards, by reducing the cost of driving HD pickups and vans, will lead to increased travel by these vehicles and, therefore, more crashes involving these vehicles. Both the Method A and B analyses, both of which are included in the NPRM and are part of this final rulemaking, consider overall impacts from both of these factors, using a methodology similar to NHTSA's analyses for the MYs 2017–2025 CAFE and GHG emission standards.

The Method A analysis included estimates of the extent to which HD pickups and vans produced during MYs 2014–2030 may be involved in fatal crashes, considering the mass, survival, and mileage accumulation of these vehicles, taking into account changes in mass and mileage accumulation under each regulatory alternative. These calculations make use of the same coefficients applied to light trucks in the MYs 2017–2025 CAFE rulemaking analysis. As discussed above, vehicle miles traveled may increase due to the fuel economy rebound effect, resulting from improvements in vehicle fuel efficiency and cost of fuel, as well as the assumed future growth in average vehicle use. Increases in total lifetime mileage increase exposure to vehicle crashes, including those that result in fatalities. Consequently, the modeling system computes total fatalities attributed to vehicle use for vehicles of a given model year based on safety class and weight threshold. These calculations also include a term that accounts for the fact that some of the vehicles involved in future crashes will comply with more stringent safety standards than those involved in past crashes upon which the base rates of involvement in fatal crashes were estimated. Since the use of mass reducing technology is present within the model, safety impacts may also be observed whenever a vehicle's base weight decreases. Thus, in addition to computing total fatalities related to vehicle use, the modeling system also estimates changes in fatalities due to reduction in a vehicle's curb weight.

The total fatalities attributed to vehicle use and vehicle weight change for vehicles of a given model year are then summed. Lastly, total fatalities occurring within the industry in a given model year are accumulated across all vehicles. In addition to using inputs to estimate the future involvement of modeled vehicles in crashes involving fatalities, the model also applies inputs defining other crash-related externalities estimated on a dollar per mile basis. For vehicles above 4,594 lbs—*i.e.,* the majority of the HD pickup and van fleet—mass reduction is estimated to reduce the net incidence of highway fatalities by 0.34 percent per 100 lbs of removed curb weight. For the few HD pickups and vans below 4,594 lbs, mass reduction is estimated to increase the net incidence of highway fatalities by 0.52 percent per 100 lbs. The overall effect of mass reduction in the segment is estimated to reduce the incidence of highway fatalities as there are more HD pickups and vans above 4,594 lbs than below. The projected increase in vehicle miles traveled, due to the fuel economy rebound effect, also potentially increases exposure to vehicle crashes and offsets these reductions.

(c) Volpe Research on MD/HD Fuel Efficiency Technologies

The 2010 National Research Council report ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles'' recommended that NHTSA perform a thorough safety analysis to identify and evaluate potential safety issues with fuel efficiency-improving technologies. The Department of Transportation Volpe Center's 2015 report titled ''Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles'' summarizes research and analysis findings on potential safety issues associated with both the diverse alternative fuels (natural gas-CNG and LNG, propane, biodiesel, and power train electrification), and the specific FE technologies recently adopted by the MD/HDV fleets.[933] These include Intelligent Transportation Systems (ITS) and telematics, speed limiters, idle reduction devices, tire technologies (single-wide tires, and tire pressure monitoring systems-TPMS and Automated Tire Inflation Systems-ATIS), aerodynamic components, vehicle light-weighting materials, and Long Combination Vehicles (LCVs).

Chapter 1 provides an overview of the study's rationale, background, and key objective, namely, to identify the technical and operational/behavioral safety benefits and disbenefits of MD/HDVs equipped with FE technologies and using emerging alternative fuels (AFs). Recent MD/HDV national fleet crash safety statistical averages are also provided for context, although no information exists in crash reports relating to specific vehicle FE technologies and fuels. (NHTSA/FARS and FMCSA/CSA databases do not include detailed information on vehicle fuel economy technologies, since the state crash report forms are not coded down to an individual fuel economy technology level).

Chapters 2 and 3 are organized by clusters of functionally-related FE technologies for vehicles and trailers (*e.g.,* tire systems, ITS, light-weighting materials, and aerodynamic systems) and alternative fuels, which are described and their respective associated potential safety issues are discussed. Chapter 2 summarizes the findings from a comprehensive review of available technical and trade literature and Internet sources regarding the benefits, potential safety hazards, and the applicable safety regulations and standards for deployed FE technologies and alternative fuels. Chapter 2 safety-relevant fuel-specific findings include:

- Both CNG- and LNG-powered vehicles present potential hazards, and call for well-known engineering and process controls to assure safe operability and crashworthiness. However, based on the reported incident rates of NGVs and the experiences of adopting fleets, it appears that NGVs can be operated at least as safely as diesel MD/HDVs.
- There are no safety contraindications to the large scale fleet adoption of CNG or LNG fueled heavy duty trucks and buses, and there is ample experience with the safe operation of large public transit fleets. Voluntary industry standards and best practices suffice for safety assurance, though improved training of CMV operators and maintenance staff in natural gas safety of equipment and operating procedures is needed.
- Observing CNG and LNG fuel system and maintenance facility standards, coupled with sound design, manufacture, and inspection of natural gas storage tanks will further reduce the

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[933] Brecher, A., Epstein, A. K., & Breck, A. (2015, June). *Review and analysis of potential safety impacts of and regulatory barriers to fuel efficiency technologies and alternative fuels in medium- and heavy-duty vehicles.* (Report No. DOT HS 812 159). Washington, DC: National Highway Traffic Safety Administration.

potential for leaks, tank ruptures, fires, and explosions.

- Biodiesel blends used as drop-in fuels have presented some operational safety concerns dependent on blending fraction, such as material compatibility, bio-fouling sludge accumulation, or cold-weather gelling. However, best practices for biodiesel storage, and improved gaskets and seals that are biodiesel resistant, combined with regular maintenance and leak inspection schedules for the fuel lines and components enable the safe use of biodiesel in newer MD/HDVs.
- Propane (LPG, or autogas) presents well-known hazards including ignition (due to leaks or crash) that are preventable by using Overfill Prevention Devices (OPDs), which supplement the automatic stop-fill system on the fueling station side, and pressure release devices (PRDs). Established best practices and safety codes (*e.g.,* NFPA) have proven that propane fueled MD/HDVs can be as operationally safe as the conventionally-fueled counterparts.
- As the market penetration of hybrid and electric drivetrain accelerates, and as the capacity and reliability of lithium ion batteries used in Rechargeable Energy Storage Systems (RESS) improve, associated potential safety hazards (*e.g.,* electrocution from stranded energy, thermal runaway leading to battery fire) have become well understood, preventable, and manageable. Existing and emerging industry technical and safety voluntary standards, applicable NHTSA regulations and guidance, and the growing experience with the operation of hybrid and electric MD/HDVs will enable the safe operation and large-scale adoption of safer and more efficient power-train electrification technologies.

The safety findings from literature review pertaining to the specific FE technologies implemented to date in the MD/HDV fleet include:

- Telematics—integrating on-board sensors, video, and audio alerts for MD/HDV drivers—offer potential improvements in both driver safety performance and fuel efficiency. Both camera and non-camera based telematics setups are currently integrated with available crash avoidance systems (such as ESC, RSC, LDWS, etc.) and appear to be well accepted by MD/HDV fleet drivers.
- Both experience abroad and the cited US studies of trucks equipped with active speed limiters indicated a safety benefit, as measured by up to 50 percent reduced crash rates, in addition to fuel savings and other benefits, with good CMV driver acceptance. Any negative aspects were small and avoidable if all the speed limitation devices were set to the same speed, so there will be less need for overtaking at highway speeds.
- No literature reports of adverse safety impacts were found regarding implementation of on-board idle-reduction technologies in MD/HDVs (such as automatic start-stop, direct-fired heaters, and APUs).
- There was no clear consensus from the literature regarding the relative crash rates and highway safety impacts of LCVs, due to lack of sufficient data and controls and inconsistent study methodologies. Recent safety evaluations of LCVs and ongoing MAP–21 mandated studies will clarify and quantify this issue.
- Tire technologies for FE (including ATIS, TPMS, LRR and single-wide tires) literature raised potential safety concerns regarding lower stability or loss of control, *e.g.,* when tire pressure is uneven or a single wide tire blows out on the highway. However, systems such as automated tire monitoring systems and stability enhancing electronic systems (ABS, ESC, and RSC) may compensate and mitigate any adverse safety impacts.
- Aerodynamic technologies that offer significant fuel savings have raised potential concerns about vehicle damage or injury in case of detached fairings or skirts, although there were no documented incidents of this type in the literature.
- Some light weighting materials may pose some fire safety and crashworthiness hazards, depending on their performance in structural or other vehicle subsystem applications (chassis, powertrain, and crash box or safety cage). Some composites (fiberglass, plastics, CFRC, foams) may become brittle on impact or due to weathering from UV exposure or extreme cold. Industry has developed advanced, high performance lightweight material options tailored to their automotive applications, *e.g.,* thermoplastics resistant to UV and weathering. No examples of such lightweight material failures on MD/HDVs were identified in the literature.

Chapter 3 provides complementary inputs on the potential safety issues associated with FE technologies and alternative fuels obtained from Subject Matter Experts (SMEs). The broad cross-section of SMEs consulted had experience with the operation of ''green'' truck and bus fleets, were Federal program managers, or were industry developers of FE systems for MD/HDVs. Safety concerns raised by the SMEs can be prevented or mitigated by complying with applicable regulations and safety standards and best practices, and are being addressed by evolving technologies, such as electronic collision prevention devices. Although SMEs raised some safety concerns, their experience indicates that system- or fuel-specific hazards can be prevented or mitigated by observing applicable industry standards, and by training managers, operators and maintenance staff in safety best practices. Specific safety concerns raised by SMEs based on their experience included:

- Alternative fuels did not raise major safety concerns, but generally required better education and training of staff and operators. There was a concern expressed regarding high pressure (4000 psi) CNG cylinders that could potentially explode in a crash scenario or if otherwise ruptured. However, aging CNG fuel tank safety can be assured by enforcing regulations such as FMVSS No. 304, and by periodic inspection and end-of-life disposal and replacement. A propane truck fleet manager stated that the fuel was as safe as or safer than gasoline, and reported no safety issues with the company's propane, nor with hybrid gasoline-electric trucks. OEMs of drivetrain hybridization and electrification systems, including advanced Lithium Ion batteries for RESS, indicated that they undergo multiple safety tests and are designed with fail-safes for various misuse and abuse scenarios. Integration of hybrid components downstream by bodybuilders in retrofits, as opposed to new vehicles, was deemed a potential safety risk. Another potential safety concern raised was the uncertain battery lifetime due to variability of climate, duty-cycles, and aging. Without state-of-charge indicators, this could conceivably leave vehicles underpowered or stranded if the battery degrades and is not serviced or replaced in a timely manner.
- ITS and telematics raised no safety concerns; on the contrary, fleet managers stated that ''efficient drivers are safer drivers.'' Monitoring and recording of driver behavior, combined with coaching, appeared to reduce distracted and aggressive driving and provided significant FE and safety benefits.
- A wide-base single tire safety concern was the decrease in tire redundancy in case of a tire blowout at highway speeds. For LRRs, a concern was that they could negatively affect truck stopping distance and stability control.
- A speed-limiter safety concern was related to scenarios when such trucks pass other vehicles on the highway instead of staying in the right-hand lane

behind other vehicles. By combining speed limiters with driver training programs, overall truck safety could actually improve, as shown by international practice.

- Aerodynamic systems' safety performance to date was satisfactory, with no instances of on-road detaching. However, covering underside or other components with aerodynamic fairings can make them harder to inspect, such as worn lugs, CNG relief valve shrouds, wheel covers, and certain fairings. Drivers and inspectors need to be able to see through wheel covers and to be able to access lug nuts through them. These covers must also be durable to withstand frequent road abuse.
- For lightweighting materials, the safety concern raised was lower crashworthiness (debonding or brittle fracture on impact) and the potential for decreased survivability in vehicle fires depending on the specific material choice and its application.

The key finding from the literature review and SME interviews is that there appear to be no major safety hazards preventing the adoption of FE technologies, or the increased use of alternative fuels and vehicle electrification. In view of the scarcity of hard data currently available on actual highway crashes that can be directly or causally attributed to adoption of FE technologies and/or alternative fuels by MD/HDVs, and the limited experience with commercial truck and transit bus fleets operations equipped with these technologies, it was not possible to perform a quantitative, probabilistic risk assessment, or even a semi-quantitative preliminary hazard analysis (PHA). Chapter 4 employs a deterministic scenario-based hazard analysis of potential crash or other safety concerns identified from the literature review or raised by subject matter experts (SMEs) interviewed (*e.g.,* interfaces with charging or refueling infrastructure). For each specific hazard scenario discussed, the recommended prevention or mitigation options, including compliance with applicable NHTSA or FMCSA regulations, and voluntary industry standards and best practices are identified, along with FE technology or fuel-specific operator training. SMEs safety concerns identified in Sec 3.3 were complemented with actual incidents, and developed into the hazard scenarios analyzed in Chapter 4.

The scenario-based deterministic hazard analysis reflected not only the literature findings and SMEs' safety concerns, but also real truck or bus mishaps that have occurred in the past. Key hazard analysis scenarios included: CNG-fueled truck and bus vehicle fires or explosions due to tank rupture, when pressurized fuel tanks were degraded due to aging or when PRDs failed; LNG truck crashes leading to fires, or LNG refueling-related mishaps; the flammability or brittle fracture issues related to light weighting materials in crashes; reduced safety performance for either LRR or wide-base tires; highway pile-ups when LCVs attempt to pass at highway speeds; aerodynamic components detaching while the vehicle traveled on a busy highway or urban roadway; and fires resulting in overheated lithium ion batteries in electric or hybrid buses. These hypothetical worst case scenarios appear to be preventable or able to be mitigated by observing safety regulations and voluntary standards, or with engineering and operational best practices.

Chapter 5 reviews and discusses the existing federal and state regulatory framework for safely operating MD/HDVs equipped with FE technologies or powered by alternative fuels. The review identifies potential regulatory barriers to their large-scale deployment in the national fleet that could delay achievement of desired fuel consumption and environmental benefits, while ensuring equal or better safety performance.

Chapter 6 summarizes the major findings and recommendations of this preliminary safety analysis of fuel efficiency technologies and alternative fuels adopted by MD/HDVs. The scenario-based hazard analysis, based on the literature review and experts' inputs, indicates that MD/HDVs equipped with advanced FE technologies and/or using alternative fuels have manageable potentially adverse safety impacts. The findings suggest that the potential safety hazards identified during operation, maintenance, and crash scenarios can be prevented or mitigated by complying with safety regulations and voluntary standards and industry best practices. The study also did not identify any major regulatory barriers to rapid adoption of FE technologies and alternative fuels by the MD/HDV fleet.

(d) Oak Ridge National Laboratory (ORNL) Research on Low Rolling Resistance Truck Tires

DOT's Federal Motor Carrier Safety Administration and NHTSA sponsored a test program conducted by Oak Ridge National Laboratory to explore the effects of tire rolling resistance levels on Class 8 tractor-trailer stopping distance performance over a range of loading and surface conditions. The objective was to determine whether a relationship exists between tire rolling resistance and stopping distance for vehicles of this type. The overall results of this research suggest that tire rolling resistance is not a reliable indicator of Class 8 tractor-trailer stopping distance.

The correlation coefficients (R2 values) for linear regressions of wet and dry stopping distance versus overall vehicle rolling resistance values did not meet the minimum threshold for statistical significance for any of the test conditions. Correlation between CRR and stopping distance was found to be negligible for the dry tests for both loading conditions. While correlation was higher for the wet testing (showing a slight trend in which lower CRRs correspond to longer stopping distances), it still did not meet the minimum threshold for statistical significance. In terms of compliance with Federal safety standards, it was found that the stopping distance performance of the vehicle with the four tire sets studied in this research (with estimated tractor CRRs which varied by 33 percent), were well under the FMVSS No. 121 stopping distance requirements.

(e) Additional Safety Considerations

The agencies considered the Organic Rankine Cycle waste heat recovery (WHR) as a fuel saving technology in the rulemaking timeframe. The basic approach of these systems is to use engine waste heat from multiple sources to evaporate a working fluid through a heat exchanger, which is then passed through a turbine or equivalent expander to create mechanical or electrical power. The working fluid is then condensed as it passes through a heat exchanger and returns to back to the fluid tank, and pulled back to the flow circuit through a pump to continue the cycle.

Despite the promising performance of pre-prototype WHR systems, manufacturers have not yet arrived at a consensus on which working fluid(s) to be used in WHR systems to balance concerns regarding performance, global warming potential (GWP), and safety. Working fluids have a high GWP (conventional refrigerant), are expensive (low GWP refrigerant), are hazardous (such as ammonia, etc.), are flammable (ethanol/methanol), or can freeze (water). One challenge is determining how to seal the working fluid properly under the vacuum condition and high temperatures to avoid safety issues for flammable/hazardous working fluids. Because of these challenges, choosing a working fluid will be an important factor for system safety, efficiency, and overall production viability.

The agencies believe manufacturers will require additional time and development effort to assure that a working fluid that is both appropriate, given the noted challenges, and has a low GWP for use in waste heat recovery systems. Based on this and other factors, the analysis used for both the proposed Preferred Alternative and for this final rule assumes that WHR will not achieve a significant market penetration for diesel tractor engines (*i.e.,* greater than 5 percent) until 2027, which will provide time for these considerations to be addressed. The agencies assume no use of this technology in the HD pickups and vans and vocational vehicle segments.

(2) Safety Related Comments to the NPRM

The agencies received safety related comments to the NPRM focused on the vehicle and operator safety benefits of central tire inflation systems, potential safety and traction impacts of low rolling resistance tires, and recommendations that NHTSA continue evaluations of potential safety impacts of fuel saving technologies.

AIR CTI, Inc., a supplier of central tire inflation systems, highlighted the safety benefits to both vehicle operation and the operators themselves through proper tire pressure management. More specifically, the proper tire inflation levels for the load being carried contributes to both proper handing for road conditions and reducing irregular road surface vibration from being transmission to vehicle component and, ultimately, the vehicle operator, where there may be potential health implications over prolonged exposure.

The agencies appreciate the additional points provided by AIR CTI in terms of not only the potential fuel efficiency benefits of central tire inflation systems but the potential equipment longevity benefits, vehicle dynamic impacts, and the potential to reduce driver fatigue and injury through proper tire inflation for the load being carried.

The American Trucking Associations (ATA) commented on the potential impact of Low Rolling Resistance Tires by indicating that, ‘‘The safety effects of LRRTs are not totally understood. While the ‘‘. . . agencies analysis indicate that this proposal should have no adverse impact on vehicle or engine safety,’’ ATA remains leery of potential unintended consequences resulting from new generation tires that have yet to be developed. This especially holds true in terms of overall truck braking distances.’’ The Owner-Operator Independent Drivers Association (OOIDA) similarly commented on LRRTs and their ability to meet the tractions needs in mountainous regions.

The agencies continue to stand behind the low rolling resistance tire research conducted to date, which includes the study mentioned in the previous section, along with any research supporting the development, and maintenance, of FMVSS No. 121. The agencies agree, though, that continuing research will be important as new tire technologies enter the marketplace, and like the extensive rolling resistance testing conducting to support the Phase 1 regulation and, in part, this final rule, the agencies will continue to monitor developments in the tire supply marketplace through the EPA Smartway program and other, potential, research. NHTSA notes that FMVSS No. 121 will continue to play a role in ensuring the safety of both current and future tire technologies.

The ATA also expressed support for the NHTSA study mentioned in the previous section, *Review and Analysis of Potential Safety Impacts of and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles.* More specifically, ATA requested that DOT/NHTSA and the DOT Volpe Center continue ‘‘to assess and evaluate potential safety impacts that may be attributed to the use of fuel efficiency devices.’’ The agencies appreciate ATA’s support and acknowledge of this comprehensive, peer-reviewed assessment and we look forward to continuing this work to as the need arises.

(3) The Agencies’ Assessment of Potential Safety Impacts

NHTSA and EPA considered the potential safety impact of technologies that improve MDHD vehicle fuel efficiency and GHG emissions as part of the assessment of regulatory alternatives and selection of the final regulatory approach. The safety assessment of the technologies in this final rule was informed by two NAS reports, an analysis of safety effects of HD pickups and vans using estimates from the DOT report on the effect of mass reduction and vehicle size on safety, and agency-sponsored safety testing and research. The agencies considered safety from the perspective of both direct effects and indirect effects.

In terms of direct effects on vehicle safety, research from NAS and Volpe, and direct testing of technologies like the ORNL tire work, indicate that there are no major safety hazards associated with the adoption of technologies that improve MDHD vehicle fuel efficiency and GHG emissions or the increased use of alternative fuels and vehicle electrification. The findings suggest that the potential safety hazards identified during operation, maintenance, and crash scenarios can be prevented or mitigated by complying with safety regulations, voluntary standards, and industry best practices. Tire testing showed tire rolling resistance did not impact of Class 8 tractor-trailer stopping distance for the tires tested. For HD pickup and vans, mass reduction is anticipated to reduce the net incidence of highway fatalities, because of the beneficial effects of mass reduction in the majority of HD pickup and vans which weigh more than 4,594 lbs. Taken together, these studies suggest that the fuel efficiency improving technologies assessed in the studies can be implemented with no degradation in overall safety.

However, analysis anticipates that the indirect effect of these standards, by reducing the operating costs, will lead to increased travel by tractor-trailers and HD pickups and vans and, therefore, more crashes involving these vehicles.

X. Analysis of the Alternatives

As discussed in the NPRM and throughout this Preamble, in developing this program, the agencies considered a number of regulatory alternatives that could result in potentially fewer or greater GHG emission and fuel consumption reductions than the Phase 2 program we are adopting. This section summarizes the alternatives we considered and presents estimates of the CO_2 reductions and fuel savings associated with them. Although some of the alternatives considered for the FRM are identical to alternatives considered for the NPRM, the preferred alternative (*i.e.* the final rule) is actually more stringent than the preferred alternative that was proposed, and includes some elements of the NPRM’s Alternative 4.

In developing alternatives, both agencies must consider a range of stringency. NHTSA must consider EISA’s requirement for the MD/HD fuel efficiency program. In particular, 49 U.S.C. 32902(k)(2) and (3) contain the following three requirements specific to the MD/HD vehicle fuel efficiency improvement program: (1) The program must be ‘‘designed to achieve the maximum feasible improvement;’’ (2) the various required aspects of the program must be appropriate, cost-effective, and technologically feasible for MD/HD vehicles; and (3) the standards adopted under the program must provide not less than four model years of lead time and three model years of regulatory stability. In considering these various requirements, NHTSA will also account for relevant environmental and safety considerations.

As explained in the Phase 1 rule, NHTSA has broad discretion in balancing the above factors in determining the improvement that the manufacturers can achieve. The fact that the factors may often be conflicting gives NHTSA significant discretion to decide what weight to give each of the competing policies and concerns and then determine how to balance them—as long as NHTSA's balancing does not undermine the fundamental purpose of the EISA: Energy conservation, and as long as that balancing reasonably accommodates ''conflicting policies that were committed to the agency's care by the statute.''[934]

EPA also has significant discretion in considering a range of stringency. Section 202(a)(2) of the Clean Air Act requires only that the standards ''take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period.'' This language affords EPA considerable discretion in how to weight the critical statutory factors of emission reductions, cost, and lead time. See 76 FR 57129–57130.

The alternatives presented here follow the format of the alternatives addressed in the NPRM. Among the alternatives are a preferred alternative (in this action, the ''final program''), more stringent alternatives, and less stringent alternatives (including ''no action'' alternatives). As discussed in this Preamble's Sections II (Engines), III (Tractors), IV (Trailers), V (Vocational Vehicles), and VI (Pickups and Vans), NHTSA and EPA determined Alternative 3 to be the preferred alternative, or the final program, for each vehicle category. This Section X describes all of the alternatives considered, and provides context for the relative stringency associated with the final program.

A. What are the alternatives that the agencies considered?

The five alternatives below represent a broad range of potential stringency levels, and thus a broad range of associated technologies, costs and benefits for a HD vehicle fuel efficiency and GHG emissions program. All of the alternatives were modeled using the same methodologies described in Chapter 5 of the RIA.

The alternatives considered for the final rule were conceptually similar to (and for some elements, identical to) to the alternatives considered for the proposal. The alternatives in order of increasing fuel efficiency and GHG emissions reductions are as follows:

1. No action, baseline
2. Less stringent than the proposal
3. Preferred alternative
4. Proposed (not FRM) standards with less lead time
5. More stringent standards than the proposal with less lead time

Comments on the alternatives overlapped with comments on the overall stringency of the proposed Phase 2 program. These comments were mixed. Some operators and manufacturers supported the least stringent alternatives. Many other commenters, however, including most non-governmental organizations, supported more stringent standards with less lead time. They generally supported Alternative 4. Many technology and component suppliers supported more stringent standards but with the proposed lead time, and thus generally supported the Alternative 3 timeframe. Vehicle manufacturers strongly opposed the more stringent standards and reduced lead time of Alternative 4. To the extent any of these commenters provided technical information to support their comments on stringency and lead time, it is discussed in Sections II through VI.

Many of the comments supporting more stringent standards stated that they would be ''cost-effective.'' In general, however, we did not find costs or cost-effectiveness to be a significantly limiting factor in determining the stringency of the standards. Rather, we found that actual technological feasibility and lead time to be the more limiting factors. Manufacturers and suppliers have limited research and development capacities, and although they have some ability to expand, that ability is constrained by the lead time required. Lead time includes time not only to design and develop a technology, but to bring it to market in reliable form. During the prototype stage, all prototype components must be available and extensive engine and vehicle tests must be conducted. The production start-up phase would follow. After that, significant efforts must be made to advance the system from a prototype to a commercial product, which typically takes about five years for complex systems. During this approximate five-year period, multiple vehicles will go through weather condition tests, long lead-time parts and tools will be identified, and market launch and initial results on operating stability will be completed. Production designs will be released, all product components should be made available, production parts on customer fleets and weather road testing will be verified before finally launching production, and distribution of parts to the vehicle service network for maintenance and repair will be readied. See Section I.C above; see also RIA Chapter 2.3.9. New technologies then are ordinarily phased into the commercial market, so that fleet operators are assured of technology reliability and utility before making extensive purchases. Commenters supporting the more stringent alternatives based on cost-effectiveness generally did not address these very real lead time constraints.

(1) Alternative 1: No Action (The Baseline for Phase 2)

OMB guidance regarding regulatory analysis indicates that proper evaluation of the benefits and costs of regulations and their alternatives requires agencies to identify a baseline:

''You need to measure the benefits and costs of a rule against a baseline. This baseline should be the best assessment of the way the world would look absent the proposed action. The choice of an appropriate baseline may require consideration of a wide range of potential factors, including:

- Evolution of the market
- changes in external factors affecting expected benefits and costs
- changes in regulations promulgated by the agency or other government entities
- degree of compliance by regulated entities with other regulations

It may be reasonable to forecast that the world absent the regulation will resemble the present. If this is the case, however, your baseline should reflect the future effect of current government programs and policies. For review of an existing regulation, a baseline assuming no change in the regulatory program generally provides an appropriate basis for evaluating regulatory alternatives. When more than one baseline is reasonable and the choice of baseline will significantly affect estimated benefits and costs, you should consider measuring benefits and costs against alternative baselines. In doing so you can analyze the effects on benefits and costs of making different assumptions about other agencies' regulations, or the degree of compliance with your own existing rules. In all cases, you must evaluate benefits and costs against the same baseline. You should also discuss

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[934] Cf. *Center for Biological Diversity* v. *National Highway Traffic Safety Admin.*, 538 F.3d 1172, 1194 (9th Cir. 2008). For further discussion see 76 FR 57198.

the reasonableness of the baselines used in the sensitivity analyses. For each baseline you use, you should identify the key uncertainties in your forecast.'' [935]

A no-action alternative is also required as a baseline against which to measure environmental impacts of these standards and alternatives. NHTSA, as required by the National Environmental Policy Act, is documenting these estimated impacts in the EIS published with this final rule.[936]

The No Action Alternative for today's analysis, alternatively referred to as the ''baseline'' or ''reference case,'' assumes that the agencies would not issue new rules regarding MD/HD fuel efficiency and GHG emissions. That is, this alternative assumes that the Phase 1 MD/HD fuel efficiency and GHG emissions program's model year 2018 standards would be extended indefinitely and without change.

The agencies recognize that there are a number of factors that create uncertainty in projecting a baseline against which to compare the future effects of the alternatives. The composition of the future fleet—such as the relative position of individual manufacturers and the mix of products they each offer—cannot be predicted with certainty at this time. As reflected, in part, by the market forecast underlying the agencies' analysis, we anticipate that the baseline market for medium- and heavy-duty vehicles will continue to evolve within a competitive market that responds to a range of factors. Additionally, the heavy-duty vehicle market is diverse, as is the range of vehicle purchasers.

Heavy-duty vehicle manufacturers have reported that their customers' purchasing decisions are influenced by their customers' own determinations of minimum total cost of ownership, which can be unique to a particular customer's circumstances. For example, some customers (*e.g.,* less-than-truckload or package delivery operators) operate their vehicles within a limited geographic region and typically own their own vehicle maintenance and repair centers within that region. These operators tend to own their vehicles for long time periods, and sometimes for the entire service life of the vehicle. Their total cost of ownership is influenced by their ability to better control their own maintenance costs, and thus they can afford to consider fuel efficiency technologies that have longer payback periods, outside of the vehicle manufacturer's warranty period. Other customers (*e.g.* truckload or long-haul operators) tend to operate cross-country, and thus must depend upon truck dealer service centers for repair and maintenance. Some of these customers tend to own their vehicles for about four to seven years, so that they typically do not have to pay for repair and maintenance costs outside of either the manufacturer's warranty period or some other extended warranty period. Many of these customers tend to require seeing evidence of fuel efficiency technology payback periods on the order of 18 to 24 months before seriously *considering* evaluating a new technology for potential adoption within their fleet.[937] Purchasing decisions, however, are not based exclusively on payback period, but also include the considerations discussed in this section. For the baseline analysis, the agencies use payback period as a proxy for all of these considerations, and therefore the payback period used for the baseline analysis may be shorter than the payback periods industry typically identifies as thresholds for the further consideration of a technology. Some owners accrue relatively few vehicle miles traveled per year, such that they may be less likely to adopt new fuel efficiency technologies, while other owners who use their vehicle(s) with greater intensity may be even more willing to pay for fuel efficiency improvements. Regardless of the type of customer, their determination of minimum total cost of ownership involves the customer balancing their own unique circumstances with a heavy-duty vehicle's initial purchase price, availability of credit and lease options, expectations of vehicle reliability, resale value and fuel efficiency technology payback periods. The degree of the incentive to adopt additional fuel efficiency technologies also depends on customer expectations of future fuel prices, which directly impacts customer expectations of the payback period.

Another factor the agencies considered is that other federal and state-level policies and programs are specifically aimed at stimulating fuel efficiency technology development and deployment. Particularly relevant to this sector are DOE's 21st Century Truck Partnership, EPA's voluntary SmartWay Transport program, and California's AB32 fleet requirements.[938] [939] [940] The future availability of more cost-effective technologies to reduce fuel consumption could provide manufacturers an incentive to produce more fuel-efficient medium- and heavy-duty vehicles, which in turn could provide customers an incentive to purchase these vehicles. The availability of more cost-effective technologies to reduce fuel consumption could also lead to a substitution of less cost-effective technologies, where overall fuel efficiency could remain fairly flat if buyers are less interested in fuel consumption improvements than in reduced vehicle purchase prices and/or improved vehicle performance and/or utility.

We have also applied the EIA's AEO estimates of future fuel prices; however, heavy-duty vehicle customers could have different expectations about future fuel prices, and could therefore be more or less inclined to apply new technology to reduce fuel consumption than might be expected based on EIA's forecast. We expect that vehicle customers will be uncertain about future fuel prices, and that this uncertainty will be reflected in the degree of enthusiasm to apply new technology to reduce fuel consumption.

Considering all of these factors, the agencies have approached the definition of the No Action Alternative separately for each vehicle and engine category covered by today's rules. Except as noted below, these baselines are largely the same as the proposed Alternatives 1a and 1b, which reflected different assumptions about the extent to which the market would pay for additional fuel-saving technology without new Phase 2 standards. The agencies received limited comments on these reference cases. Some commenters expressed support for the la baseline in the context of the need for the regulations, arguing that little improvement would occur without the regulations. Others supported the 1a

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[935] OMB Circular A–4, September 17, 2003. Available at *http://www.whitehouse.gov/omb/circulars_a004_a-4.*

[936] NEPA requires agencies to consider a ''no action'' alternative in their NEPA analyses and to compare the effects of not taking action with the effects of the reasonable action alternatives to demonstrate the different environmental effects of the action alternatives. *See* 40 CFR 1502.2(e), and 1502.14(d). CEQ has explained that ''[T]he regulations require the analysis of the no action alternative even if the agency is under a court order or legislative command to act. This analysis provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives. [*See* 40 CFR 1502.14(c).]* * * Inclusion of such an analysis in the EIS is necessary to inform Congress, the public, and the President as intended by NEPA. [*See* 40 CFR 1500.1(a).]'' Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 FR 18026 (1981) (emphasis added).

[937] NAS 2010, Roeth et al. 2013, and Klemick et al. 2014.

[938] *http://energy.gov/eere/vehicles/vehicle-technologies-office-21st-century-truck.*

[939] *http://www3.epa.gov/smartway/.*

[940] State of California Global Warming Solutions Act of 2006 (Assembly Bill 32, or AB32).

baseline because they believe it more fully captures the costs. Some commenters thought it reasonable that the agencies consider both baselines, given the uncertainty in this area. No commenters opposed the consideration of both baselines. The agencies thus continued to analyze two different baselines for the final rules as we recognize that there are a number of factors that create uncertainty in projecting a baseline against which to compare the future effects of this action and the remaining alternatives. As was shown in the previous sections, the standards are supported by the analysis using either baseline.

For trailers, the agencies considered two No Action alternatives to cover a nominal range of uncertainty. The trailer category is unique in the context of this rulemaking because it is the only heavy-duty category not regulated under Phase 1. The agencies project that in 2018, about half of new 53′ dry van and reefer trailers will have technologies qualifying for the SmartWay label for aerodynamic improvements and about 90 percent would have the lower rolling resistance tires. About half also have automatic tire inflation systems to maintain optimal tire pressure. For Alternative 1a as presented in this action (referred to as the ''flat'' baseline), this technology adoption remains constant after 2018. In the second case, Alternative 1b, the agencies projected that the combination of EPA's voluntary SmartWay program, DOE's 21st Century Truck Partnership, California's AB32 trailer requirements for fleets, and the potential for significantly reduced operating costs should result in continuing improvement to new trailers. The agencies projected that the fraction of the in-use fleet qualifying for SmartWay will continue to increase beyond 2027 as older trailers are replaced by newer trailers. We projected that these improvements will continue until 2040 when 75 percent of new trailers will be assumed to include skirts.

For vocational vehicles, the agencies considered one No Action alternative. For the vocational vehicle category the agencies recognized that these vehicles tend to operate over fewer vehicle miles travelled per year. Therefore, the projected payback periods for fuel efficiency technologies available for vocational vehicles are generally longer than the payback periods the agencies consider likely to lead to their adoption based solely on market forces. This is especially true for vehicles used in applications in which the vehicle operation is secondary to the primary business of the company using the vehicle. For example, since the fuel consumption of vehicles used by utility companies to repair power lines would generally be a smaller cost relative to the other costs of repairing lines, fuel saving technologies would generally not be as strongly demanded for such vehicles. Thus, the agencies project that fuel-saving technologies will either not be applied or will only be applied as a substitute for more expensive fuel efficiency technologies, except as necessitated by the Phase 1 fuel consumption and GHG standards.

For tractors, the agencies considered two No Action alternatives to cover a nominal range of uncertainty. For Alternative 1a the agencies project that fuel-saving technologies will either not be applied or will only be applied as a substitute for more expensive fuel efficiency technologies to tractors (thereby enabling manufacturers to offer tractors that are less expensive to purchase), except as necessitated by the Phase 1 fuel consumption and GHG standards. In Alternative 1b the agencies estimated that some available technologies will save enough fuel to pay back fairly quickly—within the first six months of ownership. The agencies considered a range of information to formulate these two baselines for tractors.

Both public[941] and confidential historical information shows that tractor trailer fuel efficiency improved steadily through improvements in engine efficiency and vehicle aerodynamics over the past 40 years, except for engine efficiency which decreased or was flat between 2000 and approximately 2007 as a consequence of incorporating technologies to meet engine emission regulations. Today vehicle manufacturers, the Federal Government, academia and others continue to invest in research to develop fuel efficiency improving technologies for the future.

In public meetings and in meetings with the agencies, the trucking industry stated that fuel cost for tractors is the number one or number two expense for many operators, and therefore is a very important factor for their business. However, the pre-Phase 1 market suggests that tractor manufacturers and operators could be slow to adopt some new technologies, even where the agencies have estimated that the technology would have paid for itself within a few months of operation. This phenomenon, which is discussed in Section IX.A, is often called the energy paradox. Consistent with the discussion above of reasons for needed lead time, tractor operators have told the agencies they generally require technologies to be demonstrated in their fleet before widespread adoption so they can assess the actual fuel savings for their fleet and any increase in cost associated with effects on vehicle operation, maintenance, reliability, mechanic training, maintenance and repair equipment, stocking unique parts and driver acceptance, as well as effects on vehicle resale value. Tractor operators often state that they would *consider* conducting an assessment of technologies when provided with data that show the technologies may payback costs through fuel savings within 18 to 24 months, based on their assumptions about future fuel costs. In other words they would treat this as a necessary condition, but generally would not consider it to be sufficient. In these cases, an operator may first conduct a detailed paper study of anticipated costs and benefits. If that study shows likely payback in 18 to 24 months for their business, the fleet may acquire one or several tractors with the technology to directly measure fuel savings, costs and driver acceptance for their fleet. Small fleets may not have resources to conduct assessments to this degree and may rely on information from larger fleets or observations of widespread acceptance of the technology within the industry before adopting a technology. This uncertainty over the actual fuel savings and costs and the lengthy process to assess technologies significantly slows the pace at which fuel efficiency technologies are adopted.

The agencies believe that using the two baselines addresses the uncertainties we have identified for tractors. The six-month payback period of Alternative 1b reflects the agencies' consideration of factors, discussed above, that could limit—yet not eliminate—manufacturers' tendencies to voluntarily improve fuel consumption. In contrast, Alternative 1a reflects a baseline for vehicles other than trailers wherein manufacturers either do not apply fuel efficiency technologies or only apply them as a substitute for more expensive fuel efficiency technologies, except as necessitated by the Phase 1 fuel consumption and GHG standards.

For HD pickups and vans, the agencies considered two No Action alternatives to cover a nominal range of

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[941] Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles; National Research Council; Transportation Research Board (2010). ''Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,'' (hereafter, ''NAS 2010''). Washington, DC. The National Academies Press. Available electronically from the National Academies Press Web site at *http://www.nap.edu/catalog.php?record_id=12845* (last accessed September 10, 2010).

uncertainty. In Alternative 1b the agencies considered additional technology application, which involved the explicit estimation of the potential to add specific fuel-saving technologies to each specific vehicle model included in the agencies' HD pickup and van fleet analysis, as discussed in Section VI. Estimated technology application and corresponding impacts depend on the modeled inputs. Also, under this approach a manufacturer that has improved fuel consumption and GHG emissions enough to achieve compliance with the standards is assumed to apply further improvements, provided those improvements reduce fuel outlays by enough (within a specified amount of time, the payback period) to offset the additional costs to purchase the new vehicle. These calculations explicitly account for and respond to fuel prices, vehicle survival and mileage accumulation, and the cost and efficacy of available fuel-saving technologies. Therefore, all else being equal, more technology is applied when fuel prices are higher and/or technology is more cost-effective. However, considering factors discussed above that could limit manufacturers' tendency to voluntarily improve HD pickup and van fuel consumption, Alternative 1b applies a 6-month payback period. In contrast, for Alternative 1a, the agencies project that fuel-saving technologies will either not be applied or only be applied as a substitute for more expensive fuel efficiency technologies, except as necessitated by the Phase 1 fuel consumption and GHG standards. The Method A sensitivity analysis presented in Section VI of the NPRM also examined other payback periods. In terms of impacts under reference case fuel prices, the payback period input plays a more significant role under the No-Action Alternatives (defined by a continuation of model year 2018 standards) than under the more stringent regulatory alternatives for HD pickups and vans described next.

(2) Alternative 2: Less Stringent Than the Preferred Alternative

For vocational vehicles and combination tractor-trailers, Alternative 2 represents a stringency level which is approximately half as stringent overall as the final standards. The agencies developed Alternative 2 to consider a continuation of the Phase 1 approach of applying off-the-shelf technologies rather than requiring the development of new technologies or fundamental improvements to existing technologies. For tractors and vocational vehicles, this also involved less integrated optimization of the vehicles and engines. Put another way, Alternative 2 is not technology-forcing.[942] See, *e.g., Sierra Club* v. *EPA*, 325 F. 3d 374, 378 (D.C. Cir. 2003) (under a technology-forcing provision, EPA ''must consider future advances in pollution control capability''); see also similar discussion in *Husqvarna AB* v. *EPA*, 254 F. 3d 195, 201 (D.C. Cir. 2001).

The agencies' decisions regarding which technologies could be applied to comply with Alternative 2 considered not only the use of off-the shelf technologies, but also considered other factors, such as how broadly certain technologies fit in-use applications and regulatory structure. The resulting Alternative 2 could be met with fewer technologies and lower penetration rates than those the agencies project will be used to meet the final Phase 2 standards. Alternative 2 is estimated to be achievable without the application of some technologies, at any level. These and other differences are described below by category. Overall, Alternative 2 for the final rules is conceptually similar to Alternative 2 in the NPRM. However, some changes have been made to reflect new information provided in public comments.

The agencies project that Alternative 2 combination tractor standards could be met by applying lower adoption rates of the projected technologies for Alternative 3. This includes a projection of slightly lower per-technology effectiveness for Alternative 2 versus 3. Alternative 2 also assumes that there would be little optimization of combination tractor powertrains.

The Alternative 2 for vocational vehicles assessed for these final rules does differ somewhat from the proposal because it reflects new duty cycles that weight idle emissions more heavily. The agencies project that the Alternative 2 vocational vehicle standard could be met without any use of strong hybrids or any other type of transmission technology. Rather, it could be met with off-the-shelf idle reduction technologies, low rolling resistance tires, and axle efficiency improvements.

The Alternative 2 trailer standards would apply to only 53-foot dry and refrigerated box trailers and could be met through the use of less effective aerodynamic technologies and higher rolling resistance tires versus what the agencies projected could be used to meet Alternative 3 (*i.e.*, the final standards).

As discussed above in Section VI, the HD pickup truck and van alternatives are characterized by an annual required percentage change (decrease) in the functions defining attribute-based targets for per-mile fuel consumption and GHG emissions. Under the standards in each alternative, a manufacturer's fleet would, setting aside any changes in production mix, be required to achieve average fuel consumption/GHG levels that increase in stringency every year relative to the standard defined for MY 2018 (and held constant through 2020) that establishes fuel consumption/GHG targets for individual vehicles. A manufacturer's specific fuel consumption/GHG requirement is the sales-weighted average of the targets defined by the work-factor curve in each year. Therefore, although the alternatives involve steady increases in the functions defining the targets, stringency increases faced by any individual manufacturer may not be steady if changes in the manufacturer's product mix cause fluctuations in the average fuel consumption and GHG levels required of the manufacturer. See Section VI for additional discussion of this topic. Alternative 2 represents a 2.0 percent annual improvement through 2025 in fuel consumption/GHG emissions relative to the work-factor curve in 2020. This would be 0.5 percent less stringent per year compared to the standards of Alternative 3.

For HD pickups and vans in the Method A analysis, NHTSA projects that most manufacturers could comply with the standards defining Alternative 2 by applying technologies similar to those that could be applied in order to comply with the Alternative 3 standards, but at lower application rates. In EPA's Method B analysis, the biggest technology difference EPA projects between Alternative 2 and the Alternative 3 final standards is that most manufacturers could meet the Alternative 2 standards without any use of stop-start or other mild or strong hybrid technologies.

The agencies are not adopting standards reflecting Alternative 2 for reasons of both policy and law. Technically feasible alternate standards are available that provide for greater emission reductions and reduced fuel consumption than provided under Alternative 2. These more stringent standards, which are being adopted, are feasible at reasonable cost, considering both per-vehicle and per-engine cost, cost-effectiveness, direct benefits to

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[942] As noted in Section I.C, in this context, the term ''technology-forcing'' has a specific legal meaning and is used to distinguish standards that will effectively require manufacturers to develop new technologies (or to significantly improve technologies) from standards that can be met using off-the-shelf technology alone. Technology-forcing standards do not require manufacturers to use any specific technologies.

consumers in the form of fuel savings, and lead time. Consequently, the agencies do not believe that the modest improvements in Alternative 2 would be appropriate or otherwise reasonable under section 202(a)(1) and (2) of the Clean Air Act, or represent the ''maximum feasible improvement'' within the meaning of 49 U.S.C. 32902(k)(2).

(3) Alternative 3: Preferred Alternative and Final Standards

The agencies are adopting Alternative 3 for HD engines, HD pickup trucks and vans, Class 2b through Class 8 vocational vehicles, Class 7 and 8 combination tractors, and trailers. Details regarding modeling of this final program are included in Chapter 5 of the RIA. Note that Alternative 3 for the final rules differs from the Alternative 3 in the NPRM. The differences are largely in response to significant comments on the proposed rule. Although some aspects of the final Alternative 3 are more aggressive than proposed (including adopting some aspects of the proposed Alternative 4), others are less aggressive. As a result of these changes, the preferred alternative in this final rule is projected to achieve more GHG emission reductions and more reductions of fuel consumption than the proposed alternative 4. See Section X.B below and RIA Chapter 5.

Unlike the Phase 1 standards where the agencies projected that manufacturers could meet the Phase 1 standards with off-the-shelf technologies only, the agencies project that meeting the Alternative 3 standards will require a combination of off-the-shelf technologies applied at higher market penetration rates and new technologies that are still in various stages of development and not yet in production. Although this alternative is technology-forcing, it must be kept in mind that the standards themselves are performance-based and thus do not mandate that any particular technology be used to meet the standards.[943] The agencies recognize that there is some uncertainty in projecting costs and effectiveness for those technologies not yet available in the market, but we do not believe, as discussed comprehensively in Sections II, III, IV, V, and VI, that such uncertainty is sufficient to render Alternative 3 beyond the reasonable or maximum feasible level of stringency for each of the engine and vehicle categories covered by this program. Moreover, we have explained what steps will be needed to bring these technologies to the commercial market, and the lead time needed to do so. Given that nearly all of the final standards are performance-based rather than mandates of specific technologies, and given that the lead time for the most stringent standards in Alternative 3 is approximately 10 years, the agencies believe that the performance that is required by these stringency levels of Alternative 3 allows each manufacturer to choose to develop technology and apply it to their vehicles (and engines, where applicable) in a way that balances their unique business constraints and reflects their specific market position and customers' needs.[944]

We have described in detail above, and also in Chapter 2 of the RIA, the precise bases for each of these standards (that is, for each segment covered under the program). Sections II through VI of this Preamble provide comprehensive explanations of the agencies' assessment of the extent to which such standards could be met through the accelerated application of technologies and our reasons for concluding that the identified technologies for each of the vehicle and engine standards that constitute the updated Alternative 3 represent the maximum feasible (within the meaning of 49 U.S.C. 32902 (k)) and reasonable (for purposes of CAA section 202(a)(1) and (2)) based on all of the information available to the agencies at the time of this rulemaking. In particular, the agencies determined that many engine improvements could be achieved sooner than we projected in our NPRM analysis, some even sooner than projected as part of the Alternative 4 analysis.

(4) Alternative 4: More Accelerated Than the Preferred Alternative in the NPRM

As indicated by its description in the title above, Alternative 4 represents standards that are effective on a more accelerated timeline in comparison to the timeline of in the proposed Alternative 3 standards. This alternative is unchanged from Alternative 4 in the proposal. The agencies believe that reanalyzing the same Alternative 4 provides a useful context for commenters who supported the proposed Alternative 4.

In the NPRM, Alternatives 3 and 4 were both designed to achieve similar fuel efficiency and GHG emission levels in the long term but with Alternative 4 being accelerated in its implementation timeline. Specifically, Alternative 4 reflects the same or similar standard stringency levels as the proposed Alternative 3, but 3 years sooner (2 years for heavy-duty pickups and vans), so that the final phase of the standards would occur in MY 2024, or (for heavy duty pickups and vans) 2025.

The agencies projected in the NPRM that meeting Alternative 4 combination tractor standards would require applying initially higher adoption rates of the projected technologies for Alternative 3. This included a projection of slightly higher per-technology effectiveness for Alternative 4 versus 3. Alternative 4 also assumes that there would be more optimization of combination tractor powertrains and earlier market penetration of engine waste heat recovery systems.

The agencies also projected that meeting the Alternative 4 vocational vehicle standard would require earlier adoption rates of the same technology packages projected for Alternative 3.

Meeting the Alternative 4 trailer standards would require earlier implementation of more effective aerodynamic technologies, including the use of aerodynamic skirts and boat tails. This would be in addition to implementing lower rolling resistance tires for nearly all trailers.

HD pickup truck and van standards defining Alternative 4 represent a 3.5 percent annual improvement in fuel consumption and GHG emissions through 2025 relative to the work-factor curves in 2020. This would require earlier adoption of all the Alternative 3 technologies.

As discussed above and in the feasibility discussions in Sections II–VI, we are adopting those elements of the proposed Alternative 4 where we have determined them to be feasible in the lead time provided. However, the agencies have determined that it is unlikely that all elements of Alternative 4 could be achieved by 2024. In fact, the agencies can only project that the engine improvements and some tire improvements will be achievable on the Alternative 4 timeline. Thus, we do not believe these alternative standards to be feasible overall, and we are consequently unable to accurately estimate costs for them. The agencies received many comments supporting the Alternative 4 standards where the commenter noted they supported them because they would be ''cost-effective'' based on the proposed analysis of costs. However, we do not consider this conclusion to be accurate. We do not believe the proposed analysis fully represents the costs for this alternative

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[943] The one exception being design standards for certain non-aero trailers.

[944] Those few standards that are design-based rather than performance based reflect comments indicating that performance-based flexibility would not be necessary or helpful for certain markets.

because it included little additional costs related to pulling ahead the development of so many additional technologies. It also does not reflect any costs associated with a decrease in the in-use reliability and durability during the initial years of implementation. It does not reflect costs of design and deployment outside of normal design cycles, an example being the necessity of developing new engine platforms if WHR were to be applied at higher penetration rates by MY 2024. See RIA Chapter 2.7.5. As we have already noted, we did not find costs or cost-effectiveness to be a significantly limiting factor in determining the stringency of the standards. Rather, we found that actual technological feasibility and lead time to be the more limiting factors. In this respect, we found Alternative 4 to provide insufficient lead time for any of the standards—engine, pickups and vans, vocational vehicles, tractors, and trailers.

(5) Alternative 5: Even More Stringent Standards With Less Lead-Time

Alternative 5 represents even more stringent standards compared to Alternatives 3 and 4, as well as the same implementation timeline as Alternative 4. As discussed in the NPRM, and as repeated above and in the feasibility discussions in Sections II–VI, we are not adopting Alternative 5 because we cannot project that manufacturers can develop and introduce in sufficient quantities the technologies that could be used to meet Alternative 5 standards. No commenters provided any new information to refute this finding. We believe that for some or all of the categories, the Alternative 5 standards are simply technically infeasible within the lead time allowed. We have not fully estimated costs for this alternative for tractors and vocational vehicles because we believe that there would be such substantial additional costs related to pulling ahead the development of so many additional technologies that we cannot accurately predict these costs. (Indeed, how can cost estimates for an alternative which essentially cannot be done at all be realistic?) We also believe this alternative, if it could somehow be effectuated, would result in a decrease in the in-use reliability and durability of new heavy-duty vehicles and that we do not have the ability to accurately quantify the costs that would be associated with such problems. Instead, we merely note that costs would be significantly greater than the estimated costs for Alternative 3, assuming (against our view) that such standards would be feasible at all.

B. How do these alternatives compare in overall fuel consumption and GHG emissions reductions?

The following tables compare the overall fuel consumption and GHG emissions reductions of each of the regulatory alternatives the agencies considered.

Note that for tractors, trailers, pickups and vans the agencies compared overall fuel consumption and GHG emissions reductions relative to two different baselines, described above in the section on the No Action alternative. Therefore, for tractors, trailers, pickups and vans two results are listed; one relative to each baseline, namely Alternative 1a and Alternative 1b.

Also note that the agencies analyzed pickup and van overall fuel consumption and emissions reductions and benefits and costs using the NHTSA's CAFE model (Method A). In addition, the agencies used EPA's MOVES model to estimate pickup and van fuel consumption and emissions and a cost methodology that applied vehicle costs in different model years (Method B). In both cases, the agencies used a version of the CAFE model to estimate average per vehicle cost, and this analysis extended through model year 2030.[945] The agencies concluded that in these instances the choice of baseline and the choice of modeling approach (Method A versus Method B) did not impact the agencies' decision to finalize Alternative 3.

The agencies are finalizing a more stringent program than proposed, so that the preferred alternative for the FRM (Alternative 3) achieves greater reductions and net benefits than the proposed program would have. Moreover, because the agencies analyzed the same Alternative 4 for the FRM as for the NPRM, the FRM preferred alternative also achieves greater reductions than Alternative 4 would have.

The regulatory impact analysis (RIA) accompanying today's notice presents more detailed results of the agencies' analysis.

(1) Impacts Using Analysis Method A

Table X–1 through Table X–4 summarize the key NHTSA estimates of the costs and benefit of the program using Method A. The first two tables show the costs and benefits using a 3 percent discount rate under both the flat and dynamic baselines. The third and fourth tables show the costs and benefits using a 7 percent discount rate for both baselines. Under all possible combinations of discount rate and baseline the net benefits from highest to lowest are as follows: Alternative 5; Alternative 3; Alternative 4; Alternative 2.

TABLE X–1—MY 2018–2029 LIFETIME SUMMARY OF PROGRAM BENEFITS AND COSTS, DISCOUNTED AT 3% (RELATIVE TO BASELINE 1a), METHOD A[a]

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Discounted pre-tax fuel savings ($billion)				
HD pickups and Vans	12.1	18.7	20.3	22.3
Vocational Vehicles	13.5	25.5	23.6	34.6
Tractors/Trailers	50.2	118.8	115.7	169.1
Total	75.7	163.0	159.6	225.9
Discounted Total technology costs ($billion)				
HD pickups and Vans	3.1	6.8	8.2	9.9
Vocational Vehicles	1.6	6.6	7.1	9.5
Tractors/Trailers	9.0	11.0	11.6	26.8

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[945] Although the agencies have considered regulatory alternatives involving standards increasing in stringency through, at the latest, 2027, the agencies extended the CAFE modeling analysis through model year 2030 rather than model year 2027 in order to obtain more fully stabilized results given projected product cadence, multiyear planning, and application of earned credits.

Table X–1—MY 2018–2029 Lifetime Summary of Program Benefits and Costs, Discounted at 3% (Relative to Baseline 1a), Method A[a]—Continued

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Total	13.7	24.4	26.9	46.2
Discounted value of emissions reductions ($billon)				
HD pickups and Vans	3.4	5.3	5.7	6.3
Vocational Vehicles	5.2	9.8	9.1	13.3
Tractors/Trailers	21.9	50.9	50.9	73.4
Total	30.5	66.0	65.7	93.0
Total costs ($billion)				
HD pickups and Vans	4.4	7.9	8.6	10.3
Vocational Vehicles	2.4	7.3	8.8	11.3
Tractors/Trailers	13.2	14.0	15.7	30.8
Total	20.0	29.2	33.1	52.4
Total benefits ($billion)				
HD pickups and Vans	18.1	28.1	30.4	33.3
Vocational Vehicles	20.2	37.8	35.1	51.2
Tractors/Trailers	78.1	179.8	176.5	255.5
Total	114.1	245.7	242.0	340.0
Net benefits ($billion)				
HD pickups and Vans	13.7	20.2	21.8	23.0
Vocational Vehicles	17.8	30.5	26.3	39.9
Tractors/Trailers	64.9	165.8	160.9	224.7
Total	94.1	216.5	208.9	287.6

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the less dynamic baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

Table X–2—MY 2018–2029 Lifetime Summary of Program Benefits and Costs, Discounted at 3% (Relative to Baseline 1 b), Method A[a]

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Discounted pre-tax fuel savings ($billion)				
HD pickups and Vans	10.7	17.4	19.5	21.9
Vocational Vehicles	13.5	25.5	23.6	34.6
Tractors/Trailers	37.6	106.2	103.1	156.5
Total	61.8	149.1	146.2	213.0
Discounted Total technology costs ($billion)				
HD pickups and Vans	2.8	6.4	7.5	9.8
Vocational Vehicles	1.6	6.6	7.1	9.5
Tractors/Trailers	8.8	10.7	11.3	26.6
Total	13.2	23.7	25.9	45.9
Discounted value of emissions reductions ($billon)				
HD pickups and Vans	3.0	4.9	5.5	6.2
Vocational Vehicles	5.2	9.8	9.1	13.3
Tractors/Trailers	16.4	45.4	45.4	67.9
Total	24.6	60.1	60.0	87.4
Total costs ($billion)				
HD pickups and Vans	4.0	7.4	8.6	10.0
Vocational Vehicles	2.4	7.3	8.8	11.3

TABLE X–2—MY 2018–2029 LIFETIME SUMMARY OF PROGRAM BENEFITS AND COSTS, DISCOUNTED AT 3% (RELATIVE TO BASELINE 1 b), METHOD A [a]—Continued

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Tractors/Trailers	12.9	13.8	15.5	30.6
Total	19.3	28.5	32.9	51.9
Total benefits ($billion)				
HD pickups and Vans	16.0	26.0	29.2	32.7
Vocational Vehicles	20.2	37.8	35.1	51.2
Tractors/Trailers	59.2	161.0	157.7	236.7
Total	95.4	224.8	222.0	320.6
Net benefits ($billion)				
HD pickups and Vans	12.0	18.6	20.6	22.7
Vocational Vehicles	17.8	30.5	26.3	39.9
Tractors/Trailers	46.3	147.2	142.2	206.1
Total	76.1	196.3	189.1	268.7

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the less dynamic baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

TABLE X–3—MY 2018–2029 LIFETIME SUMMARY OF PROGRAM BENEFITS AND COSTS, DISCOUNTED AT 7% (RELATIVE TO BASELINE 1a) METHOD A [a]

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Discounted pre-tax fuel savings ($billion)				
HD pickups and Vans	7.1	10.9	11.9	13.0
Vocational Vehicles	7.1	13.4	12.5	18.5
Tractors/Trailers	26.6	62.7	61.8	90.7
Total	40.8	87.0	86.2	122.2
Discounted Total technology costs ($billion)				
HD pickups and Vans	2.2	4.8	5.9	7.0
Vocational Vehicles	1.1	4.4	4.8	6.5
Tractors/Trailers	6.2	7.4	8.0	18.5
Total	9.5	16.6	18.7	32.0
Discounted value of emissions reductions ($billon)				
HD pickups and Vans	3.1	4.8	5.2	5.7
Vocational Vehicles	4.2	7.8	7.3	10.7
Tractors/Trailers	16.9	39.5	39.3	57.1
Total	24.2	52.1	51.8	73.5
Total costs ($billion)				
HD pickups and Vans	3.0	5.5	6.1	7.3
Vocational Vehicles	1.5	4.8	5.8	7.5
Tractors/Trailers	8.5	9.2	10.2	20.7
Total	13.0	19.5	22.1	35.5
Total benefits ($billion)				
HD pickups and Vans	11.7	18.0	19.6	21.5
Vocational Vehicles	12.1	22.6	21.1	31.0
Tractors/Trailers	47.1	108.0	106.8	155.1
Total	70.9	148.6	147.5	207.6
Net benefits ($billion)				
HD pickups and Vans	8.7	12.5	13.5	14.2

TABLE X–3—MY 2018–2029 LIFETIME SUMMARY OF PROGRAM BENEFITS AND COSTS, DISCOUNTED AT 7% (RELATIVE TO BASELINE 1a) METHOD A[a]—Continued

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Vocational Vehicles	10.6	17.8	15.3	23.5
Tractors/Trailers	38.6	98.8	96.6	134.4
Total	58.0	129.1	125.4	172.1

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the less dynamic baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

TABLE X–4—MY 2018–2029 LIFETIME SUMMARY OF PROGRAM BENEFITS AND COSTS, DISCOUNTED AT 7% (RELATIVE TO BASELINE 1b), METHOD A[a]

Vehicle segment	Alt 2	Alt 3	Alt 4	Alt 5
Discounted pre-tax fuel savings ($billion)				
HD pickups and Vans	6.3	10.1	11.5	12.9
Vocational Vehicles	7.1	13.4	12.5	18.5
Tractors/Trailers	19.9	56.1	55.2	84.1
Total	33.3	79.6	79.2	115.5
Discounted Total technology costs ($billion)				
HD pickups and Vans	2.0	4.4	5.3	7.0
Vocational Vehicles	1.1	4.4	4.8	6.5
Tractors/Trailers	6.1	7.3	7.8	18.4
Total	9.2	16.1	17.9	31.9
Discounted value of emissions reductions ($billon)				
HD pickups and Vans	2.7	4.4	5.0	5.6
Vocational Vehicles	4.2	7.8	7.3	10.7
Tractors/Trailers	12.7	35.3	35.1	52.8
Total	19.6	47.5	47.4	68.2
Total costs ($billion)				
HD pickups and Vans	2.7	5.1	6.0	7.1
Vocational Vehicles	1.6	4.8	5.8	7.5
Tractors/Trailers	8.4	9.0	10.1	20.6
Total	12.7	18.9	21.9	35.2
Total benefits ($billion)				
HD pickups and Vans	10.4	16.7	19.0	21.3
Vocational Vehicles	12.1	22.7	21.1	31.0
Tractors/Trailers	35.9	96.8	95.6	143.9
Total	58.4	136.2	135.7	195.2
Net benefits ($billion)				
HD pickups and Vans	7.7	11.6	13.0	14.2
Vocational Vehicles	10.5	17.9	15.3	23.5
Tractors/Trailers	27.5	87.8	85.5	123.3
Total	45.7	117.3	113.8	161.0

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the less dynamic baseline, 1a, and more dynamic baseline, 1b, please see Section X.A.1.

Table X–5 and Table X–6 show the estimated fuel savings and GHG reductions considering alternatives under both baselines. Under both baselines, the reductions in both fuel and GHG's are highest under Alternative 5, higher under Alternative 3 than Alternative 4, and lowest under Alternative 2.

TABLE X–5—MY 2018–2029 LIFETIME FUEL SAVINGS AND GHG EMISSIONS REDUCTIONS BY VEHICLE SEGMENT, RELATIVE TO BASELINE 1a, METHOD A[a]

MY 2018–2029 Total	Fuel reductions (billion gallons)	Upstream & downstream GHG reductions (MMT)
Alternative 2		
HD Pickup Trucks/Vans	6.2	77
Vocational Vehicles	6.5	86
Tractors and Trailers	23.4	323
Total	36.1	486
Alt. 3—Preferred Alternative		
HD Pickup Trucks/Vans	9.8	120
Vocational Vehicles	12.3	162
Tractors and Trailers	55.6	767
Total	77.7	1049
Alt. 4		
HD Pickup Trucks/Vans	10.6	130
Vocational Vehicles	11.4	150
Tractors and Trailers	54.0	744
Total	76.0	1024
Alt. 5		
HD Pickup Trucks/Vans	11.6	143
Vocational Vehicles	16.7	219
Tractors and Trailers	78.8	1087
Total	107.1	1449

Note:

[a] For an explanation of analytical Methods A and B, please see Preamble Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Preamble Section X.A.1.

TABLE X–6—MY 2018–2029 LIFETIME FUEL SAVINGS AND GHG EMISSIONS REDUCTIONS BY VEHICLE SEGMENT, RELATIVE TO BASELINE 1b METHOD A[a]

MY 2018–2029 Total	Fuel reductions (billion gallons)	Upstream & downstream GHG reductions (MMT)
Alternative 2		
HD Pickup Trucks/Vans	5.5	68
Vocational Vehicles	6.5	86
Tractors and Trailers	17.5	242
Total	29.5	396
Alt. 3—Preferred Alternative		
HD Pickup Trucks/Vans	9.0	111
Vocational Vehicles	12.4	162
Tractors and Trailers	49.7	685
Total	71.1	958
Alt. 4		
HD Pickup Trucks/Vans	10.1	125
Vocational Vehicles	11.4	150
Tractors and Trailers	48.1	663
Total	69.6	938

TABLE X–6—MY 2018–2029 LIFETIME FUEL SAVINGS AND GHG EMISSIONS REDUCTIONS BY VEHICLE SEGMENT, RELATIVE TO BASELINE 1b METHOD A[a]—Continued

MY 2018–2029 Total	Fuel reductions (billion gallons)	Upstream & downstream GHG reductions (MMT)
Alt. 5		
HD Pickup Trucks/Vans	11.3	140
Vocational Vehicles	16.7	219
Tractors and Trailers	72.9	1006
Total	100.9	1365

Note:
[a] For an explanation of analytical Methods A and B, please see Preamble Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Preamble Section X.A.1.

TABLE X–7—ANNUAL GHG AND FUEL REDUCTIONS RELATIVE TO THE DYNAMIC BASELINE IN 2040 AND 2050 USING METHOD A[a]

	Upstream & downstream GHG Reductions (MMT CO_2EQ)		Fuel reductions (billion gallons)	
	2040	2050	2040	2050
Alt. 2 Less Stringent—Total	49.1	57.3	3.6	4.2
Tractors and Trailers	30.9	36.6	2.2	2.7
HD Pickups & Vans	6.7	7.3	0.6	0.6
Vocational Vehicles	11.5	13.4	0.8	0.9
Alt. 3 Preferred—Total	139	166	10.2	12.3
Tractors and Trailers	102	124	7.4	9.0
HD Pickups & Vans	12.6	13.8	1.0	1.2
Vocational Vehicles	24.1	28.2	1.8	2.1
Alt. 4 Less Lead Time—Total	116	136	8.6	10.1
Tractors and Trailers	83.1	98.7	6.0	7.2
HD Pickups & Vans	12.6	13.8	1.1	1.2
Vocational Vehicles	20.0	23.1	1.5	1.7
Alt. 5 More Stringent—Total	167	194	12.4	14.2
Tractors and Trailers	124	146	9.0	10.6
HD Pickups & Vans	14.8	16.2	1.3	1.3
Vocational Vehicles	27.8	32.0	2.1	2.3

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

TABLE X–8—ANNUAL GHG AND FUEL REDUCTIONS RELATIVE TO THE FLAT BASELINE IN 2040 AND 2050 USING METHOD A[a]

	Upstream & downstream GHG Reductions (MMT CO_2EQ)		Fuel reductions (billion gallons)	
	2040	2050	2040	2050
Alt. 2 Less Stringent—Total	63.7	75.2	4.7	5.5
Tractors and Trailers	44.2	53.0	3.2	3.8
HD Pickups & Vans	8.0	8.8	0.6	0.7
Vocational Vehicles	11.5	13.4	0.9	1.0
Alt. 3 Preferred—Total	153	184	11.3	13.7
Tractors and Trailers	115	141	8.4	10.2
HD Pickups & Vans	13.8	15.1	1.1	1.3
Vocational Vehicles	24.1	28.2	1.8	2.2
Alt. 4 Less Lead Time—Total	131	153	9.6	11.4
Tractors and Trailers	96.5	115	7.0	8.3
HD Pickups & Vans	14.0	15.3	1.1	1.3
Vocational Vehicles	20.0	23.1	1.5	1.8
Alt. 5 More Stringent—Total	181	213	13.4	15.6
Tractors and Trailers	137	163	9.9	11.8
HD Pickups & Vans	16.0	17.6	1.4	1.5
Vocational Vehicles	27.8	32.0	2.1	2.3

Note:
[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

(2) Impacts Using Analysis Method B

Table X–9 summarizes EPA's estimates of GHG and fuel reductions of the program using Method B for calendar years 2040 and 2050.

TABLE X–9—ANNUAL GHG AND FUEL REDUCTIONS RELATIVE TO THE FLAT BASELINE IN 2040 AND 2050 USING METHOD B[a]

	Upstream & downstream GHG Reductions (MMT CO_2EQ)		Fuel reductions (billion gallons)	
	2040	2050	2040	2050
Alt. 2 Less Stringent—Total	71.8	84.0	5.4	6.3
Tractors and Trailers	44.2	53.0	3.2	3.8
HD Pickups & Vans	16.1	17.6	1.4	1.5
Vocational Vehicles	11.5	13.4	0.9	1.0
Alt. 3 Preferred—Total	166.5	198.9	12.5	14.9
Tractors and Trailers	115.5	140.7	8.4	10.2
HD Pickups & Vans	26.9	30.0	2.2	2.6
Vocational Vehicles	24.1	28.2	1.9	2.1
Alt. 4 More Stringent—Total	144.1	168.5	10.9	12.7
Tractors and Trailers	96.5	115.1	7.0	8.3
HD Pickups & Vans	27.7	30.3	2.3	2.6
Vocational Vehicles	20.0	23.1	1.5	1.8
Alt. 5 More Stringent—Total	196.8	230.0	14.8	17.2
Tractors and Trailers	136.9	162.9	9.9	11.8
HD Pickups & Vans	32.2	35.2	2.7	3.0
Vocational Vehicles	27.8	32.0	2.1	2.4

Note:

[a] For an explanation of analytical Methods A and B, please see Section I.D; for an explanation of the flat baseline, 1a, and dynamic baseline, 1b, please see Section X.A.1.

XI. Natural Gas Vehicles and Engines

NGV America estimates that approximately 65,200 natural gas trucks were operating in the U.S. in 2014. This represents 0.3 percent of the heavy-duty vehicle fleet in the U.S. based on EPA's estimated 17.5 million heavy-duty trucks operating in the U.S.[946] [947] While medium and heavy-duty natural gas vehicles continue to be produced and sold, the collapse of crude oil prices starting in 2014 has reduced the economic incentive to expand the use of natural gas fueled trucks. Although these natural gas versions are similar in many ways to their petroleum counterparts, there are significant differences. There are also both similarities and differences in the production and distribution of natural gas relative to gasoline and diesel fuel.

This combined rulemaking by EPA and NHTSA is designed to regulate two separate characteristics of heavy-duty vehicles: Emissions of GHGs and fuel consumption (especially petroleum fuels). The use of natural gas as a heavy-duty fuel can impact both of these. In the case of diesel or gasoline powered vehicles, there is a close relationship between GHG emissions and petroleum consumption. The situation is different for non-petroleum fuels like natural gas. Natural gas also has a lower carbon content than petroleum fuels. Thus, a natural gas vehicle that could achieve the same fuel efficiency as a diesel-powered vehicle would emit about 20 percent less CO_2 when operating on natural gas and consume no petroleum. A natural gas vehicle with the same fuel efficiency as a gasoline vehicle would emit about 30 percent less CO_2.[948] However, current natural gas engines are 5 to 15 percent less energy efficient than diesel engines. This means that, although natural gas engines are typically less fuel efficient, they can have lower CO_2 emissions and consume much less petroleum. In Phase 1, the agencies balanced these factors by applying the gasoline and diesel CO_2 standards to natural gas engines based on the engine type of the natural gas engine. Fuel consumption for these vehicles is then calculated according to their tailpipe CO_2 emissions. In essence, this applies a one-to-one relationship between fuel efficiency and tailpipe CO_2 emissions for all vehicles, including natural gas vehicles. The agencies determined that this approach would likely create a small balanced incentive for natural gas use. See 76 FR 57123; see also 77 FR 51705 (August 24, 2012) and 77 FR 51500 (August 27, 2012) (EPA and NHTSA, respectively, further elaborating on basis for having Phase 1 apply at the tailpipe only, including for alternative fueled vehicles); see also *Delta Construction Co.* v. *EPA*, 783 F. 3d 1291 (D.C. Cir. 2015) (dismissing challenge to Phase 1 GHG standards as being arbitrary for applying only on a tailpipe basis).

For Phase 2, the agencies have reevaluated the potential use of natural gas in the heavy-duty sector and the impacts of such use. As discussed below, based on our review of the literature and external projections we believe that the use of natural gas is unlikely to become a major fuel source for medium and heavy-duty vehicles during the Phase 2 time frame. Thus, since we project natural gas vehicles to have little impact on both overall GHG emissions and fuel consumption during the Phase 2 time frame, the agencies see no need to make fundamental changes to the Phase 1 approach for natural gas engines and vehicles.

As part of this rulemaking, the agencies developed a lifecycle analysis of natural gas used by the heavy-duty truck sector, which is presented in Section XI.B. We also present the results of analyses projecting the future use of natural gas by heavy-duty trucks, identify a number of potential emission control technologies, and discuss the

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[946] Yborra, Stephe; NGV Market Briefing to EPA and NHTSA, August 12, 2014.

[947] MOVES2014; *http://www3.epa.gov/otaq/models/moves/index.htm.*

[948] Methane emissions above the heavy-duty 0.1 g/bhp-hr methane tailpipe standard must be accounted for and offsets the lower CO_2 tailpipe emissions.

habitat within the meaning of ESA section 7(a)(2) or the implementing regulations or require ESA consultation. We have carefully considered various types of potential environmental effects, including emissions of GHGs and non-GHGs, in reaching the conclusion that ESA consultation is not required for this rule.

With respect to the projected GHG emission reductions, we are mindful of significant legal and technical analysis undertaken by FWS and the U.S. Department of the Interior in the context of listing the polar bear as a threatened species under the ESA. In that context, in 2008, FWS and DOI expressed the view that the best scientific data available were insufficient to draw a causal connection between GHG emissions and effects on the species in its habitat.[1018] The DOI Solicitor concluded that where the effect at issue is climate change, actions involving GHG emissions cannot pass the ''may affect'' test of the section 7 regulations and thus are not subject to ESA consultation. Similarly, for this action, in the absence of a causal connection between the final rules and an effect to listed species or critical habitat that is reasonably certain to occur, no consultation is required.

The agencies have also previously considered issues relating to GHG emissions in connection with the requirements of ESA section 7(a)(2). Although the GHG emission reductions projected for this rule are large, EPA evaluated comparable or larger reductions in assessing this same issue in the context of the light duty vehicle GHG emission standards for model years 2012–2016 and 2017–2025. There the agency projected emission reductions comparable to, or greater than those projected here over the lifetimes of the model years in question and, based on air quality modeling of potential environmental effects, concluded that ''EPA knows of no modeling tool which can link these small, time-attenuated changes in global metrics to particular effects on listed species in particular areas. Extrapolating from global metric to local effect with such small numbers, and accounting for further links in a causative chain, remain beyond current modeling capabilities.'' EPA, *Light Duty Vehicle Greenhouse Gas Standards and Corporate Average Fuel Economy Standards,* Response to Comment Document for Joint Rulemaking at 4–102 (Docket EPA–OAR–HQ–2009–4782). EPA reached this conclusion after evaluating issues relating to potential improvements relevant to both temperature and oceanographic pH outputs. EPA's ultimate finding was that ''any potential for a specific impact on listed species in their habitats associated with these very small changes in average global temperature and ocean pH is too remote to trigger the threshold for ESA section 7(a)(2).'' *Id.* EPA and NHTSA believe that the same conclusion will apply to the present final rule, given that the projected CO_2 emission reductions are comparable to or less than those projected for either of the light duty vehicle rules. See Section VII.D.2 and Table VII–41 of this Preamble; *See also, e.g., Ground Zero Center for Non-Violent Action* v. *U.S. Dept. of Navy,* 383 F. 3d 1082, 1091–92 (9th Cir. 2004) (where the likelihood of jeopardy to a species from a federal action is extremely remote, ESA does not require consultation).

M. Congressional Review Act (CRA)

This action is subject to the CRA, and the agencies will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is a ''major rule'' as defined by 5 U.S.C. 804(2).

XV. EPA and NHTSA Statutory Authorities

As described below, the regulations being adopted are authorized separately for EPA and NHTSA under the agencies' respective statutory authorities. See Section I for a discussion of these authorities.

A. EPA

Statutory authority for the vehicle controls is found in CAA section 202(a) (which authorizes standards for emissions of pollutants from new motor vehicles that emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare), and CAA sections 202(d), 203–209, 216, and 301 (42 U.S.C. 7521(a), 7521(d), 7522–7543, 7550, and 7601).

EPA makes certain proposed rules available to the Science Advisory Board (SAB), including rules subject to 42 U.S.C. 4365 and rules which are not, but which EPA believes should be made available to the SAB. EPA provided information to the SAB about this rulemaking and on June 11, 2014, the chartered SAB discussed the recommendations of its work group on the planned action and agreed that no further SAB consideration of the rule or its supporting science was merited. We note further that the substantial NAS report to NHTSA and to Congress evaluating medium- and heavy-duty truck fuel efficiency improvement opportunities (see Section I.A.2 (g) above) would serve as a surrogate for SAB consultation. See *American Petroleum Inst.* v. *EPA,* 665 F. 2d 1176, 1189 (D.C. Cir. 1981).

B. NHTSA

Statutory authority for the fuel consumption standards is found in section 103 of the Energy Independence and Security Act of 2007, 49 U.S.C. 32902(k). EISA authorizes a fuel efficiency improvement program, designed to achieve the maximum feasible improvement to be created for commercial medium- and heavy-duty on-highway vehicles and work trucks, to implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective and technologically feasible. To the extent motor vehicle safety is implicated, NHTSA's authority to regulate it is also derived from the National Traffic and Motor Vehicle Safety Act, 49 U.S.C. 30101 *et seq.*

List of Subjects

40 CFR Part 9

Reporting and recordkeeping requirements.

40 CFR Part 22

Administrative practice and procedure, Air pollution control, Hazardous substances, Hazardous waste, Penalties, Pesticides and pests, Poison prevention, Water pollution control.

40 CFR Part 85

Confidential business information, Imports, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Research, Warranties.

40 CFR Part 86

Administrative practice and procedure, Confidential business information, Incorporation by reference, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements.

40 CFR Part 600

Administrative practice and procedure, Electric power, Fuel economy, Incorporation by reference, Labeling, Reporting and recordkeeping requirements.

[1018] *See, e.g.,* 73 FR 28212, 28300 (May 15, 2008); 73 FR 76249 (Dec. 16, 2008); Memorandum from David Longly Bernhardt, Solicitor, U.S. Department of the Interior re: ''Guidance on the Applicability of the Endangered Species Act's Consultation Requirements to Proposed Actions Involving the Emission of Greenhouse Gases'' (Oct. 3, 2008).

40 CFR Part 1033

Administrative practice and procedure, Air pollution control.

40 CFR Parts 1036 and 1037

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Incorporation by reference, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Warranties.

40 CFR Part 1039

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Imports, Labeling, Penalties, Reporting and recordkeeping requirements, Warranties.

40 CFR Part 1042

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Imports, Incorporation by reference, Labeling, Penalties, Reporting and recordkeeping requirements, Vessels, Warranties.

40 CFR Part 1043

Environmental protection, Administrative practice and procedure, Air pollution control, Imports, Incorporation by reference, Vessels, Reporting and recordkeeping requirements.

40 CFR Parts 1065 and 1066

Administrative practice and procedure, Air pollution control, Incorporation by reference, Reporting and recordkeeping requirements, Research.

40 CFR Part 1068

Administrative practice and procedure, Confidential business information, Imports, Incorporation by reference, Motor vehicle pollution, Penalties, Reporting and recordkeeping requirements, Warranties.

49 CFR Parts 523, 534, and 535

Fuel economy, Reporting and recordkeeping requirements.

49 CFR Part 538

Administrative practice and procedure, Fuel economy, Motor vehicles, Reporting and recordkeeping requirements.

For the reasons set out in the Preamble, title 40, chapter I of the Code of Federal Regulations is amended as set forth below.

PART 9—OMB APPROVALS UNDER THE PAPERWORK REDUCTION ACT

■ 1. The authority citation for part 9 continues to read as follows:

Authority: 7 U.S.C. 135 *et seq.,* 136–136y; 15 U.S.C. 2001, 2003, 2005, 2006, 2601–2671; 21 U.S.C. 331j, 346a, 31 U.S.C. 9701; 33 U.S.C. 1251 *et seq.,* 1311, 1313d, 1314, 1318, 1321, 1326, 1330, 1342, 1344, 1345(d) and (e), 1361; E.O. 11735, 38 FR 21243, 3 CFR, 1971–1975 Comp. p. 973; 42 U.S.C. 241, 242b, 243, 246, 300f, 300g, 300g–1, 300g–2, 300g–3, 300g–4, 300g–5, 300g–6, 300j–1, 300j–2, 300j–3, 300j–4, 300j–9, 1857 *et seq.,* 6901–6992k, 7401–7671q, 7542, 9601–9657, 11023, 11048.

■ 2. In § 9.1 the table is amended by:

■ a. Adding in numerical order by CFR designation a new undesignated center heading ‘‘Control of Emissions from New and In-Use Heavy-Duty Highway Engines’’ and its entry in numerical order for ‘‘1036.825’’;

■ b. Adding in numerical order by CFR designation a new undesignated center heading ‘‘Control of Emissions from New Heavy-Duty Motor Vehicles’’ and its entry in numerical order for ‘‘1037.825’’; and

■ c. Adding in numerical order by CFR designation a new undesignated center heading ‘‘Control of NO_X SO_X, and PM Emissions from Marine Engines and Vessels Subject to the MARPOL Protocol’’ and its entries in numerical order for ‘‘1043.40–1043.95’’.

The additions read as follows:

§ 9.1 OMB approvals under the Paperwork Reduction Act.

* * * * *

40 CFR citation	OMB control No.
* * * * * * *	
Control of Emissions From New and In-Use Heavy-Duty Highway Engines	
1036.825	2060–0678
Control of Emissions From New Heavy-Duty Motor Vehicles	
1037.825	2060–0678
* * * * * * *	
Control of NO_X, SO_X, and PM Emissions From Marine Engines and Vessels Subject to the Marpol Protocol	
1043.40–1043.95	2060–0641
* * * * * * *	

* * * * *

PART 22—CONSOLIDATED RULES OF PRACTICE GOVERNING THE ADMINISTRATIVE ASSESSMENT OF CIVIL PENALTIES AND THE REVOCATION/TERMINATION OR SUSPENSION OF PERMITS

■ 3. The authority citation for part 22 continues to read as follows:

Authority: 7 U.S.C. 136(l); 15 U.S.C. 2615; 33 U.S.C. 1319, 1342, 1361, 1415 and 1418; 42 U.S.C. 300g–3(g), 6912, 6925, 6928, 6991e and 6992d; 42 U.S.C. 7413(d), 7524(c), 7545(d), 7547, 7601 and 7607(a), 9609, and 11045.

Subpart A—General

■ 4. Section 22.1 is amended by revising paragraph (a)(2) to read as follows:

§ 22.1 Scope of this part.

(a) * * *

(2) The assessment of any administrative civil penalty under sections 113(d), 205(c), 211(d) and 213(d) of the Clean Air Act, as amended (42 U.S.C. 7413(d), 7524(c), 7545(d) and 7547(d)), and a determination of nonconforming engines, vehicles or equipment under sections 207(c) and

Subpart H—Averaging, Banking, and Trading for Certification

Subpart I—Definitions and Other Reference Information

Authority: 42 U.S.C. 7401—7671q.

Subpart A—Overview and Applicability

§ 1037.1 Applicability.

(a) This part contains standards and other regulations applicable to the emission of the air pollutant defined as the aggregate group of six greenhouse gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The regulations in this part 1037 apply for all new heavy-duty vehicles, except as provided in §§ 1037.5 and 1037.104. This includes electric vehicles and vehicles fueled by conventional and alternative fuels. This also includes certain trailers as described in §§ 1037.5, 1037.150, and 1037.801.

(b) The provisions of this part apply for alternative fuel conversions as specified in 40 CFR part 85, subpart F.

§ 1037.2 Who is responsible for compliance?

The regulations in this part 1037 contain provisions that affect both vehicle manufacturers and others. However, the requirements of this part are generally addressed to the vehicle manufacturer(s). The term ‘‘you’’ generally means the vehicle manufacturer(s), especially for issues related to certification. See § 1037.801 for the definition of ‘‘manufacturer’’ and § 1037.620 for provisions related to compliance when there are multiple entities meeting the definition of ‘‘manufacturer.’’ Additional requirements and prohibitions apply to other persons as specified in subpart G of this part and 40 CFR part 1068.

§ 1037.5 Excluded vehicles.

Except for the definitions specified in § 1037.801, this part does not apply to the following vehicles:

(a) Vehicles not meeting the definition of ‘‘motor vehicle’’ in § 1037.801.

(b) Vehicles excluded from the definition of ‘‘heavy-duty vehicle’’ in § 1037.801 because of vehicle weight, weight rating, and frontal area (such as light-duty vehicles and light-duty trucks).

(c) Vehicles produced in model years before 2014, unless they were certified under § 1037.150.

(d) Medium-duty passenger vehicles and other vehicles subject to the light-duty greenhouse gas standards of 40 CFR part 86. See 40 CFR 86.1818 for greenhouse gas standards that apply for these vehicles. An example of such a vehicle would be a vehicle meeting the definition of ‘‘heavy-duty vehicle’’ in § 1037.801 and 40 CFR 86.1803, but also meeting the definition of ‘‘light truck’’ in 40 CFR 86.1818–12(b)(2).

(e) Vehicles subject to the heavy-duty greenhouse gas standards of 40 CFR part 86. See 40 CFR 86.1819 for greenhouse gas standards that apply for these vehicles. This generally applies for complete heavy-duty vehicles at or below 14,000 pounds GVWR.

(f) Aircraft meeting the definition of ‘‘motor vehicle’’. For example, this would include certain convertible aircraft that can be adjusted to operate on public roads. Standards apply separately to certain aircraft engines, as described in 40 CFR part 87.

(g) Non-box trailers other than flatbed trailers, tank trailers, and container chassis.

(h) Trailers meeting one or more of the following characteristics:

(1) Trailers with four or more axles and trailers less than 35 feet long with three axles (*i.e.,* trailers intended for hauling very heavy loads).

(2) Trailers intended for temporary or permanent residence, office space, or other work space, such as campers, mobile homes, and carnival trailers.

(3) Trailers with a gap of at least 120 inches between adjacent axle centerlines. In the case of adjustable axle spacing, this refers to the closest possible axle positioning.

(4) Trailers built before January 1, 2018.

(5) Note that the definition of ‘‘trailer’’ in § 1037.801 excludes equipment that serves similar purposes but are not intended to be pulled by a tractor. This exclusion applies to such equipment whether or not they are known commercially as trailers. For example, any equipment pulled by a heavy-duty vehicle with a pintle hook or hitch instead of a fifth wheel does not qualify as a trailer under this part.

(i) Where it is unclear, you may ask us to make a determination regarding the exclusions identified in this section. We recommend that you make your request before you produce the vehicle.

§ 1037.10 How is this part organized?

This part 1037 is divided into the following subparts:

(a) Subpart A of this part defines the applicability of part 1037 and gives an overview of regulatory requirements.

(b) Subpart B of this part describes the emission standards and other requirements that must be met to certify vehicles under this part. Note that § 1037.150 discusses certain interim requirements and compliance provisions that apply only for a limited time.

(c) Subpart C of this part describes how to apply for a certificate of conformity for vehicles subject to the standards of § 1037.105 or § 1037.106.

(d) Subpart D of this part addresses testing of production vehicles.

(e) Subpart E of this part addresses testing of in-use vehicles.

(f) Subpart F of this part describes how to test your vehicles and perform emission modeling (including references to other parts of the Code of Federal Regulations) for vehicles subject to the standards of § 1037.105 or § 1037.106.

(g) Subpart G of this part and 40 CFR part 1068 describe requirements, prohibitions, and other provisions that apply to manufacturers, owners, operators, rebuilders, and all others. Section 1037.601 describes how 40 CFR part 1068 applies for heavy-duty vehicles.

(h) Subpart H of this part describes how you may generate and use emission credits to certify vehicles.

(i) Subpart I of this part contains definitions and other reference information.

conform to these criteria, the test is not valid and must be repeated.

(e) Run test cycles as specified in 40 CFR part 1066. For testing vehicles equipped with cruise control over the highway cruise cycles, use the vehicle's cruise control to control the vehicle speed. For vehicles equipped with adjustable vehicle speed limiters, test the vehicle with the vehicle speed limiter at its highest setting.

(f) For Phase 1, test the vehicle using its adjusted loaded vehicle weight, unless we determine this would be unrepresentative of in-use operation as specified in 40 CFR 1065.10(c)(1).

(g) For hybrid vehicles, correct for the net energy change of the energy storage device as described in 40 CFR 1066.501.

§ 1037.515 Determining CO_2 emissions to show compliance for trailers.

This section describes a compliance approach for trailers that is consistent with the modeling for vocational vehicles and tractors described in § 1037.520, but is simplified consistent with the smaller number of trailer parameters that affect CO_2 emissions. Note that the calculated CO_2 emission rate, e_{CO2}, is equivalent to the value that would result from running GEM with the same input values.

(a) *Compliance equation.* Calculate CO_2 emissions for demonstrating compliance with emission standards for each trailer configuration.

(1) Use the following equation:

$$e_{\mathrm{CO2}} = \left(C_1 + C_2 \cdot TRRL + C_3 \cdot \Delta C_{\mathrm{d}}A + C_4 \cdot WR\right) \cdot C_5$$

Eq. 1037.515-1

Where:

C_i = constant values for calculating CO_2 emissions from this regression equation derived from GEM, as shown in Table 1 of this section. Let C_5 = 0.988 for trailers that have automatic tire inflation systems with all wheels, and let C_5 = 0.990 for trailers that have tire pressure monitoring systems with all wheels (or a mix of the two systems); otherwise, let C_5 = 1.

$TRRL$ = tire rolling resistance level as specified in paragraph (b) of this section.

ΔC_dA = the ΔC_dA value for the trailer as specified in paragraph (c) of this section.

WR = weight reduction as specified in paragraph (d) or (e) of this section.

TABLE 1 OF § 1037.515—REGRESSION COEFFICIENTS FOR CALCULATING CO_2 EMISSIONS

Trailer category	C_1	C_2	C_3	C_4
Long dry box van	76.1	1.67	−5.82	−0.00103
Long refrigerated box van	77.4	1.75	−5.78	−0.00103
Short dry box van	117.8	1.78	−9.48	−0.00258
Short refrigerated box van	121.1	1.88	−9.36	−0.00264

(2) The following is an example for calculating the mass of CO_2 emissions, e_{CO2}, from a long dry box van that has a tire pressure monitoring system for all wheels, an aluminum suspension assembly, aluminum floor, and is designated as Bin IV:

C_1 = 76.1
C_2 = 1.67
$TRRL$ = 4.6 kg/tonne
C_3 = −5.82
ΔC_dA = 0.7 m^2
C_4 = −0.00103
WR = 655 lbs
C_5 = 0.990
e_{CO2} = (76.1 + 1.67 + (−5.82 ·0.7) + (−0.00103 ·655)) ·0.990
e_{CO2} = 78.24 g/ton-mile

(b) *Tire rolling resistance.* Use the procedure specified in § 1037.520(c) to determine the tire rolling resistance level for your tires. Note that you may base tire rolling resistance levels on measurements performed by tire manufacturers, as long as those measurements meet this part's specifications.

(c) *Drag area.* You may use ΔC_dA values approved under § 1037.211 for device manufacturers if your trailers are properly equipped with those devices. Determine ΔC_dA values for other trailers based on testing. Measure C_dA and determine ΔC_dA values as described in § 1037.526(a). You may use ΔC_dA values from one trailer configuration to represent any number of additional trailers based on worst-case testing. This means that you may apply ΔC_dA values from your measurements to any trailer models of the same category with drag area at or below that of the tested configuration. For trailers in the short dry box vans and short refrigerated box vans that are not 28 feet long, apply the ΔC_dA value established for a comparable 28-foot trailer model; you may use the same devices designed for 28-foot trailers or you may adapt those devices as appropriate for the different trailer length, consistent with good engineering judgment. For example, 48-foot trailers may use longer side skirts than the skirts that were tested with a 28-foot trailer. Trailer and device manufacturers may seek preliminary approval for these adaptations. Determine bin levels based on ΔC_dA test results as described in the following table:

TABLE 2 OF § 1037.515—BIN DETERMINATIONS FOR TRAILERS BASED ON AERODYNAMIC TEST RESULTS

[ΔC_dA in m^2]

If a trailer's measured ΔC_dA is . . .	designate the trailer as . . .	and use the following value for ΔC_dA
≤0.09	Bin I	0.0
0.10–0.39	Bin II	0.1
0.40–0.69	Bin III	0.4
0.70–0.99	Bin IV	0.7

record, which may be made available for inspection. The hearing record includes, but is not limited to, the following materials:

(1) All documents relating to the application for certification, including the certificate of conformity itself, if applicable.

(2) Your request for a hearing and the accompanying supporting data.

(3) Correspondence and other data relevant to the hearing.

(4) The Presiding Officer's written decision regarding the subject of the hearing, together with any accompanying material.

(c) You may appear in person or you may be represented by counsel or by any other representative you designate.

(d) The Presiding Officer may arrange for a prehearing conference, either in response to a request from any party or at his or her own discretion. The Presiding Officer will select the time and place for the prehearing conference. The Presiding Officer will summarize the results of the conference and include the written summary as part of the record. The prehearing conference may involve consideration of the following items:

(1) Simplification of the issues.

(2) Stipulations, admissions of fact, and the introduction of documents.

(3) Limitation of the number of expert witnesses.

(4) Possibility of reaching an agreement to resolve any or all of the issues in dispute.

(5) Any other matters that may aid in expeditiously and successfully concluding the hearing.

(e) Hearings will be conducted as follows:

(1) The Presiding Officer will conduct informal hearings in an orderly and expeditious manner. The parties may offer oral or written evidence; however, the Presiding Officer may exclude evidence that is irrelevant, immaterial, or repetitious.

(2) Witnesses will not be required to testify under oath; however, the Presiding Officer must make clear that 18 U.S.C. 1001 specifies civil and criminal penalties for knowingly making false statements or representations or using false documents in any matter within the jurisdiction of EPA or any other department or agency of the United States.

(3) Any witness may be examined or cross-examined by the Presiding Officer, by you, or by any other parties.

(4) Written transcripts must be made for all hearings. Anyone may purchase copies of transcripts from the reporter.

(f) The Presiding Officer will make a final decision with written findings, conclusions and supporting rationale on all the substantial factual issues presented in the record. The findings, conclusions, and written decision must be provided to the parties and made a part of the record.

■ 373. Appendix I to part 1068 is amended by revising paragraph IV to read as follows:

Appendix I to Part 1068—Emission-Related Components

* * * * *

IV. Emission-related components also include any other part whose primary purpose is to reduce emissions or whose failure would commonly increase emissions without significantly degrading engine/equipment performance.

Department of Transportation

National Highway Traffic Safety Administration

49 CFR Chapter V

In consideration of the foregoing, under the authority of 49 U.S.C. 322, 5 U.S.C. 552, 49 U.S.C. 30166, 49 U.S.C. 30167, 49 U.S.C. 32307, 49 U.S.C. 32505, 49 U.S.C. 32708, 49 U.S.C. 32910, 49 U.S.C. 33116, 49 U.S.C. 32901, 49 U.S.C. 32902, 49 U.S.C. 30101, 49 U.S.C. 32905, 49 U.S.C. 32906, and delegation of authority at 49 CFR 1.95, NHTSA amends 49 CFR chapter V as follows:

PART 523—VEHICLE CLASSIFICATION

■ 374. Revise the authority citation for part 523 to read as follows:

Authority: 49 U.S.C. 32901; delegation of authority at 49 CFR 1.95.

■ 375. Revise § 523.2 to read as follows:

§ 523.2 Definitions.

As used in this part:

Ambulance has the meaning given in 40 CFR 86.1803.

Approach angle means the smallest angle, in a plane side view of an automobile, formed by the level surface on which the automobile is standing and a line tangent to the front tire static loaded radius arc and touching the underside of the automobile forward of the front tire.

Axle clearance means the vertical distance from the level surface on which an automobile is standing to the lowest point on the axle differential of the automobile.

Base tire (for passenger automobiles, light trucks, and medium duty passenger vehicles) means the tire size specified as standard equipment by the manufacturer on each unique combination of a vehicle's footprint and model type. Standard equipment is defined in 40 CFR 86.1803.

Basic vehicle frontal area is used as defined in 40 CFR 86.1803 for passenger automobiles, light trucks, medium duty passenger vehicles and Class 2b through 3 pickup trucks and vans. For heavy-duty tracts and vocational vehicles, it has the meaning given in 40 CFR 1037.801.

Breakover angle means the supplement of the largest angle, in the plan side view of an automobile that can be formed by two lines tangent to the front and rear static loaded radii arcs and intersecting at a point on the underside of the automobile.

Bus has the meaning given in 49 CFR 571.3.

Cab-complete vehicle means a vehicle that is first sold as an incomplete vehicle that substantially includes the vehicle cab section as defined in 40 CFR 1037.801. For example, vehicles known commercially as chassis-cabs, cab-chassis, box-deletes, bed-deletes, and cut-away vans are considered cab-complete vehicles. A cab includes a steering column and a passenger compartment. Note that a vehicle lacking some components of the cab is a cab-complete vehicle if it substantially includes the cab.

Cargo-carrying volume means the luggage capacity or cargo volume index, as appropriate, and as those terms are defined in 40 CFR 600.315–08, in the case of automobiles to which either of these terms apply. With respect to automobiles to which neither of these terms apply, ''cargo-carrying volume'' means the total volume in cubic feet, rounded to the nearest 0.1 cubic feet, of either an automobile's enclosed nonseating space that is intended primarily for carrying cargo and is not accessible from the passenger compartment, or the space intended primarily for carrying cargo bounded in the front by a vertical plane that is perpendicular to the longitudinal centerline of the automobile and passes through the rearmost point on the rearmost seat and elsewhere by the automobile's interior surfaces.

Class 2b vehicles are vehicles with a gross vehicle weight rating (GVWR) ranging from 8,501 to 10,000 pounds.

Class 3 through Class 8 vehicles are vehicles with a gross vehicle weight rating (GVWR) of 10,001 pounds or more as defined in 49 CFR 565.15.

Coach bus has the meaning given in 40 CFR 1037.801.

Commercial medium- and heavy-duty on-highway vehicle means an on-highway vehicle with a gross vehicle weight rating of 10,000 pounds or more as defined in 49 U.S.C. 32901(a)(7).

Complete vehicle has the meaning given to *completed vehicle* as defined in 49 CFR 567.3.

Concrete mixer has the meaning given in 40 CFR 1037.801.

Curb weight has the meaning given in 49 CFR 571.3.

Dedicated vehicle has the same meaning as dedicated automobile as defined in 49 U.S.C. 32901(a)(8).

Departure angle means the smallest angle, in a plane side view of an automobile, formed by the level surface on which the automobile is standing and a line tangent to the rear tire static loaded radius arc and touching the underside of the automobile rearward of the rear tire.

Dual-fueled vehicle (multi-fuel, or flexible-fuel vehicle) has the same meaning as dual fueled automobile as defined in 49 U.S.C. 32901(a)(9).

Electric vehicle means a vehicle that does not include an engine, and is powered solely by an external source of electricity and/or solar power. Note that this does not include electric hybrid or fuel-cell vehicles that use a chemical fuel such as gasoline, diesel fuel, or hydrogen. Electric vehicles may also be referred to as all-electric vehicles to distinguish them from hybrid vehicles.

Emergency vehicle means one of the following:

(1) For passenger cars, light trucks and medium duty passenger vehicles, emergency vehicle has the meaning given in 49 U.S.C. 32902(e).

(2) For heavy-duty vehicles, emergency vehicle has the meaning given in 40 CFR 1037.801.

Engine code has the meaning given in 40 CFR 86.1803.

Final stage manufacturer has the meaning given in 49 CFR 567.3.

Fire truck has the meaning given in 40 CFR 86.1803.

Footprint is defined as the product of track width (measured in inches, calculated as the average of front and rear track widths, and rounded to the nearest tenth of an inch) times wheelbase (measured in inches and rounded to the nearest tenth of an inch), divided by 144 and then rounded to the nearest tenth of a square foot. For purposes of this definition, track width is the lateral distance between the centerlines of the base tires at ground, including the camber angle. For purposes of this definition, wheelbase is the longitudinal distance between front and rear wheel centerlines.

Full-size pickup truck means a light truck or medium duty passenger vehicle that meets the requirements specified in 40 CFR 86.1866–12(e).

Gross axle weight rating (GAWR) has the meaning given in 49 CFR 571.3.

Gross combination weight rating (GCWR) has the meaning given in 49 CFR 571.3.

Gross vehicle weight rating (GVWR) has the meaning given in 49 CFR 571.3.

Heavy-duty engine means any engine used for (or for which the engine manufacturer could reasonably expect to be used for) motive power in a heavy-duty vehicle. For purposes of this definition in this part, the term ‘‘engine’’ includes internal combustion engines and other devices that convert chemical fuel into motive power. For example, a fuel cell and motor used in a heavy-duty vehicle is a heavy-duty engine. Heavy duty-engines include those engines subject to the standards in 49 CFR part 535.

Heavy-duty vehicle means a vehicle as defined in § 523.6.

Hitch means a device attached to the chassis of a vehicle for towing.

Incomplete vehicle has the meaning given in 49 CFR 567.3.

Light truck means a non-passenger automobile meeting the criteria in § 523.5.

Manufacturer has the meaning given in 49 U.S.C. 32901(a)(14).

Medium duty passenger vehicle means a vehicle which would satisfy the criteria in § 523.5 (relating to light trucks) but for its gross vehicle weight rating or its curb weight, which is rated at more than 8,500 lbs GVWR or has a vehicle curb weight of more than 6,000 pounds or has a basic vehicle frontal area in excess of 45 square feet, and which is designed primarily to transport passengers, but does not include a vehicle that—

(1) Is an ‘‘incomplete vehicle’’ ' as defined in this subpart; or

(2) Has a seating capacity of more than 12 persons; or

(3) Is designed for more than 9 persons in seating rearward of the driver's seat; or

(4) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition.

Mild hybrid gasoline-electric vehicle means a vehicle as defined by EPA in 40 CFR 86.1866–12(e).

Motor home has the meaning given in 49 CFR 571.3.

Motor vehicle has the meaning given in 49 U.S.C. 30102.

Passenger-carrying volume means the sum of the front seat volume and, if any, rear seat volume, as defined in 40 CFR 600.315–08, in the case of automobiles to which that term applies. With respect to automobiles to which that term does not apply, ‘‘passenger-carrying volume’’ means the sum in cubic feet, rounded to the nearest 0.1 cubic feet, of the volume of a vehicle's front seat and seats to the rear of the front seat, as applicable, calculated as follows with the head room, shoulder room, and leg room dimensions determined in accordance with the procedures outlined in Society of Automotive Engineers Recommended Practice J1100, Motor Vehicle Dimensions (Report of Human Factors Engineering Committee, Society of Automotive Engineers, approved November 2009).

(1) For front seat volume, divide 1,728 into the product of the following SAE dimensions, measured in inches to the nearest 0.1 inches, and round the quotient to the nearest 0.001 cubic feet.

(i) H61-Effective head room—front.

(ii) W3-Shoulder room—front.

(iii) L34-Maximum effective leg room-accelerator.

(2) For the volume of seats to the rear of the front seat, divide 1,728 into the product of the following SAE dimensions, measured in inches to the nearest 0.1 inches, and rounded the quotient to the nearest 0.001 cubic feet.

(i) H63-Effective head room—second.

(ii) W4-Shoulder room—second.

(iii) L51-Minimum effective leg room—second.

Pickup truck means a non-passenger automobile which has a passenger compartment and an open cargo area (bed).

Pintle hooks means a type of towing hitch that uses a tow ring configuration to secure to a hook or a ball combination for the purpose of towing.

Recreational vehicle or RV means a motor vehicle equipped with living space and amenities found in a motor home.

Refuse hauler has the meaning given in 40 CFR 1037.801.

Running clearance means the distance from the surface on which an automobile is standing to the lowest point on the automobile, excluding unsprung weight.

School bus has the meaning given in 49 CFR 571.3.

Static loaded radius arc means a portion of a circle whose center is the center of a standard tire-rim combination of an automobile and whose radius is the distance from that center to the level surface on which the automobile is standing, measured with the automobile at curb weight, the wheel parallel to the vehicle's longitudinal centerline, and the tire inflated to the manufacturer's recommended pressure.

Strong hybrid gasoline-electric vehicle means a vehicle as defined by EPA in 40 CFR 86.1866–12(e).

Temporary living quarters means a space in the interior of an automobile in which people may temporarily live and which includes sleeping surfaces, such as beds, and household conveniences, such as a sink, stove, refrigerator, or toilet.

Transmission class has the meaning given in 40 CFR 600.002.

Tranmission configuration has the meaning given in 40 CFR 600.002.

Transmission type has the meaning given in 40 CFR 86.1803.

Truck tractor has the meaning given in 49 CFR 571.3 and 49 CFR 535.5(c). This includes most heavy-duty vehicles specifically designed for the primary purpose of pulling trailers, but does not include vehicles designed to carry other loads. For purposes of this definition ''other loads'' would not include loads carried in the cab, sleeper compartment, or toolboxes. Examples of vehicles that are similar to tractors but that are not tractors under this part include dromedary tractors, automobile haulers, straight trucks with trailers hitches, and tow trucks.

Van means a vehicle with a body that fully encloses the driver and a cargo carrying or work performing compartment. The distance from the leading edge of the windshield to the foremost body section of vans is typically shorter than that of pickup trucks and sport utility vehicles.

Vocational tractor means a tractor that is classified as a vocational vehicle according to 40 CFR 1037.630

Vocational vehicle (or heavy-duty vocational vehicle) has the meaning given in § 523.8 and 49 CFR 535.5(b). This includes any vehicle that is equipped for a particular industry, trade or occupation such as construction, heavy hauling, mining, logging, oil fields, refuse and includes vehicles such as school buses, motorcoaches and RVs.

Work truck means a vehicle that is rated at more than 8,500 pounds and less than or equal to 10,000 pounds gross vehicle weight, and is not a medium-duty passenger vehicle as defined in 49 U.S.C. 32901(a)(19).

■ 376. Revise § 523.6 to read as follows:

§ 523.6 Heavy-duty vehicle.

(a) A heavy-duty vehicle is any commercial medium or heavy-duty on-highway vehicle or a work truck, as defined in 49 U.S.C. 32901(a)(7) and (19). For the purpose of this section, heavy-duty vehicles are divided into four regulatory categories as follows:

(1) Heavy-duty pickup trucks and vans;

(2) Heavy-duty vocational vehicles;

(3) Truck tractors with a GVWR above 26,000 pounds; and

(4) Heavy-duty trailers.

(b) The heavy-duty vehicle classification does not include vehicles excluded as specified in 49 CFR 535.3.

■ 377. Revise § 523.7 to read as follows:

§ 523.7 Heavy-duty pickup trucks and vans.

(a) Heavy-duty pickup trucks and vans are pickup trucks and vans with a gross vehicle weight rating between 8,501 pounds and 14,000 pounds (Class 2b through 3 vehicles) manufactured as complete vehicles by a single or final stage manufacturer or manufactured as incomplete vehicles as designated by a manufacturer. See references in 40 CFR 86.1801–12, 40 CFR 86.1819–17, 40 CFR 1037.150, and 49 CFR 535.5(a).

(b) Heavy duty vehicles above 14,000 pounds GVWR may be optionally certified as heavy-duty pickup trucks and vans and comply with fuel consumption standards in 49 CFR 535.5(a), if properly included in a test group with similar vehicles at or below 14,000 pounds GVWR. Fuel consumption standards apply to these vehicles as if they were Class 3 heavy-duty vehicles. The work factor for these vehicles may not be greater than the largest work factor that applies for vehicles in the test group that are at or below 14,000 pounds GVWR (see 40 CFR 86.1819–14).

(c) Incomplete heavy-duty vehicles at or below 14,000 pounds GVWR may be optionally certified as heavy-duty pickup trucks and vans and comply with to the fuel consumption standards in 49 CFR 535.5(a).

■ 378. Add § 523.10 to read as follows:

§ 523.10 Heavy-duty trailers.

(a) A trailer means a motor vehicle with or without motive power, designed for carrying cargo and for being drawn by another motor vehicle as defined in 49 CFR 571.3. For the purpose of this part, heavy-duty trailers include only those trailers designed to be drawn by a truck tractor excluding non-box trailers other than flatbed trailer, tanker trailers and container chassis and those that are coupled to vehicles exclusively by pintle hooks or hitches instead of a fifth wheel. Heavy-duty trailers may be divided into different types and categories as follows:

(1) Box vans are trailers with enclosed cargo space that is permanently attached to the chassis, with fixed sides, nose, and roof. Tank trailers are not box vans.

(2) Box van with front-mounted HVAC systems are refrigerated vans. Note that this includes systems that provide cooling, heating, or both. All other box vans are dry vans.

(3) Trailers that are not box vans are non-box trailers. Note that the standards for non-box trailers in 49 CFR 535.5(e)(2) apply only to flatbed trailers, tank trailers, and container chassis.

(4) Box van with a length greater than 50 feet are long box vans. Other box vans are short box vans.

(5) The following types of equipment are not trailers:

(i) Containers that are not permanently mounted on chassis.

(ii) Dollies used to connect tandem trailers.

(iii) Equipment that serves similar purposes but are not intended to be pulled by a tractor.

(b) Heavy-duty trailers do not include trailers excluded in 49 CFR 535.3.

PART 534—RIGHTS AND RESPONSIBILITIES OF MANUFACTURERS IN THE CONTEXT OF CHANGES IN CORPORATE RELATIONSHIPS

■ 379. Revise the authority citation for part 534 to read as follows:

Authority: 49 U.S.C. 32901; delegation of authority at 49 CFR 1.95.

■ 380. Add § 534.8 to read as follows:

§ 534.8 Shared corporate relationships.

(a) Vehicles and engines built by multiple manufacturers can share responsibility for complying with fuel consumption standards in 49 CFR part 535, by following the EPA requirements in 40 CFR 1037.620 and by sending a joint agreement between the parties to EPA and NHTSA before submitting any certificates of conformity for the applicable vehicles or engines in accordance with 40 CFR part 1036, subpart C, and 40 CFR part 1037, subpart C.

(1) Each joint agreement must—

(i) Define how each manufacturer shares responsibility for the planned vehicles or engines.

(ii) Specify which manufacturer(s) will be responsible for the EPA certificates of conformity;

(iii) Describe the planned vehicles and engines in terms of the model types, production volumes, and model years (if known);

(iv) Describe which manufacturer(s) have engineering and design control and sale distribution ownership over the vehicles and/or engines; and

(v) Include signatures from all parties involved in the shared corporate relationship.

(2) After defining the shared relationship between the manufacturers, any contractual changes must be

notified to EPA and NHTSA before the next model year's production of the applicable vehicles or engines begins.

(3) Multiple manufacturers must designate the same shared responsibility for complying with fuel consumption standards as selected for GHG standards unless otherwise allowed by EPA and NHTSA.

(b) NHTSA and EPA reserve the right to reject the joint agreement.

■ 381. Revise part 535 to read as follows:

PART 535 MEDIUM-AND HEAVY-DUTY VEHICLE FUEL EFFICIENCY PROGRAM

Authority: 49 U.S.C. 32902 and 30101; delegation of authority at 49 CFR 1.95.

§ 535.1 Scope.

This part establishes fuel consumption standards pursuant to 49 U.S.C. 32902(k) for work trucks and commercial medium- and heavy-duty on-highway vehicles, including trailers (hereafter referenced as heavy-duty vehicles), and engines manufactured for sale in the United States. This part establishes a credit program manufacturers may use to comply with standards and requirements for manufacturers to provide reports to the National Highway Traffic Safety Administration regarding their efforts to reduce the fuel consumption of heavy-duty vehicles and engines.

§ 535.2 Purpose.

The purpose of this part is to reduce the fuel consumption of new heavy-duty vehicles and engines by establishing maximum levels for fuel consumption standards while providing a flexible credit program to assist manufacturers in complying with standards.

§ 535.3 Applicability.

(a) This part applies to manufacturers that produce complete and incomplete heavy-duty vehicles as defined in 49 CFR part 523, and to the manufacturers of all heavy-duty engines manufactured for use in the applicable vehicles for each given model year.

(b) This part also applies to alterers, final stage manufacturers, and intermediate manufacturers producing vehicles and engines or assembling motor vehicles or motor vehicle equipment under special conditions. Manufacturers comply with this part by following the special conditions in 40 CFR 1037.620, 1037.621, and 1037.622 in which EPA allows manufacturer to:

(1) Share responsibility for the vehicles they produce. Manufacturers sharing responsibility for complying with emissions and fuel consumption standards must submit to the agencies a joint agreement as specified in 49 CFR 534.8(a);

(2) Have certificate holders sell or ship vehicles that are missing certain emission-related components to be installed by secondary vehicle manufacturers;

(3) Ship partially complete vehicles to secondary manufacturers;

(4) Build electric vehicles; and

(5) Build alternative fueled vehicles from all types of heavy duty engine conversions. The conversion manufacturer must:

(i) Install alternative fuel conversion systems into vehicles acquired from vehicle manufacturers prior to first retail sale or prior to the vehicle's introduction into interstate commerce.

(ii) Be designated by the vehicle manufacturer and EPA to be the certificate holder.

(iii) Omit alternative fueled vehicles from compliance with vehicle fuel consumption standards, if—

(A) Excluded from EPA emissions standards; and

(B) A reasonable technical basis exist that the modified vehicle continues to meet emissions and fuel consumption vehicle standards.

(c) Vehicle and engine manufacturers that must comply with this part include manufacturers required to have approved certificates of conformity from EPA as specified in 40 CFR parts 86, 1036, and 1037.

(d) The following heavy-duty vehicles and engines are excluded from the requirements of this part:

(1) Vehicles and engines manufactured prior to January 1, 2014, unless certified early under NHTSA's voluntary provisions in § 535.5.

(2) Medium-duty passenger vehicles and other vehicles subject to the light-duty corporate average fuel economy standards in 49 CFR parts 531 and 533.

(3) Recreational vehicles, including motor homes manufactured before January 1, 2021, except those produced by manufacturers voluntarily complying with NHTSA's early vocational standards for model years 2013 through 2020.

(4) Aircraft vehicles meeting the definition of ''motor vehicle''. For example, this would include certain convertible aircraft that can be adjusted to operate on public roads.

(5) Heavy-duty trailers as defined in 49 CFR 523.10 meeting one or more of the following criteria are excluded from trailer standards in § 535.5(e):

(i) Trailers with four or more axles and trailers less than 35 feet long with three axles (*i.e.,* trailers intended for hauling very heavy loads).

(ii) Trailers intended for temporary or permanent residence, office space, or other work space, such as campers, mobile homes, and carnival trailers.

(iii) Trailers with a gap of at least 120 inches between adjacent axle centerlines. In the case of adjustable axle spacing, this refers to the closest possible axle positioning.

(iv) Trailers built before January 1, 2021, except those trailers built by manufacturers after January 1, 2018, and voluntarily complying with NHTSA's early trailer standards for model years 2018 through 2020.

(v) Note that the definition of ''heavy-duty trailer'' in 49 CFR 523.10 excludes equipment that serves similar purposes but are not intended to be pulled by a tractor. This exclusion applies to such equipment whether or not they are known commercially as trailers. For example, any equipment pulled by a heavy-duty vehicle with a pintle hook or hitch instead of a fifth wheel does not qualify as a trailer under this part.

(6) Engines installed in heavy-duty vehicles that are not used to propel vehicles. Note, this includes engines used to indirectly propel vehicles (such as electrical generator engines that power to batteries for propulsion).

(7) The provisions of this part do not apply to engines that are not internal combustion engines. For example, the provisions of this part do not apply to fuel cells. Note that gas turbine engines are internal combustion engines.

(e) The following heavy-duty vehicles and engines are exempted from the requirements of this part:

(1) *Off-road vehicles.* Vehicle manufacturers producing vehicles intended for off-road may exempt vehicles without requesting approval from the agencies subject to the criteria in § 535.5(b)(9)(i) and 40 CFR 1037.631(a). If unusual circumstances exist and a manufacturer is uncertain as to whether its vehicles qualify, the manufacturer should ask for a preliminary determination from the agencies before submitting its application for certification in

accordance with 40 CFR 1037.205 for the applicable vehicles. Send the request with supporting information to EPA and the agencies will coordinate in making a preliminary determination as specified in 40 CFR 1037.210. These decisions are considered to be preliminary approvals and subject to final review and approval.

(2) *Small business manufacturers.* (i) For Phase 1, small business manufacturers are exempted from the vehicle and engine standards of § 535.5, but must comply with the reporting requirements of § 535.8(g).

(ii) For Phase 2, fuel consumption standards apply on a delayed schedule for manufacturers meeting the small business criteria specified in 13 CFR 121.201 and in 40 CFR 86.1819–14(k)(5), 40 CFR 1036.150, and 40 CFR 1037.150. Qualifying manufacturers of truck tractors, vocational vehicles, heavy duty pickups and vans, and engines are not subject to the fuel consumption standards for vehicles built before January 1, 2022 and engines (such as those engines built by small alternative fuel engine converters) with a date of manufacturer on or after November 14, 2011 and before January 1, 2022. Qualifying manufacturers may choose to voluntarily comply early.

(iii) Small business manufacturers producing vehicles and engines that run on any fuel other than gasoline, E85, or diesel fuel meeting the criteria specified in 13 CFR 121.201 and in 40 CFR 86.1819–14(k)(5), 40 CFR 1036.150, and 40 CFR 1037.150 may delay complying with every new mandatory standard under this part by one model year.

(3) *Transitional allowances for trailers.* Through model year 2026, trailer manufacturers may calculate a number of trailers that are exempt from the fuel consumption standards of this part. Calculate the number of exempt box vans in a given model year by multiplying the manufacturer's total U.S.-directed production volume of certified box vans by 0.20 and rounding to the nearest whole number; however, in no case may the number of exempted box vans be greater than 350 units in any given model year. Repeat this calculation to determine the number of non-box trailers, up to 250 annual units, that are exempt from standards and certification requirements. Manufacturers perform the calculation based on their projected production volumes in the first year that standards apply; in later years, use actual production volumes from the preceding model year. Manufacturers must include these calculated values and the production volumes of exempt trailers in their annual production reports required under § 535.8(g)(12).

(4) *Engines for specialty vehicles.* Engines certified to the alternative standards specified in 40 CFR 86.007–11 and 86.008–10 for use in specialty vehicles as described in 40 CFR 1037.605. Compliance with the vehicle provisions in 40 CFR 1037.605 satisfies compliance for NHTSA under this part.

(f) For model year 2021 and later, vocational vehicle manufacturers building custom chassis vehicles (*e.g.* emergency vehicles) may be exempted from standards in § 535.5(b)(4) and may comply with alternative fuel consumption standards as specified in § 535.5(b)(6). Manufacturers complying with alternative fuel consumption standards in § 535.5(b)(6) are restricted in using fuel consumption credits as specified in § 535.7(c).

(g) The fuel consumption standards in some cases apply differently for spark-ignition and compression-ignition engines or vehicles as specified in 40 CFR parts 1036 and 1037. Engine requirements are similarly differentiated by engine type and by primary intended service class, as described in 40 CFR 1036.140.

(h) NHTSA may exclude or exempt vehicles and engines under special conditions allowed by EPA in accordance with 40 CFR parts 85, 86, 1036, 1037, 1039, and 1068. Manufacturers should consult the agencies if uncertain how to apply any EPA provision under the NHTSA fuel consumption program. It is recommend that manufacturers seek clarification before producing a vehicle. Upon notification by EPA of a fraudulent use of an exemption, NHTSA reserves that right to suspend or revoke any exemption or exclusion.

(i) In cases where there are differences between the application of this part and the corresponding EPA program regarding whether a vehicle is regulated or not (such as due to differences in applicability resulting from differing agency definitions, etc.), manufacturers should contact the agencies to identify these vehicles and assess the applicability of the agencies' standards. The agencies will provide guidance on how the vehicles can comply. Manufacturers are required to identify these vehicles in their final reports submitted in accordance with § 535.8.

§ 535.4 Definitions.

The terms manufacture and manufacturer are used as defined in section 501 of the Act and the terms commercial medium-duty and heavy-duty on highway vehicle, fuel and work truck are used as defined in 49 U.S.C. 32901. See 49 CFR 523.2 for general definitions related to NHTSA's fuel efficiency programs.

Act means the Motor Vehicle Information and Cost Savings Act, as amended by Pub. L. 94–163 and 96–425.

Administrator means the Administrator of the National Highway Traffic Safety Administration (NHTSA) or the Administrator's delegate.

Advanced technology means vehicle technology under this fuel consumption program in §§ 535.6 and 535.7 and by EPA under 40 CFR 86.1819–14(d)(7), 1036.615, or 1037.615.

Alterers means a manufacturer that modifies an altered vehicle as defined in 49 CFR 567.3

Alternative fuel conversion has the meaning given for clean alternative fuel conversion in 40 CFR 85.502.

A to B testing has the meaning given in 40 CFR 1037.801.

Automated manual transmission has the meaning given in 40 CFR 1037.801.

Automatic tire inflation system has the meaning given in 40 CFR 1037.801.

Automatic transmission (AT) has the meaning given in 40 CFR 1037.801.

Auxiliary power unit has the meaning given in 40 CFR 1037.801.

Averaging set means, a set of engines or vehicles in which fuel consumption credits may be exchanged. Credits generated by one engine or vehicle family may only be used by other respective engine or vehicle families in the same averaging set as specified in § 535.7 . Note that an averaging set may comprise more than one regulatory subcategory. The averaging sets for this HD program are defined as follows:

(1) Heavy-duty pickup trucks and vans.

(2) Light heavy-duty (LHD) vehicles.

(3) Medium heavy-duty (MHD) vehicles.

(4) Heavy heavy-duty (HHD) vehicles.

(5) Light heavy-duty engines subject to compression-ignition standards.

(6) Medium heavy-duty engines subject to compression-ignition standards.

(7) Heavy heavy-duty engines subject to compression-ignition standards.

(8) Engines subject to spark-ignition standards.

(9) Long trailers.

(10) Short trailers.

(11) Vehicle types certifying to optional custom chassis standards as specified in § 535.5(b)(6) form separate averaging sets for each vehicle type as specified in § 535.7(c).

Axle ratio or Drive axle ratio, k_a has the meaning given in 40 CFR 1037.801.

Basic vehicle frontal area has the meaning given in 40 CFR 1037.801.

Cab-complete vehicle has the meaning given in 49 CFR 523.2.

Carryover has the meaning given in 40 CFR 1037.801.

Certificate holder means the manufacturer who holds the certificate of conformity for the vehicle or engine and that assigns the model year based on the date when its manufacturing operations are completed relative to its annual model year period.

Certificate of Conformity means an approval document granted by EPA to a manufacturer that submits an application for a vehicle or engine emissions family in 40 CFR 1036.205 and 1037.205. A certificate of conformity is valid from the indicated effective date until December 31 of the model year for which it is issued. The certificate must be renewed annually for any vehicle a manufacturer continues to produce.

Certification has the meaning given in 40 CFR 1037.801.

Certified emission level has the meaning given in 40 CFR 1036.801.

Chassis-cab means the incomplete part of a vehicle that includes a frame, a completed occupant compartment and that requires only the addition of cargo-carrying, work-performing, or load-bearing components to perform its intended functions.

Chief Counsel means the NHTSA Chief Counsel, or his or her designee.

Class means relating to GVWR classes for vehicles other than trailers, as follows:

(1) *Class 2b vehicles* are vehicles with a gross vehicle weight rating (GVWR) ranging from 8,501 to 10,000 pounds.

(2) *Class 3 through Class 8 vehicles* are vehicles with a gross vehicle weight rating (GVWR) of 10,001 pounds or more as defined in 49 CFR 565.15.

Complete sister vehicle is a complete vehicle of the same configuration as a cab-complete vehicle.

Complete vehicle has the meaning given in 49 CFR part 523.

Compression-ignition (CI) means relating to a type of reciprocating, internal-combustion engine, such as a diesel engine, that is not a spark-ignition engine. Note, in accordance with 40 CFR 1036.1, gas turbine engines and other engines not meeting the definition of compression-ignition are deemed to be compression-ignition engines for complying with fuel consumption standards.

Configuration means a subclassification within a test group for passenger cars, light trucks and medium-duty passenger vehicles and heavy-duty pickup trucks and vans which is based on basic engine, engine code, transmission type and gear ratios, and final drive ratio.

Container chassis trailer has the same meaning as container chassis in 40 CFR 1037.801.

Curb weight has the meaning given in 40 CFR 86.1803.

Custom chassis vehicle means a vocational vehicle that is a motor home, school bus, refuse hauler, concrete mixer, emergency vehicle, mixed-use vehicle or other buses that are not school buses or motor coaches. These vehicle types are defined in 49 CFR 523.3. A ''mixed-use vehicle'' is one that meets at least one of the criteria specified in 40 CFR 1037.631(a)(1) or at least one of the criteria in 40 CFR 1037.631(a)(2), but not both.

Date of manufacture means the date on which the certifying vehicle manufacturer completes its manufacturing operations, except as follows:

(1) Where the certificate holder is an engine manufacturer that does not manufacture the complete or incomplete vehicle, the date of manufacture of the vehicle is based on the date assembly of the vehicle is completed.

(2) EPA and NHTSA may approve an alternate date of manufacture based on the date on which the certifying (or primary) vehicle manufacturer completes assembly at the place of main assembly, consistent with the provisions of 40 CFR 1037.601 and 49 CFR 567.4.

(3) A vehicle manufacturer that completes assembly of a vehicle at two or more facilities may ask to use as the month and year of manufacture, for that vehicle, the month and year in which manufacturing is completed at the place of main assembly, consistent with provisions of 49 CFR 567.4, as the model year. Note that such staged assembly is subject to the provisions of 40 CFR 1068.260(c). NHTSA's allowance of this provision is effective when EPA approves the manufacturer's certificates of conformity for these vehicles.

Day cab has the meaning given in 40 CFR 1037.801.

Drayage tractor has the meaning given in 40 CFR 1037.801.

Dual-clutch transmission (DCT) means a transmission has the meaning given in 40 CFR 1037.801.

Dual-fuel has the meaning given in 40 CFR 1037.801.

Electric vehicle has the meaning given in 40 CFR 1037.801.

Emergency vehicle means a vehicle that meets one of the criteria in 40 CFR 1037.801.

Engine family has the meaning given in 40 CFR 1036.230. Manufacturers designate families in accordance with EPA provisions and may not choose different families between the NHTSA and EPA programs.

Excluded means a vehicle or engine manufacturer or component is not required to comply with any aspects with the NHTSA fuel consumption program.

Exempted means a vehicle or engine manufacturer or component is not required to comply with certain provisions of the NHTSA fuel consumption program.

Family certification level (FCL) has the meaning given in 40 CFR 1036.801.

Family emission limit (FEL) has the meaning given in 40 CFR 1037.801.

Final drive ratio has the meaning given in 40 CFR 1037.801.

Final-stage manufacturer has the meaning given in 49 CFR 567.3 and includes secondary vehicle manufacturers as defined in 40 CFR 1037.801.

Flatbed trailer has the meaning given in 40 CFR 1037.801.

Fleet in this part means all the heavy-duty vehicles or engines within each of the regulatory sub-categories that are manufactured by a manufacturer in a particular model year and that are subject to fuel consumption standards under § 535.5.

Fleet average fuel consumption is the calculated average fuel consumption performance value for a manufacturer's fleet derived from the production weighted fuel consumption values of the unique vehicle configurations within each vehicle model type that makes up that manufacturer's vehicle fleet in a given model year. In this part, the fleet average fuel consumption value is determined for each manufacturer's fleet of heavy-duty pickup trucks and vans.

Fleet average fuel consumption standard is the actual average fuel consumption standard for a manufacturer's fleet derived from the production weighted fuel consumption standards of each unique vehicle configuration, based on payload, tow capacity and drive configuration (2, 4 or all-wheel drive), of the model types that makes up that manufacturer's vehicle fleet in a given model year. In this part, the fleet average fuel consumption standard is determined for each manufacturer's fleet of heavy-duty pickup trucks and vans.

Fuel cell means an electrochemical cell that produces electricity via the non-combustion reaction of a consumable fuel, typically hydrogen.

Fuel cell electric vehicle means a motor vehicle propelled solely by an electric motor where energy for the motor is supplied by a fuel cell.

Fuel efficiency means the amount of work performed for each gallon of fuel consumed.

Gaseous fuel has the meaning given in 40 CFR 1037.801.

Greenhouse gas Emissions Model (GEM) has the meaning given in 40 CFR 1037.801.

Gross axle weight rating (GAWR) has the meaning given in 49 CFR 571.3.

Gross combination weight rating (GCWR) has the meaning given in 49 CFR 571.3.

Gross vehicle weight rating (GVWR) has the meaning given in 49 CFR 571.3.

Good engineering judgment has the meaning given in 40 CFR 1068.30. See 40 CFR 1068.5 for the administrative process used to evaluate good engineering judgment.

Heavy-duty off-road vehicle means a heavy-duty vocational vehicle or vocational tractor that is intended for off-road use.

Heavy-duty vehicle has the meaning given in 49 CFR part 523.

Heavy-haul tractor has the meaning given in 40 CFR 1037.801.

Heavy heavy-duty (HHD) vehicle has the meaning given in vehicle service class.

Hybrid engine or hybrid powertrain means an engine or powertrain that includes energy storage features other than a conventional battery system or conventional flywheel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Note that certain provisions in this part treat hybrid engines and powertrains intended for vehicles that include regenerative braking different than those intended for vehicles that do not include regenerative braking.

Hybrid vehicle means a vehicle that includes energy storage features (other than a conventional battery system or conventional flywheel) in addition to an internal combustion engine or other engine using consumable chemical fuel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems Note that certain provisions in this part treat hybrid vehicles that include regenerative braking different than those that do not include regenerative braking.

Idle operation has the meaning given in 40 CFR 1037.801.

Incomplete vehicle has the meaning given in 49 CFR part 523. For the purpose of this regulation, a manufacturer may request EPA and NHTSA to allow the certification of a vehicle as an incomplete vehicle if it manufactures the engine and sells the unassembled chassis components, provided it does not produce and sell the body components necessary to complete the vehicle.

Innovative technology means technology certified under § 535.7 and by EPA under 40 CFR 86.1819–14(d)(13), 1036.610, and 1037.610 in the Phase 1 program.

Intermediate manufacturer has the meaning given in 49 CFR 567.3.

Light heavy-duty (LHD) vehicle has the meaning given in vehicle service class.

Liquefied petroleum gas (LPG) has the meaning given in 40 CFR 1036.801.

Low rolling resistance tire means a tire on a vocational vehicle with a tire rolling resistance level (TRRL) of 7.7 kg/metric ton or lower, a steer tire on a tractor with a TRRL of 7.7 kg/metric ton or lower, or a drive tire on a tractor with a TRRL of 8.1 kg/metric ton or lower.

Manual transmission (MT) has the meaning given in 40 CFR 1037.801.

Medium heavy-duty (MHD) vehicle has the meaning given in vehicle service class.

Model type has the meaning given in 40 CFR 600.002.

Model year as it applies to vehicles means:

(1) For tractors and vocational vehicles with a date of manufacture on or after January 1, 2021, the vehicle's *model year* is the calendar year corresponding to the date of manufacture; however, the vehicle's model year may be designated to be the year before the calendar year corresponding to the date of manufacture if the engine's model year is also from an earlier year. Note that subparagraph (2) of this definition limits the extent to which vehicle manufacturers may install engines built in earlier calendar years. Note that 40 CFR 1037.601(a)(2) limits the extent to which vehicle manufacturers may install engines built in earlier calendar years.

(2) For trailers and for Phase 1 tractors and vocational vehicles with a date of manufacture before January 1, 2021, *model year* means the manufacturer's annual new model production period, except as restricted under this definition. It must include January 1 of the calendar year for which the model year is named, may not begin before January 2 of the previous calendar year, and it must end by December 31 of the named calendar year. The model year may be set to match the calendar year corresponding to the date of manufacture.

(i) The manufacturer who holds the certificate of conformity for the vehicle must assign the model year based on the date when its manufacturing operations are completed relative to its annual model year period. In unusual circumstances where completion of your assembly is delayed, we may allow you to assign a model year one year earlier, provided it does not affect which regulatory requirements will apply.

(ii) Unless a vehicle is being shipped to a secondary manufacturer that will hold the certificate of conformity, the model year must be assigned prior to introduction of the vehicle into U.S. commerce. The certifying manufacturer must redesignate the model year if it does not complete its manufacturing operations within the originally identified model year. A vehicle introduced into U.S. commerce without a model year is deemed to have a model year equal to the calendar year of its introduction into U.S. commerce unless the certifying manufacturer assigns a later date.

Model year as it applies to engines means the manufacturer's annual new model production period, except as restricted under this definition. It must include January 1 of the calendar year for which the model year is named, may not begin before January 2 of the previous calendar year, and it must end by December 31 of the named calendar year. Manufacturers may not adjust model years to circumvent or delay compliance with emission standards or to avoid the obligation to certify annually.

Natural gas has the meaning given in 40 CFR 1036.801. Vehicles that use a pilot-ignited natural gas engine (which uses a small diesel fuel ignition system), are still considered natural gas vehicles.

NHTSA Enforcement means the NHTSA Associate Administrator for Enforcement, or his or her designee.

Neutral coasting has the meaning given in 40 CFR 1037.801.

Off-cycle technology means technology certified under § 535.7 and by EPA under 40 CFR 86.1819–14(d)(13), 1036.610, and 1037.610 in the Phase 2 program.

Party means the person alleged to have committed a violation of § 535.9, and includes manufacturers of vehicles and manufacturers of engines.

Payload means in this part the resultant of subtracting the curb weight from the gross vehicle weight rating.

Petroleum has the meaning given in 40 CFR 1037.801.

Phase 1 means the joint NHTSA and EPA program established in 2011 for fuel efficiency standards and greenhouse gas emissions standards regulating medium- and heavy-duty engines and vehicles. See § 535.5 for the specific model years that standards apply to vehicles and engines.

Phase 2 means the joint NHTSA and EPA program established in 2016 for fuel efficiency standards and greenhouse gas emissions standards regulating medium- and heavy-duty vehicles including trailers, and engines. See § 535.5 for the specific model years that standards apply to vehicles and engines.

Pickup truck has the meaning given in 49 CFR part 523.

Plug-in hybrid electric vehicle (PHEV) means a hybrid electric vehicle that has the capability to charge the battery or batteries used for vehicle propulsion from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion.

Power take-off (PTO) means a secondary engine shaft or other system on a vehicle that provides substantial auxiliary power for purposes unrelated to vehicle propulsion or normal vehicle accessories such as air conditioning, power steering, and basic electrical accessories. A typical PTO uses a secondary shaft on the engine to transmit power to a hydraulic pump that powers auxiliary equipment such as a boom on a bucket truck.

Powertrain family has the meaning given in 40 CFR 1037.231. Manufacturers choosing to perform powertrain testing as specified in 40 CFR 1037.550, divide product lines into powertrain families that are expected to have similar fuel consumptions and CO_2 emission characteristics throughout the useful life.

Preliminary approval means approval granted by an authorized EPA representative prior to submission of an application for certification, consistent with the provisions of 40 CFR 1037.210. For requirements involving NHTSA, EPA will ensure decisions are jointly made and will convey the decision to the manufacturer.

Primary intended service class has the same meaning for engines as specified in 40 CFR 1036.140. Manufacturers must identify a single primary intended service class for each engine family that best describes vehicles for which it designs and markets the engine, as follows:

(1) Divide compression-ignition engines into primary intended service classes based on the following engine and vehicle characteristics:

(i) Light heavy-duty ''LHD'' engines usually are not designed for rebuild and do not have cylinder liners. Vehicle body types in this group might include any heavy-duty vehicle built from a light-duty truck chassis, van trucks, multi-stop vans, and some straight trucks with a single rear axle. Typical applications would include personal transportation, light-load commercial delivery, passenger service, agriculture, and construction. The GVWR of these vehicles is normally below 19,500 pounds.

(ii) Medium heavy-duty ''MHD'' engines may be designed for rebuild and may have cylinder liners. Vehicle body types in this group would typically include school buses, straight trucks with single rear axles, city tractors, and a variety of special purpose vehicles such as small dump trucks, and refuse trucks. Typical applications would include commercial short haul and intra-city delivery and pickup. Engines in this group are normally used in vehicles whose GVWR ranges from 19,500 to 33,000 pounds.

(iii) Heavy heavy-duty ''HHD'' engines are designed for multiple rebuilds and have cylinder liners. Vehicles in this group are normally tractors, trucks, straight trucks with dual rear axles, and buses used in inter-city, long-haul applications. These vehicles normally exceed 33,000 pounds GVWR.

(2) Divide spark-ignition engines into primary intended service classes as follows:

(i) Spark-ignition engines that are best characterized by paragraph (1)(i) or (ii) of this definition are in a separate ''spark-ignition'' primary intended service class.

(ii) Spark-ignition engines that are best characterized by paragraph (1)(iii) of this definition share a primary intended service class with compression-ignition heavy heavy-duty engines. Gasoline-fueled engines are presumed not to be characterized by paragraph (1)(iii) of this definition; for example, vehicle manufacturers may install some number of gasoline-fueled engines in Class 8 trucks without causing the engine manufacturer to consider those to be heavy heavy-duty engines.

(iii) References to ''spark-ignition standards'' in this part relate only to the spark-ignition engines identified in paragraph (b)(1) of this section. References to ''compression-ignition standards'' in this part relate to compression-ignition engines, to spark-ignition engines optionally certified to standards that apply to compression-ignition engines, and to all engines identified under paragraph (b)(2) of this section as heavy heavy-duty engines.

Rechargeable Energy Storage System (RESS) means the component(s) of a hybrid engine or vehicle that store recovered energy for later use, such as the battery system in a electric hybrid vehicle.

Refuse hauler has the meaning given in 40 CFR 1037.801.

Regional has the meaning relating to the Regional duty cycle as specified in 40 CFR 1037.510.

Regulatory category means each of the four types of heavy-duty vehicles defined in 49 CFR 523.6 and the heavy-duty engines used in these heavy-duty vehicles.

Regulatory subcategory means the sub-groups in each regulatory category to which mandatory fuel consumption standards and requirements apply as specified in 40 CFR 1036.230 and 1037.230 and are defined as follows:

(1) Heavy-duty pick-up trucks and vans.

(2) Vocational vehicle subcategories have 18 separate vehicle service classes as shown in Tables 1 and 2 below and include vocational tractors. Table 1 includes vehicles complying with Phase 1 standards. Phase 2 vehicles are included in Table 2 which have separate subcategories to account for engine characteristics, GVWR, and the selection of duty cycle for vocational vehicles as specified in 40 CFR 1037.510; vehicles may additionally fall into one of the subcategories defined by the custom-chassis standards in § 535.5(b)(6) and 40 1037.105(h). Manufacturers using the alternate standards in § 535.5(b)(6) and 40 CFR 1037.105(h) should treat each vehicle type as a separate vehicle subcategory.

TABLE 1—PHASE 1 VOCATIONAL VEHICLE SUBCATEGORIES

Vocational LHD vehicles.
Vocational MHD vehicles.
Vocational HHD vehicles.

TABLE 2—PHASE 2 VOCATIONAL VEHICLE SUBCATEGORIES

Engine type	Vocational LHD vehicles	Vocational MHD vehicles	Vocational HHD vehicles
CI	Urban	Urban	Urban.
CI	Multi-Purpose	Multi-Purpose	Multi-Purpose.
CI	Regional	Regional	Regional.

TABLE 2—PHASE 2 VOCATIONAL VEHICLE SUBCATEGORIES—Continued

Engine type	Vocational LHD vehicles	Vocational MHD vehicles	Vocational HHD vehicles
SI	Urban	Urban	NA.
SI	Multi-Purpose	Multi-Purpose	NA.
SI	Regional	Regional	NA.

(3) Tractor subcategories are shown in Table 3 below for Phase 1 and 2. Table 3 includes 10 separate subcategories for tractors complying with Phase 1 and 2 standards. The heavy-haul tractor subcategory only applies for Phase 2.

TABLE 3—PHASE 1 AND 2 TRUCK TRACTOR SUBCATEGORIES

Class 7	Class 8 day cabs	Class 8 sleeper cabs
Low-roof tractors	Low-roof day cab tractors	Low-roof sleeper cab tractors.
Mid-roof tractors	Mid-roof day cab tractors	Mid-roof sleeper cab tractors.
High-roof tractors	High-roof day cab tractors	High-roof sleeper cab tractors.
NA	Heavy-haul tractors (applies only to Phase 2 program).	

(4) Trailer subcategories are shown in Table 4 of this section for the Phase 2 program. Trailers do not comply under the Phase 1 program. Table 4 includes 10 separate subcategories for trailers, which are only subject to Phase 2 only standards.

TABLE 4—TRAILER SUBCATEGORIES

Full-aero trailers	Partial-aero trailers	Other trailers
Long box dry vans	Long box dry vans	Non-aero box vans.
Short box dry vans	Short box dry vans	Non-box trailers.
Long box refrigerated vans	Long box refrigerated vans	NA.
Short box refrigerated vans	Short box refrigerated vans	NA.

(5) Engine subcategories are shown for each primary intended service class in Table 5 below. Table 5 includes 6 separate subcategories for engines which are the same for Phase 1 and 2 standards.

TABLE 5—ENGINE SUBCATEGORIES

LHD engines	MHD engines	HHD engines
CI engines for vocational vehicles	CI engines for vocational vehicles	CI engines for vocational vehicles.
NA	CI engines for truck tractors	CI engines for truck tractors.
All spark-ignition engines		NA.

Revoke has the same meaning given in 40 CFR 1068.30.

Roof height means the maximum height of a vehicle (rounded to the nearest inch), excluding narrow accessories such as exhaust pipes and antennas, but including any wide accessories such as roof fairings. Measure roof height of the vehicle configured to have its maximum height that will occur during actual use, with properly inflated tires and no driver, passengers, or cargo onboard. Determine the base roof height on fully inflated tires having a static loaded radius equal to the arithmetic mean of the largest and smallest static loaded radius of tires a manufacturer offers or a standard tire EPA approves. If a vehicle is equipped with an adjustable roof fairing, measure the roof height with the fairing in its lowest setting. Once the maximum height is determined, roof heights are divided into the following categories:

(1) Low-roof means a vehicle with a roof height of 120 inches or less.

(2) Mid-roof means a vehicle with a roof height between 121 and 147 inches.

(3) High-roof means a vehicle with a roof height of 148 inches or more.

Secondary vehicle manufacturer has the same meaning as final-stage manufacturer in 49 CFR part 567.

Service class group means a group of engine and vehicle averaging sets defined as follows:

(1) Spark-ignition engines, light heavy-duty compression-ignition engines, light heavy-duty vocational vehicles and heavy-duty pickup trucks and vans.

(2) Medium heavy-duty compression-ignition engines and medium heavy-duty vocational vehicles and tractors.

(3) Heavy heavy-duty compression-ignition engines and heavy heavy-duty vocational vehicles and tractors.

Sleeper cab means a type of truck cab that has a compartment behind the driver's seat intended to be used by the driver for sleeping. This includes both cabs accessible from the driver's compartment and those accessible from outside the vehicle.

Small business manufacturer means a manufacturer meeting the criteria specified in 13 CFR 121.201. For manufacturers owned by a parent company, the employee and revenue limits apply to the total number employees and total revenue of the parent company and all its subsidiaries.

Spark-ignition (SI) means relating to a gasoline-fueled engine or any other type of engine with a spark plug (or other sparking device) and with operating characteristics significantly similar to the theoretical Otto combustion cycle. Spark-ignition engines usually use a throttle to regulate intake air flow to control power during normal operation. Note that some spark-ignition engines are subject to requirements that apply for compression-ignition engines as described in 40 CFR 1036.140.

Standard payload means the payload assumed for each vehicle, in tons, for modeling and calculating emission credits, as follows:

(1) For vocational vehicles:

(i) 2.85 tons for light heavy-duty vehicles.

(ii) 5.6 tons for medium heavy-duty vehicles.

(iii) 7.5 tons for heavy heavy-duty vocational vehicles.

(2) For tractors:

(i) 12.5 tons for Class 7.

(ii) 19 tons for Class 8.

(iii) 43 tons for heavy-haul tractors.

(3) For trailers:

(i) 10 tons for short box vans.

(ii) 19 tons for other trailers.

Standard tractor has the meaning given in 40 CFR 1037.501.

Standard trailer has the meaning given in 40 CFR 1037.501.

Subconfiguration means a unique combination within a vehicle configuration of equivalent test weight, road-load horsepower, and any other operational characteristics or parameters that EPA determines may significantly affect CO_2 emissions within a vehicle configuration as defined in 40 CFR 600.002.

Tank trailer has the meaning given in 40 CFR 1037.801.

Test group means the multiple vehicle lines and model types that share critical emissions and fuel consumption related features and that are certified as a group by a common certificate of conformity issued by EPA and is used collectively with other test groups within an averaging set or regulatory subcategory and is used by NHTSA for determining the fleet average fuel consumption.

The agencies means the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) in this part.

Tire pressure monitoring system (TPMS) has the meaning given in section S3 of 49 CFR 571.138.

Tire rolling resistance level (TRRL) means a value with units of kg/metric ton that represents that rolling resistance of a tire configuration. TRRLs are used as inputs to the GEM model under 40 CFR 1037.520. Note that a manufacturer may assign a value higher than a measured rolling resistance of a tire configuration.

Towing capacity in this part is equal to the resultant of subtracting the gross vehicle weight rating from the gross combined weight rating.

Trade means to exchange fuel consumption credits, either as a buyer or a seller.

U.S.-directed production volume means the number of vehicle units, subject to the requirements of this part, produced by a manufacturer for which the manufacturer has a reasonable assurance that sale was or will be made to ultimate purchasers in the United States.

Useful life has the meaning given in 40 CFR 1036.801 and 1037.801.

Vehicle configuration means a unique combination of vehicle hardware and calibration (related to measured or modeled emissions) within a vehicle family as specified in 40 CFR 1037.801. Vehicles with hardware or software differences, but that have no hardware or software differences related to measured or modeled emissions or fuel consumption can be included in the same vehicle configuration. Note that vehicles with hardware or software differences related to measured or modeled emissions or fuel consumption are considered to be different configurations even if they have the same GEM inputs and FEL. Vehicles within a vehicle configuration differ only with respect to normal production variability or factors unrelated to measured or modeled emissions and fuel consumption for EPA and NHTSA.

Vehicle family has the meaning given in 40 CFR 1037.230. Manufacturers designate families in accordance with EPA provisions and may not choose different families between the NHTSA and EPA programs. If a manufacturer is certifying vehicles within a vehicle family to more than one FEL, it must subdivide its greenhouse gas and fuel consumption vehicle families into subfamilies that include vehicles with identical FELs. Note that a manufacturer may add subfamilies at any time during the model year.

Vehicle service class has the same meaning for vehicles as specified in 40 CFR 1037.140. Fuel consumption standards and other provisions of this part apply to specific vehicle service classes for tractors and vocational vehicles as follows:

(1) Phase 1 and Phase 2 tractors are divided based on GVWR into Class 7 tractors and Class 8 tractors. Where provisions apply to both tractors and vocational vehicles, Class 7 tractors are considered medium heavy-duty ''MHD'' vehicles and Class 8 tractors are considered heavy heavy-duty ''HHD'' vehicles.

(2) Phase 1 vocational vehicles are divided based on GVWR. Light heavy-duty ''LHD'' vehicles includes Class 2b through Class 5 vehicles; medium heavy-duty ''MHD'' vehicles includes Class 6 and Class 7 vehicles; and heavy heavy-duty ''HHD'' vehicles includes Class 8 vehicles.

(3) Phase 2 vocational vehicles with spark-ignition engines are divided based on GVWR. Light heavy-duty ''LHD'' vehicles includes Class 2b through Class 5 vehicles, and medium heavy-duty ''MHD'' vehicles includes Class 6 through Class 8 vehicles.

(4) Phase 2 vocational vehicles with compression-ignition engines are divided as follows:

(i) Class 2b through Class 5 vehicles are considered light heavy-duty ''LHD'' vehicles.

(ii) Class 6 through 8 vehicles are considered heavy heavy-duty ''HHD'' vehicles if the installed engine's primary intended service class is heavy heavy-duty (see 40 CFR 1036.140). All other Class 6 through Class 8 vehicles are considered medium heavy-duty ''MHD'' vehicles.

(5) In certain circumstances, manufacturers may certify vehicles to standards that apply for a different vehicle service class such as allowed in § 535.5(b)(6) and (c)(7). If manufacturers optionally certify vehicles to different standards, those vehicles are subject to all the regulatory requirements as if the standards were mandatory.

Vehicle subfamily or subfamily means a subset of a vehicle family including vehicles subject to the same FEL(s).

Vocational tractor has the meaning given in 40 CFR 1037.801.

Zero emissions vehicle means an electric vehicle or a fuel cell vehicle.

§ 535.5 Standards.

(a) *Heavy-duty pickup trucks and vans.* Each manufacturer's fleet of heavy-duty pickup trucks and vans shall comply with the fuel consumption standards in this paragraph (a) expressed in gallons per 100 miles. Each vehicle must be manufactured to comply for its full useful life. For the Phase 1 program, if the manufacturer's fleet includes conventional vehicles (gasoline, diesel and alternative fueled vehicles) and advanced technology vehicles (hybrids with powertrain designs that include energy storage systems, vehicles with waste heat recovery, electric vehicles and fuel cell vehicles), it may divide its fleet into two separate fleets each with its own separate fleet average fuel consumption standard which the manufacturer must comply with the requirements of this paragraph (a). For Phase 2, manufacturers may calculate their fleet average fuel consumption standard for a conventional fleet and multiple advanced technology vehicle fleets. Advanced technology vehicle fleets should be separated into plug-in hybrid electric vehicles, electric vehicles and fuel cell vehicles. NHTSA standards correspond to the same requirements for EPA as specified in 40 CFR 86.1819–14.

(1) *Mandatory standards.* For model years 2016 and later, each manufacturer must comply with the fleet average standard derived from the unique subconfiguration target standards (or groups of subconfigurations approved by EPA in accordance with 40 CFR 86.1819) of the model types that make up the manufacturer's fleet in a given model year. Each subconfiguration has a unique attribute-based target standard, defined by each group of vehicles having the same payload, towing capacity and whether the vehicles are equipped with a 2-wheel or 4-wheel drive configuration. Phase 1 target standards apply for model years 2016 through 2020. Phase 2 target standards apply for model year 2021 and afterwards.

(2) *Subconfiguration target standards.* (i) Two alternatives exist for determining the subconfiguration target standards for Phase 1. For each alternative, separate standards exist for compression-ignition and spark-ignition vehicles:

(A) The first alternative allows manufacturers to determine a fixed fuel consumption standard that is constant over the model years; and

(B) The second alternative allows manufacturers to determine standards that are phased-in gradually each year.

(ii) Calculate the subconfiguration target standards as specified in this paragraph (a)(2)(ii), using the appropriate coefficients from Table 6 choosing between the alternatives in paragraph (a)(2)(i) of this section. For electric or fuel cell heavy-duty vehicles, use compression-ignition vehicle coefficients ''c'' and ''d'' and for hybrid (including plug-in hybrid), dedicated and dual-fueled vehicles, use coefficients ''c'' and ''d'' appropriate for the engine type used. Round each standard to the nearest 0.001 gallons per 100 miles and specify all weights in pounds rounded to the nearest pound. Calculate the subconfiguration target standards using the following equation:

Subconfiguration Target Standard (gallons per 100 miles) = [c × (WF)] + d

Where:

WF = Work Factor = [0.75 x (Payload Capacity + Xwd)] + [0.25 x Towing Capacity]

Xwd = 4wd Adjustment = 500 lbs if the vehicle group is equipped with 4wd and all-wheel drive, otherwise equals 0 lbs for 2wd.

Payload Capacity = GVWR (lbs)—Curb Weight (lbs) (for each vehicle group)

Towing Capacity = GCWR (lbs)—GVWR (lbs) (for each vehicle group)

TABLE 6—COEFFICIENTS FOR MANDATORY SUBCONFIGURATION TARGET STANDARDS

Model Year(s)	c	d
Phase 1 Alternative 1—Fixed Target Standards		
CI Vehicle Coefficients		
2016 to 2018	0.0004322	3.330
2019 to 2020	0.0004086	3.143
SI Vehicle Coefficients		
2016 to 2017	0.0005131	3.961
2018 to 2020	0.0004086	3.143
Phase 1 Alternative 2—Phased-in Target Standards		
CI Vehicle Coefficients		
2016	0.0004519	3.477
2017	0.0004371	3.369
2018 to 2020	0.0004086	3.143
SI Vehicle Coefficients		
2016	0.0005277	4.073
2017	0.0005176	3.983
2018 to 2020	0.0004951	3.815
Phase 2—Fixed Target Standards		
CI Vehicle Coefficients		
2021	0.0003988	3.065
2022	0.0003880	2.986
2023	0.0003792	2.917
2024	0.0003694	2.839
2025	0.0003605	2.770
2026	0.0003507	2.701
2027 and later	0.0003418	2.633
SI Vehicle Coefficients		
2021	0.0004827	3.725
2022	0.0004703	3.623

TABLE 6—COEFFICIENTS FOR MANDATORY SUBCONFIGURATION TARGET STANDARDS—Continued

Model Year(s)	c	d
2023	0.0004591	3.533
2024	0.0004478	3.443
2025	0.0004366	3.364
2026	0.0004253	3.274
2027 and later	0.0004152	3.196

(3) *Fleet average fuel consumption standard.* (i) For the Phase 1 program, calculate each manufacturer's fleet average fuel consumption standard for a conventional fleet and a combined advanced technology fleet separately based on the subconfiguration target standards specified in paragraph (a)(2) of this section, weighted to production volumes and averaged using the following equation combining all the applicable vehicles in a manufacturer's U.S.-directed fleet (compression-ignition, spark-ignition and advanced technology vehicles) for a given model year, rounded to the nearest 0.001 gallons per 100 miles:

$$\text{Fleet Average Standard} = \frac{\sum\left[\text{Subconfiguration Target Standard}_i \times \text{Volume}_i\right]}{\sum\left[\text{Volume}_i\right]}$$

Where:

Subconfiguration Target Standard$_i$ = fuel consumption standard for each group of vehicles with same payload, towing capacity and drive configuration (gallons per 100 miles).

Volume$_i$ = production volume of each unique subconfiguration of a model type based upon payload, towing capacity and drive configuration.

(A) A manufacturer may group together subconfigurations that have the same test weight (ETW), GVWR, and GCWR. Calculate work factor and target value assuming a curb weight equal to two times ETW minus GVWR.

(B) A manufacturer may group together other subconfigurations if it uses the lowest target value calculated for any of the subconfigurations.

(ii) For Phase 1, manufacturers must select an alternative for subconfiguration target standards at the same time they submit the model year 2016 pre-model year Report, specified in § 535.8. Once selected, the decision cannot be reversed and the manufacturer must continue to comply with the same alternative for subsequent model years.

(4) *Voluntary standards.* (i) Manufacturers may choose voluntarily to comply early with fuel consumption standards for model years 2013 through 2015, as determined in paragraphs (a)(4)(iii) and (iv) of this section, for example, in order to begin accumulating credits through over-compliance with the applicable standard. A manufacturer choosing early compliance must comply with all the vehicles and engines it manufactures in each regulatory category for a given model year.

(ii) A manufacturer must declare its intent to voluntarily comply with fuel consumption standards at the same time it submits a Pre-Model Report, prior to the compliance model year beginning as specified in § 535.8; and, once selected, the decision cannot be reversed and the manufacturer must continue to comply for each subsequent model year for all the vehicles and engines it manufactures in each regulatory category for a given model year.

(iii) Calculate separate subconfiguration target standards for compression-ignition and spark-ignition vehicles for model years 2013 through 2015 using the equation in paragraph (a)(2)(ii) of this section, substituting the appropriate values for the coefficients in the following table as appropriate:

TABLE 7—COEFFICIENTS FOR VOLUNTARY SUBCONFIGURATION TARGET STANDARDS

Model Year(s)	c	d
CI Vehicle Coefficients		
2013 and 14	0.0004695	3.615
2015	0.0004656	3.595
SI Vehicle Coefficients		
2013 and 14	0.0005424	4.175
2015	0.0005390	4.152

(iv) Calculate the fleet average fuel consumption standards for model years 2013 through 2015 using the equation in paragraph (a)(3) of this section.

(5) *Exclusion of vehicles not certified as complete vehicles.* The vehicle standards in paragraph (a) of this section do not apply for vehicles that are chassis-certified with respect to EPA's criteria pollutant test procedure in 40 CFR part 86, subpart S. Any chassis-certified vehicles must comply with the vehicle standards and requirements of paragraph (b) of this section and the engine standards of paragraph (d) of this section for engines used in these vehicles. A vehicle manufacturer choosing to comply with this paragraph and that is not the engine manufacturer is required to notify the engine manufacturers that their engines are subject to paragraph (d) of this section and that it intends to use their engines in excluded vehicles.

(6) *Optional certification under this section.* Manufacturers may certify certain complete or cab-complete

vehicles to the fuel consumption standards of this section. All vehicles optionally certified under this paragraph (6) are deemed to be subject to the fuel consumption standards of this section given the following conditions:

(i) For fuel consumption compliance, manufacturers may certify any complete or cab-complete spark-ignition vehicles above 14,000 pounds GVWR and at or below 26,000 pounds GVWR to the fuel consumption standards of this section.

(ii) Manufacturers may apply the provisions of this section to cab-complete vehicles based on a complete sister vehicle. In unusual circumstances, manufacturers may ask the agencies to apply these provisions to Class 2b or Class 3 incomplete vehicles that do not meet the definition of cab-complete.

(A) Except as specified in paragraph (a)(6)(iii) of this section, for purposes of this section, a complete sister vehicle is a complete vehicle of the same vehicle configuration as the cab-complete vehicle. A manufacturer may not apply the provisions of this paragraph (6) to any vehicle configuration that has a four-wheel rear axle if the complete sister vehicle has a two-wheel rear axle.

(B) Calculate the target value for the fleet-average fuel consumption standard under paragraph (a)(3) of this section based on the work factor value that applies for the complete sister vehicle.

(C) Test these cab-complete vehicles using the same equivalent test weight and other dynamometer settings that apply for the complete vehicle from which you used the work factor value (the complete sister vehicle). For fuel consumption certification, manufacturers may submit the test data from that complete sister vehicle instead of performing the test on the cab-complete vehicle.

(D) Manufacturers are not required to produce the complete sister vehicle for sale to use the provisions of this paragraph (a)(6)(ii). This means the complete sister vehicle may be a carryover vehicle from a prior model year or a vehicle created solely for the purpose of testing.

(iii) For fuel consumption purposes, if a cab-complete vehicle is not of the same vehicle configuration as a complete sister vehicle due only to certain factors unrelated to coastdown performance, manufacturers may use the road-load coefficients from the complete sister vehicle for certification testing of the cab-complete vehicle, but it may not use fuel consumption data from the complete sister vehicle for certifying the cab-complete vehicle.

(7) *Loose engines.* For model year 2023 and earlier spark-ignition engines with identical hardware compared with engines used in vehicles certified to the standards of this section, where such engines are sold as loose engines or as engines installed in incomplete vehicles that are not cab-complete vehicles. Manufacturers may certify such engines to the standards of this section, subject to the following provisions:

(i) For 2020 and earlier model years, the maximum allowable U.S.-directed production volume of engines manufacturers may sell under this paragraph (7) in any given model year is ten percent of the total U.S-directed production volume of engines of that design that the manufacturer produces for heavy-duty applications for that model year, including engines it produces for complete vehicles, cab-complete vehicles, and other incomplete vehicles. The total number of engines a manufacturer may certify under this paragraph (7), of all engine designs, may not exceed 15,000 in any model year. Engines produced in excess of either of these limits are not covered by your certificate. For example, a manufacturer produces 80,000 complete model year 2017 Class 2b pickup trucks with a certain engine and 10,000 incomplete model year 2017 Class 3 vehicles with that same engine, and the manufacturer did not apply the provisions of this paragraph (a)(7) to any other engine designs, it may produce up to 10,000 engines of that design for sale as loose engines under this paragraph (a)(7). If a manufacturer produced 11,000 engines of that design for sale as loose engines, the last 1,000 of them that it produced in that model year 2017 would be considered uncertified.

(ii) For model years 2021 through 2023, the U.S.-directed production volume of engines manufacturers sell under this paragraph (a)(7) in any given model year may not exceed 10,000 units. This paragraph (a)(7) does not apply for engines certified to the standards of paragraph (d) of this section and 40 CFR 1036.108.

(iii) Vehicles using engines certified under this paragraph (a)(7) are subject to the fuel consumption and emission standards of paragraph (b) of this section and 40 CFR 1037.105 and engine standards in 40 CFR 1036.150(j).

(iv) For certification purposes, engines are deemed to have a fuel consumption target values and test result equal to the fuel consumption target value and test result for the complete vehicle in the applicable test group with the highest equivalent test weight, except as specified in paragraph (a)(7)(iv)(B) of this section. Manufacturers use these values to calculate target values and the fleet-average fuel consumption rate. Where there are multiple complete vehicles with the same highest equivalent test weight, select the fuel consumption target value and test result as follows:

(A) If one or more of the fuel consumption test results exceed the applicable target value, use the fuel consumption target value and test result of the vehicle that exceeds its target value by the greatest amount.

(B) If none of the fuel consumption test results exceed the applicable target value, select the highest target value and set the test result equal to it. This means that the manufacturer may not generate fuel consumption credits from vehicles certified under this paragraph (a)(7).

(8) *Alternative fuel vehicle conversions.* Alternative fuel vehicle conversions may demonstrate compliance with the standards of this part or other alternative compliance approaches allowed by EPA in 40 CFR 85.525.

(9) *Advanced, innovative and off-cycle technologies.* For vehicles subject to Phase 1 standards, manufacturers may generate separate credit allowances for advanced and innovative technologies as specified in § 535.7(f)(1) and (2). For vehicles subject to Phase 2 standards, manufacturers may generate separate credits allowance for off-cycle technologies in accordance with § 535.7(f)(2). Separate credit allowances for advanced technology vehicles cannot be generated; instead manufacturers may use the credit multipliers specified in § 535.7(f)(1)(iv) through model year 2026.

(10) *Useful life.* The following useful life values apply for the standards of this section:

(i) 120,000 miles or 10 years, whichever comes first, for Class 2b through Class 3 heavy-duty pickup trucks and vans certified to Phase 1 standards.

(ii) 150,000 miles or 15 years, whichever comes first, for Class 2b through Class 3 heavy-duty pickup trucks and vans certified to Phase 2 standards.

(iii) For Phase 1 credits that you calculate based on a useful life of 120,000 miles, multiply any banked credits that you carry forward for use into the Phase 2 program by 1.25. For Phase 1 credit deficits that you generate based on a useful life of 120,000 miles multiply the credit deficit by 1.25 if offsetting the shortfall with Phase 2 credits.

(11) *Compliance with standards.* A manufacturer complies with the standards of this part as described in § 535.10.

(b) *Heavy-duty vocational vehicles.* Each manufacturer building complete or incomplete heavy-duty vocational vehicles shall comply with the fuel consumption standards in this paragraph (b) expressed in gallons per 1000 ton-miles. Engines used in heavy-duty vocational vehicles shall comply with the standards in paragraph (d) of this section. Each vehicle must be manufactured to comply for its full useful life. Standards apply to the vehicle subfamilies based upon the vehicle service classes within each of the vocational vehicle regulatory subcategories in accordance with § 535.4 and based upon the applicable modeling and testing specified in § 535.6. Determine the duty cycles that apply to vocational vehicles according to 40 CFR 1037.140 and 1037.150(z).

(1) *Mandatory standards.* Heavy-duty vocational vehicle subfamilies produced for Phase 1 must comply with the fuel consumption standards in paragraph (b)(3) of this section. For Phase 2, each vehicle manufacturer of heavy-duty vocational vehicle subfamilies must comply with the fuel consumption standards in paragraph (b)(4) of this section.

(i) For model years 2016 to 2020, the heavy-duty vocational vehicle category is subdivided by GVWR into three regulatory subcategories as defined in § 535.4, each with its own assigned standard.

(ii) For model years 2021 and later, the heavy-duty vocational vehicle category is subdivided into 15 regulatory subcategories depending upon whether vehicles are equipped with a compression or spark-ignition engine, as defined in § 535.4. Standards also differ based upon vehicle service class and intended vehicle duty cycles. See 40 CFR 1037.140 and 1037.150(z).

(iii) For purposes of certifying vehicles to fuel consumption standards, manufacturers must divide their product lines in each regulatory subcategory into vehicle families that have similar emissions and fuel consumption features, as specified by EPA in 40 CFR 1037.230. These families will be subject to the applicable standards. Each vehicle family is limited to a single model year.

(A) Vocational vehicles including custom chassis vehicles must use qualified automatic tire inflation systems or tire pressure monitoring systems for wheels on all axles.

(B) Tire pressure monitoring systems must use low pressure warning and malfunction telltales in clear view of the driver as specified in S4.3 and S4.4 of 49 CFR 571.138.

(2) *Voluntary compliance.* (i) For model years 2013 through 2015, a manufacturer may choose voluntarily to comply early with the fuel consumption standards provided in paragraph (b)(3) of this section. For example, a manufacturer may choose to comply early in order to begin accumulating credits through over-compliance with the applicable standards. A manufacturer choosing early compliance must comply with all the vehicles and engines it manufacturers in each regulatory category for a given model year.

(ii) A manufacturer must declare its intent to voluntarily comply with fuel consumption standards and identify its plans to comply before it submits its first application for a certificate of conformity for the respective model year as specified in § 535.8; and, once selected, the decision cannot be reversed and the manufacturer must continue to comply for each subsequent model year for all the vehicles and engines it manufacturers in each regulatory category for a given model year.

(3) *Regulatory subcategory standards for model years 2013 to 2020.* The mandatory and voluntary fuel consumption standards for heavy-duty vocational vehicles are given in the following table:

TABLE 8—PHASE 1 VOCATIONAL VEHICLE FUEL CONSUMPTION STANDARDS

[Gallons per 1000 ton-miles]

Regulatory subcategories	Vocational LHD vehicles	Vocational MHD vehicles	Vocational HHD vehicles
Model Years 2013 to 2016 Voluntary Standards			
Standard	38.1139	22.9862	22.2004
Model Years 2017 to 2020 Mandatory Standards			
Standard	36.6405	22.1022	21.8075

(4) *Regulatory subcategory standards for model years 2021 and later.* The mandatory fuel consumption standards for heavy-duty vocational vehicles are given in the following table:

TABLE 9—PHASE 2 VOCATIONAL VEHICLE FUEL CONSUMPTION STANDARDS

[Gallons per 1,000 ton-miles]

Duty cycle	LHD Vocational vehicles	MHD Vocational vehicles	Vocational HHD vehicles
Model Years 2021 to 2023 Standards for CI Vehicles			
Urban	41.6503	29.0766	30.2554
Multi-Purpose	36.6405	26.0314	25.6385
Regional	30.5501	22.9862	20.2358
Model Years 2021 to 2023 Standards for SI Vehicles			
Urban	51.8735	36.9078	NA

TABLE 9—PHASE 2 VOCATIONAL VEHICLE FUEL CONSUMPTION STANDARDS—Continued

[Gallons per 1,000 ton-miles]

Duty cycle	LHD Vocational vehicles	MHD Vocational vehicles	Vocational HHD vehicles
Multi-Purpose	45.7972	32.9695	NA
Regional	37.6955	29.3687	NA
Model Years 2024 to 2026 Standards for CI Vehicles			
Urban	37.8193	26.6208	27.7996
Multi-Purpose	33.7917	24.1650	23.7721
Regional	29.0766	21.7092	19.0570
Model Years 2024 to 2026 Standards for SI Vehicles			
Urban	48.6103	34.8824	NA
Multi-Purpose	43.3217	31.3942	NA
Regional	36.4577	28.2435	NA
Model Years 2027 and later Standards for CI Vehicles			
Urban	36.0511	25.3438	26.4244
Multi-Purpose	32.4165	23.0845	22.5933
Regional	28.5855	21.4145	18.5658
Model Years 2027 and later Standards for SI Vehicles			
Urban	46.4724	33.4196	NA
Multi-Purpose	41.8589	30.1564	NA
Regional	35.8951	27.7934	NA

(5) *Subfamily standards.* Manufacturers may specify a family emission limit (FEL) in terms of fuel consumption for each vehicle subfamily. The FEL may not be less than the result of fuel consumption modeling from 40 CFR 1037.520. The FELs is the fuel consumption standards for the vehicle subfamily instead of the standards specified in paragraph (b)(3) and (4) of this section and can be used for calculating fuel consumption credits in accordance with § 535.7.

(6) *Alternate standards for custom chassis vehicles for model years 2021 and later.* Manufacturers may elect to certify certain vocational vehicles to the alternate standards for custom chassis vehicles specified in this paragraph (b)(6) instead of the standards specified in paragraph (b)(4) of this section. Note that, although these standards were established for custom chassis vehicles, manufacturers may apply these provisions to any qualifying vehicle even though these standards were established for custom chassis vehicles. For example, large diversified vehicle manufacturers may certify vehicles to the refuse hauler standards of this section as long as the manufacturer ensures that those vehicles qualify as refuse haulers when placed into service. GEM simulates vehicle operation for each type of vehicle based on an assigned vehicle service class, independent of the vehicle's actual characteristics, as shown in Table 10 of this section; however, standards apply for the vehicle's useful life based on its actual characteristics as specified in paragraph (b)(10) of this section. Vehicles certified to these alternative standards must use engines certified to requirements under paragraph (d) of this section and 40 CFR part 1036 for the appropriate model year, except that motor homes and emergency vehicles may use engines certified with the loose-engine provisions of paragraph (a)(7) of this section and 40 CFR 1037.150(m). This also applies for vehicles meeting standards under paragraphs (b)(6)(iv) through (vi) of this section. The fuel consumption standards for custom chassis vehicles are given in the following table:

TABLE 10—PHASE 2 CUSTOM CHASSIS FUEL CONSUMPTION STANDARDS

[Gallon per 1,000 ton-mile]

Vehicle type [1]	Assigned vehicle service class	MY 2021	MY 2027
Coach Bus	HHD Vehicle	20.6287	20.1375
Motor Home	MDH Vehicle	22.3969	22.2004
School Bus	MHD Vehicle	28.5855	26.6208
Other bus	HHD Vehicle	29.4695	28.0943
Refuse hauler	HHD Vehicle	30.7466	29.2731
Concrete mixer	HHD Vehicle	31.3360	31.0413
Mixed-use vehicle	HHD Vehicle	31.3360	31.0413
Emergency Vehicle	HHD Vehicle	31.8271	31.3360

[1] Vehicle types are generally defined in § 535.3. "Other bus" includes any bus that is not a school bus or a coach bus. A "mixed-use vehicle" is one that meets at least one of the criteria specified in 40 CFR 1037.631(a)(1) or at least one of the criteria in 40 CFR 1037.631(a)(2), but not both.

(i) Manufacturers may generate or use fuel consumption credits for averaging to demonstrate compliance with the alternative standards as described in § 535.7(c). This requires that manufacturers specify a Family Emission Limit (FEL) for fuel consumption for each vehicle subfamily. The FEL may not be less than the result of emission modeling as described in this paragraph (b). These FELs serve as the fuel consumption standards for the vehicle subfamily instead of the standards specified in this paragraph (b)(6). Manufacturers may only use fuel consumption credits for vehicles certified to the optional standards in this paragraph (b)(6) as specified in § 535.7(c)(6) through (8) and you may not bank or trade fuel consumption credits from any vehicles certified under this paragraph (b)(6).

(ii) For purposes of this paragraph (b)(6), each separate vehicle type identified in Table 10 of this section is in a separate averaging set.

(iii) For purposes of emission and fuel consumption modeling under 40 CFR 1037.520, consider motor homes and coach buses to be subject to the Regional duty cycle, and consider all other vehicles to be subject to the Urban duty cycle.

(iv) Emergency vehicles are deemed to comply with the standards of this paragraph (6) if manufacturers use tires with TRRL at or below 8.4 kg/ton (8.7 g/ton for model years 2021 through 2026).

(v) Concrete mixers are deemed to comply with the standards of this paragraph (6) if manufacturers use tires with TRRL at or below 7.1 kg/ton (7.6 g/ton for model years 2021 through 2026).

(vi) Motor homes are deemed to comply with the standards of this paragraph (b)(6) if manufacturers use the following technologies:

(A) Tires with TRRL at or below 6.0 kg/ton (6.7 g/ton for model years 2021 through 2026).

(B) Automatic tire inflation systems or tire pressure monitoring systems with wheels on all axles.

(C) Tire pressure monitoring systems must use low pressure warning and malfunction telltales in clear view of the driver as specified in S4.3 and S4.4 of 49 CFR 571.138.

(vii) Small business manufacturers using the alternative standards for custom chassis vehicles under this paragraph (b)(6) may use fuel consumption credits subject to the unique provisions in § 535.7(a)(9).

(7) *Advanced, innovative and off-cycle technologies.* For vocational vehicles subfamilies subject to Phase 1 standards, manufacturers must create separate vehicle subfamilies for vehicles that contain advanced or innovative technologies and group those vehicles together in a vehicle subfamily if they use the same advanced or innovative technologies. Manufacturers may generate separate credit allowances for advanced and innovative technologies as specified in § 535.7(f)(1) and (2). For vehicles subfamilies subject to Phase 2 standards, manufacturers may generate separate credit allowances for off-cycle technologies in accordance with § 535.7(f)(2). Separate credit allowances for advanced technology vehicles cannot be generated but instead manufacturers may use the credit multipliers specified in § 535.7(f)(1)(iv) through model year 2026.

(8) *Certifying across service classes.* A manufacturer may optionally certify a vocational vehicle subfamilies to the standards and useful life applicable to a heavier vehicle service class (such as MHD vocational vehicles instead of LHD vocational vehicles). Provisions related to generating fuel consumption credits apply as follows:

(i) If a manufacturer certifies all its vehicles from a given vehicle service class in a given model year to the standards and useful life that applies for a heavier vehicle service class, it may generate credits as appropriate for the heavier service class.

(ii) Class 8 hybrid vehicles with light or medium heavy-duty engines may be certified to compression-ignition standards for the Heavy HDV service class. A manufacturer may generate and use credits as allowed for the Heavy HDV service class.

(iii) Except as specified in paragraphs (b)(8)(i) and (ii) of this section, a manufacturer may not generate credits with the vehicle. If you include lighter vehicles in a subfamily of heavier vehicles with an FEL below the standard, exclude the production volume of lighter vehicles from the credit calculation. Conversely, if a manufacturer includes lighter vehicles in a subfamily with an FEL above the standard, it must include the production volume of lighter vehicles in the credit calculation.

(9) *Off-road exemptions.* This section provides an exemption for heavy-duty vocational vehicle subfamilies, including vocational tractors that are intended to be used extensively in off-road environments such as forests, oil fields, and construction sites from the fuel consumption standards in this paragraph (b). Vehicle exempted by this part do not comply with vehicle standards in this paragraph (b), but the engines in these vehicles must meet the engine requirements of paragraph (d) of this section. Note that manufacturers may not include these exempted vehicles in any credit calculations under this part.

(i) *Qualifying criteria.* Vocational vehicles intended for off-road use are exempt without request, subject to the provisions of this section, if they are primarily designed to perform work off-road (such as in oil fields, mining, forests, or construction sites), and they meet at least one of the criteria of paragraph (b)(9)(i)(A) of this section and at least one of the criteria of paragraph (b)(9)(i)(B) of this section. See paragraph (b)(6) of this section for alternate standards that apply for vehicles meeting only one of these sets of criteria.

(A) The vehicle must have affixed components designed to work inherently in an off-road environment (such as hazardous material equipment or off-road drill equipment) or be designed to operate at low speeds such that it is unsuitable for normal highway operation.

(B) The vehicle must meet one of the following criteria:

(1) Have an axle that has a gross axle weight rating (GAWR) at or above 29,000 pounds.

(2) Have a speed attainable in 2.0 miles of not more than 33 mi/hr.

(3) Have a speed attainable in 2.0 miles of not more than 45 mi/hr, an unloaded vehicle weight that is not less than 95 percent of its gross vehicle weight rating, and no capacity to carry occupants other than the driver and operating crew.

(4) Have a maximum speed at or below 54 mi/hr. A manufacturer may consider the vehicle to be appropriately speed-limited if engine speed at 54 mi/hr is at or above 95 percent of the engine's maximum test speed in the highest available gear. A manufacturer may alternatively limit vehicle speed by programming the engine or vehicle's electronic control module in a way that is tamper-resistant.

(ii) *Tractors.* The provisions of this section may apply for tractors only if each tractor qualifies as a vocational tractor under paragraph (c)(9) of this section or is granted approval for the exemption as specified in paragraph (b)(9)(iii) of this section.

(iii) *Preliminary approval before certification.* If a manufacturers has unusual circumstances where it may be questionable whether its vehicles qualify for the off-road exemption of this part, the manufacturer may send the agencies information before finishing its application for certification (see 40 CFR 1037.205) for the applicable vehicles and ask for a preliminary informal approval. The agencies will review the request and make an appropriate determination in accordance with 40 CFR 1037.210. The agencies will generally not reverse a decision where they have given a manufacturer preliminary approval, unless the agencies find new information supporting a different decision. However, the agencies will normally not grant relief in cases where the vehicle manufacturer has credits or can otherwise comply with the applicable standards.

(iv) *Recordkeeping and reporting.* (A) A manufacturers must keep records to document that its exempted vehicle configurations meet all applicable requirements of this section. Keep these records for at least eight years after you stop producing the exempted vehicle model. The agencies may review these records at any time.

(B) A manufacturers must also keep records of the individual exempted vehicles you produce, including the vehicle identification number and a description of the vehicle configuration.

(C) Within 90 days after the end of each model year, manufacturers must send to EPA a report as specified in § 535.8(g)(7) and EPA will make the report available to NHTSA.

(v) *Compliance.* (A) Manufacturers producing vehicles meeting the off-road exemption criteria in paragraph (b)(9)(i) of this section or that are granted a preliminary approval comply with the standards of this part.

(B) In situations where a manufacturer would normally ask for a preliminary approval subject to paragraph (b)(9)(iii) of this section but introduces its vehicle into U.S. commerce without seeking approval first from the agencies, those vehicles violate compliance with the fuel consumption standards of this part and the EPA provisions under 40 CFR 1068.101(a)(1).

(C) If at any time, the agencies find new information that contradicts a manufacturer's use of the off-road exemption of this part, the manufacturers vehicles will be determined to be non-compliant with the regulations of this part and the manufacturer may be liable for civil penalties.

(10) *Useful life.* The following useful life values apply for the standards of this section:

(i) 110,000 miles or 10 years, whichever comes first, for vocational LHD vehicles certified to Phase 1 standards.

(ii) 150,000 miles or 15 years, whichever comes first, for vocational LHD vehicles certified to Phase 2 standards.

(iii) 185,000 miles or 10 years, whichever comes first, for vocational MHD vehicles for Phase 1 and 2.

(iv) 435,000 miles or 10 years, whichever comes first, for vocational HHD vehicles for Phase 1 and 2.

(v) For Phase 1 credits calculated based on a useful life of 110,000 miles, multiply any banked credits carried forward for use into the Phase 2 program by 1.36. For Phase 1 credit deficits generated based on a useful life of 110,000 miles multiply the credit deficit by 1.36, if offsetting the shortfall with Phase 2 credits.

(11) *Recreational vehicles.* Recreational vehicles manufactured after model year 2020 must comply with the fuel consumption standards of this section. Manufacturers producing these vehicles may also certify to fuel consumption standards from 2014 through model year 2020. Manufacturers may earn credits retroactively for early compliance with fuel consumption standards. Once selected, a manufacturer cannot reverse the decision and the manufacturer must continue to comply for each subsequent model year for all the vehicles it manufacturers in each regulatory subcategory for a given model year.

(12) *Loose engines.* Manufacturers may certify certain spark-ignition engines along with chassis-certified heavy-duty vehicles where there are identical engines used in those vehicles as described in 40 CFR 86.1819(k)(8) and 40 CFR 1037.150(m). Vehicles in which those engines are installed are subject to standards under this part.

(13) *Compliance with Standards.* A manufacturer complies with the standards of this part as described in § 535.10.

(c) *Truck tractors.* Each manufacturer building truck tractors, except vocational tractors or vehicle constructed in accordance with § 571.7(e), with a GVWR above 26,000 pounds shall comply with the fuel consumption standards in this paragraph (c) expressed in gallons per 1000 ton-miles. Engines used in heavy-duty truck tractors vehicles shall comply with the standards in paragraph (d) of this section. Each vehicle must be manufactured to comply for its full useful life. Standards apply to the vehicle subfamilies within each of the tractor vehicle regulatory subcategories in accordance with § 535.4 and 40 CFR 1037.230 and based upon the applicable modeling and testing specified in § 535.6. Determine the vehicles in each regulatory subcategory in accordance with 40 CFR 1037.140.

(1) *Mandatory standards.* For model years 2016 and later, each manufacturer's truck tractor subfamilies must comply with the fuel consumption standards in paragraph (c)(3) of this section.

(i) Based on the roof height and the design of the cab, the truck tractor category is divided into subcategories as described in § 535.4. The standards that apply to each regulatory subcategory are shown in paragraphs (c)(2) and (3) of this section, each with its own assigned standard.

(ii) For purposes of certifying vehicles to fuel consumption standards, manufacturers must divide their product lines in each regulatory subcategory into vehicles subfamilies that have similar emissions and fuel consumption features, as specified by EPA in 40 CFR 1037.230, and these subfamilies will be subject to the applicable standards. Each vehicle subfamily is limited to a single model year.

(iii) Standards for truck tractor engines are given in paragraph (d) of this section.

(2) *Voluntary compliance.* (i) For model years 2013 through 2015, a manufacturer may choose voluntarily to comply early with the fuel consumption standards provided in paragraph (c)(3) of this section. For example, a manufacturer may choose to comply early in order to begin accumulating credits through over-compliance with the applicable standards. A manufacturer choosing early compliance must comply with all the vehicles and engines it manufacturers in each regulatory category for a given model year.

(ii) A manufacturer must declare its intent to voluntarily comply with fuel consumption standards and identify its plans to comply before it submits its first application for a certificate of conformity for the respective model year as specified in § 535.8; and, once selected, the decision cannot be reversed and the manufacturer must continue to comply for each subsequent model year for all the vehicles and engines it manufacturers in each regulatory category for a given model year.

(3) *Regulatory subcategory standards.* The fuel consumption standards for truck tractors, except for vocational tractors, are given in the following table:

TABLE 11—TRUCK TRACTOR FUEL CONSUMPTION STANDARDS

[Gallons per 1,000 ton-miles]

Regulatory subcategories	Day cab		Sleeper cab	Heavy-Haul
	Class 7	Class 8	Class 8	
Phase 1—Model Years 2013 to 2015 Voluntary Standards				
Low Roof	10.5108	7.9568	6.6798	
Mid Roof	11.6896	8.6444	7.4656	
High Roof	12.1807	9.0373	7.3674	
Phase 1—Model Year 2016 Mandatory Standard				
Low Roof	10.5108	7.9568	6.6798	NA
Mid Roof	11.6896	8.6444	7.4656	
High Roof	12.1807	9.0373	7.3674	
Phase 1—Model Years 2017 to 2020 Mandatory Standards				
Low Roof	10.2161	7.8585	6.4833	NA
Mid Roof	11.2967	8.4479	7.1709	
High Roof	11.7878	8.7426	7.0727	
Phase 2—Model Years 2021 to 2023 Mandatory Standards				
Low Roof	10.36346	7.90766	7.10216	5.14735
Mid Roof	11.11984	8.38900	7.66208	
High Roof	11.14931	8.40864	7.43615	
Phase 2—Model Years 2024 to 2026 Mandatory Standards				
Low Roof	9.80354	7.48527	6.67976	4.93124
Mid Roof	10.52063	7.94695	7.22004	
High Roof	10.47151	7.89784	6.94499	
Phase 2—Model Years 2027 and later Mandatory Standards				
Low Roof	9.44990	7.21022	6.29666	4.74460
Mid Roof	10.15717	7.66208	6.83694	
High Roof	9.82318	7.43615	6.31631	

(4) *Subfamily standards.* Manufacturers may generate or use fuel consumption credits for averaging, banking, and trading as described in § 535.7(c). This requires that manufacturers calculate a credit quantity if they specify a Family Emission Limit (FEL) that is different than the standard specified in this section. The FEL may not be less than the result of emission and fuel consumption modeling from 40 CFR 1037.520. These FELs serve as the emission standards for the specific vehicle subfamily instead of the standards specified in paragraph (2) of this section.

(5) *Alternate standards for tractors at or above 120,000 pounds GCWR.* Manufacturers may certify tractors at or above 120,000 pounds GCWR to the following fuel consumption standards in the following table:

TABLE 12—ALTERNATE FUEL CONSUMPTION STANDARDS FOR TRACTORS ABOVE 120,000 POUNDS GCWR FOR 2021 MY AND LATER FUEL CONSUMPTION

[Gallons per 1,000 ton-miles]

Low roof day cab	Mid roof day cab	High roof day cab	Low roof sleeper cab	Mid roof sleeper cab	High roof sleeper cab
3.59528	3.82122	3.84086	3.26130	3.52652	3.43811

(6) *Advanced, innovative and off-cycle technologies.* For tractors subject to Phase 1 standards, manufacturers must create separate vehicle subfamilies for vehicles that contain advanced or innovative technologies and group those vehicles together in a vehicle subfamilies if they use the same advanced or innovative technologies. Manufacturers may generate separate credit allowances for advanced and innovative technologies as specified in § 535.7(f)(1) and (2). For vehicles subject to Phase 2 standards, manufacturers may generate separate credits allowance for off-cycle technologies in accordance with § 535.7(f)(2). Separate credit allowances for advanced technology vehicles cannot be generated but instead manufacturers may use the credit multipliers specified in § 535.7(f)(1)(iv) through model year 2026.

(7) *Certifying across service classes.* Manufacturers may certify Class 7 tractors to Class 8 tractors standards as follows:

(i) A manufacturer may optionally certify 4x2 tractors with heavy heavy-duty engines to the standards and useful life for Class 8 tractors, with no restriction on generating or using fuel consumption credits within the Class 8 averaging set.

(ii) A manufacturer may optionally certify a Class 7 tractor to the standards and useful life applicable to Class 8 tractors. Credit provisions apply as follows:

(A) If a manufacturer certifies all of its Class 7 tractors to Class 8 standards, it may use these Heavy HDV credits without restriction.

(B) This paragraph (c)(7)(ii)(B) applies if a manufacturer certifies some Class 7 tractors to Class 8 standards under this paragraph (c)(7)(ii) but not all of them. If a manufacturer includes Class 7 tractors in a subfamily of Class 8 tractors with an FEL below the standard, exclude the production volume of Class 7 tractors from the credit calculation. Conversely, if a manufacturer includes Class 7 tractors in a subfamily of Class 8 tractors with an FEL above the standard, it must include the production volume of Class 7 tractors in the credit calculation.

(8) *Expanded families.* Manufacturers may combine dissimilar vehicles into a single vehicle subfamilies for applying standards and for testing in special circumstances as follows:

(i) For a Phase 1 vehicle model that straddles a roof-height, cab type, or GVWR division, manufacturers can include all the vehicles in the same vehicle family if it certifies the vehicle family to the more stringent standard. For roof height, the manufacturer must certify to the taller roof standard. For cab-type and GVWR, the manufacturers must certify to the numerically lower standard.

(ii) For a Phase 2 vehicle model that includes a range of GVWR values that straddle weight classes, manufacturers may include all the vehicles in the same vehicle family if it certifies the vehicle family to the numerically lower fuel consumption standard from the affected service classes. Vehicles that are optionally certified to a more stringent standard under this paragraph are subject to useful-life and all other provisions corresponding to the weight class with the numerically lower fuel consumption standard. For a Phase 2 tractor model that includes a range of roof heights that straddle subcategories, a manufacturer may include all the vehicles in the same vehicle family if it certifies the vehicle family to the appropriate subcategory as follows:

(A) A manufacturer may certify mid-roof tractors as high-roof tractors, but it may not certify high-roof tractors as mid-roof tractors.

(B) For tractor families straddling the low-roof/mid-roof division, a manufacturer may certify the family based on the primary roof-height as long as no more than 10 percent of the tractors are certified to the otherwise inapplicable subcategory. For example, if 95 percent of the tractors in the family are less than 120 inches tall, and the other 5 percent are 122 inches tall, a manufacturer may certify the tractors as a single family in the low-roof subcategory.

(C) Determine the appropriate aerodynamic bin number based on the actual roof height if the C_dA value is measured. However, use the GEM input for the bin based on the standards to which the manufacturer certifies. For example, of a manufacturer certifies as mid roof tractors some low-roof tractors with a measured C_dA value of 4.2 m^2, it qualifies as Bin IV; and must input into GEM the mid-roof Bin IV value of 5.85 m^2.

(9) *Vocational tractors.* Tractors meeting the definition of vocational tractors in 49 CFR 523.2 must comply with requirements for heavy-duty vocational vehicles specified in paragraphs (b) and (d) of this section. For Phase 1, Class 7 and Class 8 tractors certified or exempted as vocational tractors are limited in production to no more than 21,000 vehicles in any three consecutive model years. If a manufacturer is determined as not applying this allowance in good faith by EPA in its applications for certification in accordance with 40 CFR 1037.205 and 1037.610, a manufacturer must comply with the tractor fuel consumption standards in paragraph (c)(3) of this section. No production limit applies for vocational tractors subject to Phase 2 standards.

(10) *Small business manufacturers converting to mid roof or high roof configurations.* Small manufacturers are to allowed convert low and mid roof tractors to high roof configurations without recertification, provided it is for the purpose of building a custom sleeper tractor or conversion to a natural gas tractor as specified in 40 CFR 1037.150(r).

(11) *Useful life.* The following useful life values apply for the standards of this section:

(i) 185,000 miles or 10 years, whichever comes first, for vehicles at or below 33,000 pounds GVWR.

(ii) 435,000 miles or 10 years, whichever comes first, for vehicles above 33,000 pounds GVWR.

(12) *Conversion to high-roof configurations.* Secondary vehicle manufacturers that qualify as small manufacturers may convert low- and mid-roof tractors to high-roof configurations without recertification for the purpose of building a custom sleeper tractor or converting it to run on natural gas, as follows:

(i) The original low- or mid-roof tractor must be covered by a valid certificate of conformity by EPA.

(ii) The modifications may not increase the frontal area of the tractor beyond the frontal area of the equivalent high-roof tractor with the corresponding standard trailer. If a manufacturer cannot use the original manufacturer's roof fairing for the high-roof tractor, use good engineering judgment to achieve similar or better aerodynamic performance.

(iii) The agencies may require that these manufacturers submit annual production reports as described in § 535.8 and 40 CFR 1037.250 indicating the original roof height for requalified vehicles.

(13) *Compliance with standards.* A manufacturer complies with the standards of this part as described in § 535.10.

(d) *Heavy-duty engines.* Each manufacturer of heavy-duty engines shall comply with the fuel consumption standards in this paragraph (d) of this section expressed in gallons per 100 horsepower-hour. Each engine must be manufactured to comply for its full useful life, expressed in service miles, operating hours, or calendar years, whatever comes first. The provisions of this part apply to all new 2014 model year and later heavy-duty engines fueled by conventional and alternative fuels and manufactured for use in heavy-duty tractors or vocational vehicles. Standards apply to the engine families based upon the primary intended service classes within each of the engine regulatory subcategories as described in § 535.4 and based upon the applicable modeling and testing specified in § 535.6.

(1) *Mandatory standards.* Manufacturers of heavy-duty engine families shall comply with the mandatory fuel consumption standards in paragraphs (d)(3) through (6) of this section for model years 2017 and later for compression-ignition engines and for model years 2016 and later for spark-ignition engines.

(i) The heavy-duty engine regulatory category is divided into six regulatory subcategories, five compression-ignition subcategories and one spark-ignition subcategory, as shown in Table 14 of this section.

(ii) Separate standards exist for engine families manufactured for use in heavy-duty vocational vehicles and in truck tractors.

(iii) For purposes of certifying engines to fuel consumption standards, manufacturers must divide their product lines in each regulatory subcategory into engine families. Fuel consumption standards apply each model year to the same engine families used to comply with EPA standards in 40 CFR 1036.108 and 40 CFR 1037.230. An engine family is designated under the EPA program based upon testing specified in 40 CFR part 1036, subpart F, and the engine family's primary intended service class. Each engine family manufactured for use in a heavy-duty tractor or vocational vehicle must be certified to the primary intended service class that it is designed for in accordance with 40 CFR 1036.108 and 1036.140.

(2) *Voluntary compliance.* (i) For model years 2013 through 2016 for compression-ignition engine families, and for model year 2015 for spark-ignition engine families, a manufacturer may choose voluntarily to comply with the fuel consumption standards provided in paragraphs (d)(3) through (5) of this section. For example, a manufacturer may choose to comply early in order to begin accumulating credits through over-compliance with the applicable standards. A manufacturer choosing early compliance must comply with all the vehicles and engines it manufacturers in each regulatory category for a given model year except in model year 2013 the manufacturer may comply with individual engine families as specified in 40 CFR 1036.150(a)(2).

(ii) A manufacturer must declare its intent to voluntarily comply with fuel consumption standards and identify its plans to comply before it submits its first application for a certificate of conformity for the respective model year as specified in § 535.8; and, once selected, the decision cannot be reversed and the manufacturer must continue to comply for each subsequent model year for all the vehicles and engines it manufacturers in each regulatory category for a given model year.

(3) *Regulatory subcategory standards.* The primary fuel consumption standards for heavy-duty engine families are given in the following table:

TABLE 13—PRIMARY HEAVY-DUTY ENGINE FUEL CONSUMPTION STANDARDS

[Gallons per 100 hp-hr]

Regulatory subcategory	CI LHD engines and all other engines	CI MHD engines and all other engines		HHD CI engines and all other engines		SI engines
Application	Vocational	Vocational	Tractor	Vocational	Tractor	All
Phase 1—Voluntary Standards						
2015						7.0552
2013 to 2016	5.8939	5.8939	4.9312	5.5697	4.666	
Phase 1—Mandatory Standards						
2016						7.0552
2017 to 2020	5.6582	5.6582	4.6660	5.4519	4.4401	7.0552
Phase 2—Mandatory Standards						
2021 to 2023	5.5305	5.3536	4.6464	5.0393	4.3910	7.0552
2024 to 2026	5.4519	5.2849	4.5285	4.9705	4.2829	7.0552
2027 and later	5.4224	5.2554	4.4892	4.9411	4.2436	7.0552

(4) *Alternate subcategory standards.* The alternative fuel consumption standards for heavy-duty compression-ignition engine families are as follows:

(i) Manufacturers entering the voluntary program in model years 2014 through 2016, may choose to certify compression-ignition engine families unable to meet standards provided in paragraph (d)(3) of this section to the alternative fuel consumption standards of this paragraph (d)(4).

(ii) Manufacturers may not certify engines to these alternate standards if they are part of an averaging set in which they carry a balance of banked credits. For purposes of this section, manufacturers are deemed to carry credits in an averaging set if they carry credits from advance technology that are allowed to be used in that averaging set in accordance with § 535.7(d)(12).

(iii) The emission standards of this section are determined as specified by EPA in 40 CFR 1036.620(a) through (c) and should be converted to equivalent fuel consumption values.

(5) *Alternate phase-in standards.* Manufacturers have the option to comply with EPA emissions standards for compression-ignition engine families using an alternative phase-in schedule that correlates with EPA's OBD standards. If a manufacturer chooses to use the alternative phase-in schedule for meeting EPA standards and optionally chooses to comply early with the NHTSA fuel consumption program, it must use the same phase-in schedule beginning in model year 2013 for fuel consumption standards and must remain in the program for each model year thereafter until model year 2020. The fuel consumption standard for each model year of the alternative phase-in schedule is provided in Table 15 of this section. Note that engine families certified to these standards are not eligible for early credits under § 535.7.

TABLE 14—PHASE 1 ALTERNATIVE PHASE-IN CI ENGINE FUEL CONSUMPTION STANDARDS

[Gallons per 100 hp-hr]

Tractors	LHD engines	MHD engines	HHD engines
Model Years 2013 to 2015	NA	5.0295	4.7642
Model Years 2016 to 2020 †	NA	4.7839	4.5187
Vocational	LHD engines	MHD engines	HHD engines
Model Years 2013 to 2015	6.0707	6.0707	5.6680
Model Years 2016 to 2020 †	5.6582	5.6582	5.4519

† **Note:** These alternate standards for 2016 and later are the same as the otherwise applicable standards for 2017 through 2020.

(6) *Alternative fuel conversions.* Engines that have been converted to operate on alternative fuels may demonstrate compliance with the standards of this part or other alternative compliance approaches allowed by EPA in 40 CFR 85.525.

(7) *Optional certification under this section.* Manufacturers certifying spark-ignition engines to the compression-ignition standards for EPA must treat those engines as compression-ignition engines for all the provisions of this part.

(8) *Advanced, innovative and off-cycle technologies.* For engines subject to Phase 1 standards, manufacturers must create separate engine families for engines that contain advanced or innovative technologies and group those engines together in an engine family if they use the same advanced or innovative technologies. Manufacturers may generate separate credit allowances for advanced and innovative technologies as specified in § 535.7(f)(1) and (2). For engines subject to Phase 2 standards, manufacturers may generate separate credits allowance for off-cycle technologies in accordance with § 535.7(f)(2). Credit incentives for advanced technology engines do not apply during the Phase 2 period.

(9) *Useful life.* The exhaust emission standards of this section apply for the full useful life, expressed in service miles, operating hours, or calendar years, whichever comes first. The following useful life values apply for the standards of this section:

(i) 120,000 miles or 11 years, whichever comes first, for CI and SI LHD engines certified to Phase 1 standards.

(ii) 150,000 miles or 15 years, whichever comes first, for CI and SI LHD and spark-ignition engines certified to Phase 2 standards.

(iii) 185,000 miles or 10 years, whichever comes first, for CI MHD engines certified to Phase 1 and for Phase 2.

(iv) 435,000 miles or 10 years, whichever comes first, for CI HHD engines certified to Phase 1 and for Phase 2.

(v) For Phase 1 credits that manufacturers calculate based on a useful life of 110,000 miles, multiply any banked credits that it carries forward for use into the Phase 2 program by 1.36. For Phase 1 credit deficits that manufacturers generate based on a useful life of 110,000 miles multiply the credit deficit by 1.36, if offsetting the shortfall with Phase 2 credits.

(10) *Loose engines.* This paragraph (10) describes alternate emission and fuel consumption standards for loose engines certified under. The standards of this paragraph (d) and 1036.108 do not apply for loose engines certified under paragraph (a) of this section and 40 CFR 86.1819–14(k)(8). The standards in 40 CFR 1036.150(j) apply for the emissions and equivalent fuel consumption measured with the engine installed in a complete vehicle consistent with the provisions of 40 CFR 86.1819–14(k)(8)(vi).

(11) *Alternate transition option for Phase 2 engine standards.* (i) Manufacturers may optionally elect to comply with the model year 2021 primary (Phase 2) vocational vehicle and tractor engine standards in paragraph (d)(3) of this section beginning in model year 2020 (*e.g.* comply with the more stringent standards one year early). The model year 2021 standard would apply to these manufacturers for model years 2020 through 2023. Manufacturers that voluntarily certify their engines to model year 2021 standards early would then be eligible for less stringent engine tractor standards in model years 2024 through 2026, as follows:

(A) 5.2849 gallons per 100 hp-hr for MHD vocational vehicle engines.

(B) 4.5874 gallons per 100 hp-hr for MHD tractor engines.

(C) 4.9705 gallons per 100 hp-hr for HHD vocational vehicle engines.

(D) 4.3418 gallons per 100 hp-hr for HHD tractor engines.

(ii) The primary standard in paragraph (d)(3) applies for all manufacturers in model year 2027 and later years.

(iii) Manufacturers may apply these provisions separately for medium heavy-duty engines and heavy heavy-duty engines. This election applies to all engines in each segment. For example, if a manufacturer elects this alternate option for its medium heavy-duty engines, all of the manufacturer's medium heavy-duty vocational and tractor engines must comply. Engine fuel consumption credits generated under § 535.7(d) for manufacturers complying early with the model year 2021 standards follow the temporary extended credit life allowance in § 535.7(d)(9).

(12) *Compliance with Standards.* A manufacturer complies with the standards of this part as described in § 535.10.

(e) *Heavy-duty Trailers.* Each manufacturer of heavy-duty trailers as specified in 49 CFR 523.10, except trailers constructed in accordance with 49 CFR 571.7(f), shall comply with the fuel consumption standards in paragraph (e)(1) of this section expressed in gallons per 1000 ton-miles. Each vehicle must be manufactured to comply for its full useful life. There are no Phase 1 standards for trailers. Different levels of stringency apply for box vans depending on features that may affect aerodynamic performance. Standards apply to the trailer vehicle families within each of the trailer regulatory subcategories in accordance with § 535.4 and 40 CFR 1037.230 and based upon the applicable modeling and testing specified in § 535.6.

(1) *Fuel consumption standards for Box-Vans.* Box van trailer families manufactured in model year 2021 and later must comply with the fuel consumption standards of this section. For model years 2018 through 2020, box van trailer manufacturers have the option to voluntarily comply with the fuel consumption standards of this section. Different levels of stringency

apply for box vans depending on features that may affect aerodynamic performance. A manufacturer may optionally meet less stringent standards for different trailer types, which are characterized as follows:

(i) For trailers 35 feet or longer, a manufacturer may designate as ''non-aero box vans'' those box vans that have a rear lift gate or rear hinged ramp, and at least one of the following side features: Side lift gate, side-mounted pull-out platform, steps for side-door access, a drop-deck design, or belly boxes that occupy at least half the length of both sides of the trailer between the centerline of the landing gear and the leading edge of the front wheels. For trailers less than 35 feet long, manufacturers may designate as ''non-aero box vans'' any refrigerated box vans with at least one of the side features identified for longer trailers.

(ii) A manufacturer may designate as ''partial-aero box vans'' those box vans that have at least one of the side features identified in paragraph (a)(1)(i) of this section. Long box vans may also qualify as partial-aero box vans if they have a rear lift gate or rear hinged ramp. Note that this paragraph (e)(1)(ii) does not apply for box vans designated as ''non-aero box vans'' under paragraph (e)(1)(i) of this section.

(iii) ''Full-aero box vans'' are box vans that are not designated as non-aero box vans or partial-aero box vans under this paragraph (e)(1).

(iv) Fuel consumption standards apply for full-aero box vans as specified in the following table:

TABLE 15—PHASE 2 FULL AERO BOX VAN FUEL CONSUMPTION STANDARDS

[Gallons per 1,000 ton-miles]

Model years	Dry van		Refrigerated van	
	Long	Short	Long	Short
Voluntary Standards				
2018 to 2020	7.98625	12.31827	8.15324	12.68173
Mandatory Standards				
2021 to 2023	7.75049	12.15128	7.91749	12.52456
2024 to 2026	7.58350	11.87623	7.75049	12.24951
2027 and later	7.43615	11.72888	7.60314	12.10216

(v) Fuel consumption standards apply for partial-aero box vans as specified in the following table:

TABLE 16—PHASE 2 FUEL CONSUMPTION STANDARDS FOR PARTIAL-AERO BOX VANS

[Gallons per 1,000 ton-mile]

Model year	Dry van		Refrigerated van	
	Short	Long	Short	Long
2018–2020	12.31827	7.98625	12.68173	8.15324
2021 and later	12.15128	7.91749	12.52456	8.08448

(2) *Fuel consumption standards for Non-aero Box Vans and Non-box Trailers.* (i) Non-aero box van and non-box trailer families manufactured in model year 2021 and later must comply with the fuel consumption standards of this section. For model years 2018 through 2020, trailer manufacturers have the option to voluntarily comply with the fuel consumption standards of this section.

(ii) Non-aero box vans and non-box vans must meet the following standards:

(A) Trailers must use automatic tire inflation systems or tire pressure monitoring systems with wheels on all axles. Tire pressure monitoring systems must use low pressure warning and malfunction telltales in clear view of the driver as specified in S4.3 and S4.4 of 49 CFR 571.138.

(B) Non-box trailers must use tires with a TRRL at or below 5.1 kg/tonne. Through model year 2020, non-box trailers may instead use tires with a TRRL at or below 6.0 kg/tonne.

(C) Non-aero box vans must use tires with a TRRL at or below 4.7 kg/tonne. Through model year 2020, non-aero box vans may instead use tires with a TRRL at or below 5.1 kg/tonne.

(3) *Subfamily standards.* Starting in model year 2027, manufacturers may generate or use fuel consumption credits for averaging to demonstrate compliance with the standards specified in paragraph (e)(1)(iii) of this section as described in § 535.7(e). This requires that manufacturers specify a Family Emission Limit (FEL) for fuel consumption for each vehicle subfamily. The FEL may not be less than the result of the emission and fuel consumption calculation in 40 CFR 1037.515. The FEL may not be greater than the appropriate standard for model year 2021 trailers. These FELs serve as the fuel consumption standards for the specific vehicle subfamily instead of the standards specified in paragraph (e)(1) of this section. Manufacturers may not use averaging for non-box trailers, partial-aero box vans, or non-aero box vans that meet standards under paragraph (e)(1)(i) or (e)(1)(ii) of this section, and manufacturers may not use fuel consumption credits for banking or trading for any trailers.

(4) *Useful life.* The fuel consumption standards of this section apply for a useful life equal to 10 years.

(5) *Transitional allowances for trailers.* Through model year 2026, trailer manufacturers may calculate a number of trailers that are exempt from

the standards and certification requirements of this part. Calculate the number of exempt box vans in a given model year by multiplying the manufacturer's total U.S.-directed production volume of certified box vans by 0.20 and rounding to the nearest whole number; however, in no case may the number of exempted box vans be greater than 350 units in any given model year. Repeat this calculation to determine the number of non-box trailers, up to 250 annual units, that are exempt from standards and certification requirements. Perform the calculation based on the manufacturer's projected production volumes in the first year that standards apply; in later years, use actual production volumes from the preceding model year. Manufacturers include these calculated values of the production volumes of exempt trailers in their annual production report under § 535.8 and 40 CFR 1037.250.

(6) *Roll-up doors for non-aero box vans.* Through model year 2023, box vans may qualify for non-aero or partial-aero standards under this paragraph (e) by treating roll-up rear doors as being equivalent to rear lift gates.

(7) *Expanded families.* A manufacturer may include refrigerated box vans in a vehicle family with dry box vans by treating them all as dry box vans for demonstrating compliance with fuel consumption standards. A manufacturer may include certain other types of trailers in a vehicle family with a different type of trailer, such that the combined set of trailers are all subject to the more stringent standards, as follows:

(i) Standards for long trailers are more stringent than standards for short trailers.

(ii) Standards for long dry box vans are more stringent than standards for short refrigerated box vans.

(iii) Standards for non-aero box vans are more stringent than standards for non-box trailers.

(8) *Compliance with standards.* A manufacturer complies with the standards of this part as described in § 535.10.

§ 535.6 Measurement and calculation procedures.

This part describes the measurement and calculation procedures manufacturers use to determine annual fuel consumption performance results. Manufacturers use the fuel consumption results determined in this part for calculating credit balances specified in § 535.7 and then determine whether they comply with standards as specified in § 535.10. Manufacturers must use EPA emissions test results for deriving NHTSA's fuel consumption performance rates. Consequently, manufacturers conducting testing for certification or annual demonstration testing and providing CO_2 emissions data to EPA must also provide equivalent fuel consumption results to NHTSA for all values. NHTSA and EPA reserve the right to verify separately or in coordination the results of any testing and measurement established by manufacturers in complying with the provisions of this program and as specified in 40 CFR 1037.301 and § 535.9. Any carry over data from the Phase 1 program may be carried into the Phase 2 only with approval from EPA and by using good engineering judgment considering differences in testing protocols between test procedures.

(a) *Heavy-duty pickup trucks and vans.* This section describes the method for determining the fuel consumption performance rates for test groups and for fleets of complete heavy-duty pickup trucks and vans each model year. The NHTSA heavy-duty pickup truck and van fuel consumption performance rates correspond to the same requirements for EPA as specified in 40 CFR 86.1819–14.

(1) For the Phase 1 program, if the manufacturer's fleet includes conventional vehicles (gasoline, diesel and alternative fueled vehicles) and advanced technology vehicles (hybrids with powertrain designs that include energy storage systems, vehicles with waste heat recovery, electric vehicles and fuel cell vehicles), it may divide its fleet into two separate fleets each with its own separate fleet average fuel consumption performance rate. For Phase 2, manufacturers may calculate their fleet average fuel consumption rates for a conventional fleet and separate advanced technology vehicle fleets. Advanced technology vehicle fleets should be separated into plug-in hybrid electric vehicles, electric vehicles and fuel cell vehicles.

(2) Vehicles in each fleet should be selected and divided into test groups or subconfigurations according to EPA in 40 CFR 86.1819–14(d).

(3) Use the EPA CO_2 emissions test results for each test group, in grams per mile, for the selected vehicles.

(i) Use CO_2 emissions test results for vehicles fueled by conventional and alternative fuels, including dedicated and dual-fueled (multi-fuel and flexible-fuel) vehicles using each fuel type as specified in 40 CFR 86.1819–14(d)(10).

(ii) Use CO_2 emissions test results for dual-fueled vehicles using a weighted average of the manufacturer's emission results as specified in 40 CFR 600.510–12(k) for light-duty trucks.

(iii) All electric vehicles are deemed to have zero emissions of CO_2, CH_4, and N_2O. No emission testing is required for such electric vehicles. Assign the fuel consumption test group result to a value of zero gallons per 100 miles in paragraph (a)(4) of this section.

(iv) Use CO_2 emissions test results for cab-complete and incomplete vehicles based upon the applicable complete sister vehicles as determined in 40 CFR 1819–14(j)(2).

(v) Use CO_2 emissions test results for loose engines using applicable complete vehicles as determined in 40 CFR 86.1819–14(k)(8).

(vi) Manufacturers can choose to analytically derive CO_2 emission rates (ADCs) for test groups or subconfigurations. Use ADCs for test groups or subconfigurations in accordance with 40 CFR 86.1819–14 (d) and (g).

(4) Calculate equivalent fuel consumption results for all test groups, in gallons per 100 miles, from CO_2 emissions test group results, in grams per miles, and round to the nearest 0.001 gallon per 100 miles.

(i) Calculate the equivalent fuel consumption test group results as follows for compression-ignition vehicles and alternative fuel compression-ignition vehicles. CO_2 emissions test group result (grams per mile)/10,180 grams per gallon of diesel fuel) $\times (10^2)$ = Fuel consumption test group result (gallons per 100 mile).

(ii) Calculate the equivalent fuel consumption test group results as follows for spark-ignition vehicles and alternative fuel spark-ignition vehicles. CO_2 emissions test group result (grams per mile)/8,877 grams per gallon of gasoline fuel) $\times (10^2)$ = Fuel consumption test group result (gallons per 100 mile).

(5) Calculate the fleet average fuel consumption result, in gallons per 100 miles, from the equivalent fuel consumption test group results and round the fuel consumption result to the nearest 0.001 gallon per 100 miles. Calculate the fleet average fuel consumption result using the following equation.

$$\text{Fleet Average Fuel Consumption} = \frac{\sum\left[\text{Fuel Consumption Test Group Result}_i \times \text{Volume}_i\right]}{\sum\left[\text{Volume}_i\right]}$$

Where:

Fuel Consumption Test Group Result$_i$ = fuel consumption performance for each test group as defined in 49 CFR 523.4.

Volume$_i$ = production volume of each test group.

(6) Compare the fleet average fuel consumption standard to the fleet average fuel consumption performance. The fleet average fuel consumption performance must be less than or equal to the fleet fuel consumption standard to comply with standards in § 535.5(a).

(b) *Heavy-duty vocational vehicles and tractors.* This section describes the method for determining the fuel consumption performance rates for vehicle families of heavy-duty vocational vehicles and tractors. The NHTSA heavy-duty vocational vehicle and tractor fuel consumption performance rates correspond to the same requirements for EPA as specified in 40 CFR 1037, subpart F.

(1) Select vehicles and vehicle family configurations to test as specified in 40 CFR 1037.230 for vehicles that make up each of the manufacturer's regulatory subcategories of vocational vehicles and tractors. For the Phase 2 program, select powertrain, axle and transmission families in accordance with 40 CFR 1037.231 and 1037.232.

(2) Follow the EPA testing requirements in 40 CFR 1037.230 and 1037.501 to derive inputs for the Greenhouse gas Emissions Model (GEM).

(3) Enter inputs into GEM, in accordance with 40 CFR 1037.520, to derive the emissions and fuel consumption performance results for all vehicles (conventional, alternative fueled and advanced technology vehicles).

(4) For Phase 1 and 2, all of the following GEM inputs apply for vocational vehicles and other tractor regulatory subcategories, as follows:

(i) Model year and regulatory subcategory (see § 535.3 and 40 CFR 1037.230).

(ii) Coefficient of aerodynamic drag or drag area, as described in 40 CFR 1037.520(b) (tractors only for Phase 1).

(iii) Steer and drive tire rolling resistance, as described in 40 CFR 1037.520(c).

(iv) Vehicle speed limit, as described in 40 CFR 1037.520(d) (tractors only).

(v) Vehicle weight reduction, as described in 40 CFR 1037.520(e) (tractors only for Phase 1).

(vi) Automatic engine shutdown systems, as described in 40 CFR 1037.660 (only for Phase 1 Class 8 sleeper cabs). For Phase 1, enter a GEM input value of 5.0 g/ton-mile, or an adjusted value as specified in 40 CFR 1037.660.

(5) For Phase 2 vehicles, the GEM inputs described in paragraphs (b)(4)(i) through (v) of this section continue to apply. Note that the provisions related to vehicle speed limiters and automatic engine shutdown systems are available for vocational vehicles in Phase 2. The additional GEM inputs that apply for vocational vehicles and other tractor regulatory subcategories for demonstrating compliance with Phase 2 standards are as follows:

(i) *Engine characteristics.* Enter information from the engine manufacturer to describe the installed engine and its operating parameters as described in 40 CFR 1036.510 and 1037.520(f).

(ii) *Vehicle information.* Enter information in accordance with 40 CFR 1037.520(g) for the vehicle and its operating parameters including:

(A) Transmission make, model and type;

(B) Drive axle configuration;

(C) Drive axle ratio, k_a;

(D) GEM inputs associated with powertrain testing include powertrain family, transmission calibration identifier, test data from 40 CFR 1037.550, and the powertrain test configuration (dynamometer connected to transmission output or wheel hub).

(iii) *Idle-reduction technologies.* Identify whether the manufacturer's vehicle has qualifying idle-reduction technologies, subject to the qualifying criteria in 40 and 1037.660 and enter values for stop start and neutral idle technologies as specified in 40 CFR 1037.520(h).

(iv) *Axle and transmission efficiency.* Manufacturers may use axle efficiency maps as described in 40 CFR 1037.560 and transmission efficiency maps as described in 40 CFR 1037.565 to replace the default values in GEM.

(v) *Additional reduction technologies.* Enter input values in GEM as follows to characterize the percentage CO_2 emission reduction corresponding to certain technologies and vehicle configurations, or enter 0 as specified in 40 CFR 1037.520(j):

(A) Intelligent controls

(B) Accessory load

(C) Tire-pressure systems

(D) Extended-idle reduction

(E) Additional GEM inputs may apply as follows:

(1) Enter 1.7 and 0.9, respectively, for school buses and coach buses that have at least seven available forward gears.

(2) If the agencies approve an off-cycle technology under § 535.7(f) and 40 CFR 1037.610 in the form of an improvement factor, enter the improvement factor expressed as a percentage reduction in CO_2 emissions. (Note: In the case of approved off-cycle technologies whose benefit is quantified as a g/ton-mile credit, apply the credit to the GEM result, not as a GEM input value.)

(vi) *Vehicles with hybrid power take-off (PTO).* For vocational vehicles, determine the delta PTO emission result of the manufacturer's engine and hybrid power take-off system as described in 40 CFR 1037.540.

(vii) *Aerodynamic improvements for vocational vehicles.* For vocational vehicles certified using the Regional duty cycle, enter ΔC_dA values to account for using rear fairings and a reduced minimum frontal area as specified in 40 CFR 1037.520(m) and 1037.527.

(viii) *Alternate fuels.* For fuels other than those identified in GEM, perform the simulation by identifying the vehicle as being diesel-fueled if the engine is subject to the compression-ignition standard, or as being gasoline-fueled if the engine is subject to the spark-ignition standards. Correct the engine or powertrain fuel map for mass-specific net energy content as described in 40 CFR 1036.535(b).

(ix) *Custom chassis vehicles.* A simplified versions of GEM applies for custom chassis vehicle subject § 535.5(b)(6) in accordance with 40 CFR 1037.520(a)(2)(ii).

(6) In unusual circumstances, manufacturers may ask EPA to use weighted average results of multiple GEM runs to represent special technologies for which no single GEM run can accurately reflect.

(7) From the GEM results, select the CO_2 family emissions level (FEL) and equivalent fuel consumption values for vocational vehicle and tractor families in each regulatory subcategory for each model year. Equivalent fuel consumption FELs are derived in GEM and expressed to the nearest 0.0001 gallons per 1000 ton-mile. For families containing multiple subfamilies, identify the FELs for each subfamily.

(c) [Reserved]

(d) *Heavy-duty engines.* This section describes the method for determining equivalent fuel consumption family certification level (FCL) values for engine families of heavy-duty truck tractors and vocational vehicles. The NHTSA heavy-duty engine fuel consumption FCLs are determined from the EPA FCLs tested in accordance with 40 CFR 1036, subpart F. Each engine family must use the same primary intended service class as designated for EPA in accordance with 40 CFR 1036.140.

(1) Manufacturers must select emission-data engines representing the tested configuration of each engine family specified in 40 CFR part 86 and 40 CFR 1036.235 for engines in heavy-duty truck tractors and vocational vehicles that make up each of the manufacture's regulatory subcategories.

(2) Standards in § 535.5(d) apply to the CO_2 emissions rates for each emissions-data engine in an engine family subject to the procedures and equipment specified in 40 CFR part 1036, subpart F. Determine equivalent fuel consumptions rates using CO_2 emissions rates in grams per hp-hr measured to at least one more decimal place than that of the applicable EPA standard in 40 CFR 1036.108.

(i) Use the CO_2 emissions test results for engines running on each fuel type for conventional, dedicated, multi-fueled (dual-fuel, and flexible-fuel) engines as specified in 40 CFR part 1036, subpart F.

(ii) Use the CO_2 emissions result for multi-fueled engines using the same weighted fuel mixture emission results as specified in 40 CFR 1036.235 and 40 CFR part 1036, subpart F.

(iii) Use the CO_2 emissions test results for hybrid engines as described in 40 CFR 1036.525.

(iv) All electric vehicles are deemed to have zero emissions of CO_2 and zero fuel consumption. No emission or fuel consumption testing is required for such electric vehicles.

(3) Use the CO_2 emissions test results for tractor engine families in accordance with 40 CFR 1036.501 and for vocational vehicle engine families in accordance with 40 CFR part 86, subpart N, for each heavy-duty engine regulatory subcategory for each model year.

(i) If a manufacturer certifies an engine family for use both as a vocational engine and as a tractor engine, the manufacturer must split the family into two separate subfamilies in accordance with 40 CFR 1036.230. The manufacturer may assign the numbers and configurations of engines within the respective subfamilies at any time prior to the submission of the end-of-year report required by 40 CFR 1036.730 and § 535.8. The manufacturer must track into which type of vehicle each engine is installed, although EPA may allow the manufacturer to use statistical methods to determine this for a fraction of its engines.

(ii) The following engines are excluded from the engine families used to determine fuel consumption FCL values and the benefit for these engines is determined as an advanced technology credit under the ABT provisions provided in § 535.7(e); these provisions apply only for the Phase 1 program:

(A) Engines certified as hybrid engines or power packs.

(B) Engines certified as hybrid engines designed with PTO capability and that are sold with the engine coupled to a transmission.

(C) Engines with Rankine cycle waste heat recovery.

(4) Manufacturers generating CO_2 emissions rates to demonstrate compliance to EPA vehicle standards for model years 2021 and later, using engine fuel maps determined in accordance with 40 CFR 1036.535 and 1036.540 or engine powertrain results in accordance with 40 CFR 1036.630 and 40 CFR 1037.550 for each engine configuration, must use the same compliance pathway and model years for certifying under the NHTSA program. Manufacturers may omit providing equivalent fuel consumption FCLs under this section if all of its engines will be installed in vehicles that are certified based on powertrain testing as described in 40 CFR 1037.550.

(5) Calculate equivalent fuel consumption values from the emissions CO_2 FCLs levels for certified engines, in gallons per 100 hp-hr and round each fuel consumption value to the nearest 0.0001 gallon per 100 hp-hr.

(i) Calculate equivalent fuel consumption FCL values for compression-ignition engines and alternative fuel compression-ignition engines. CO_2 FCL value (grams per hp-hr)/10,180 grams per gallon of diesel fuel) × (10^2) = Fuel consumption FCL value (gallons per 100 hp-hr).

(ii) Calculate equivalent fuel consumption FCL values for spark-ignition engines and alternative fuel spark-ignition engines. CO_2 FCL value (grams per hp-hr)/8,877 grams per gallon of gasoline fuel) × (10^2) = Fuel consumption FCL value (gallons per 100 hp-hr).

(iii) Manufacturers may carryover fuel consumption data from a previous model year if allowed to carry over emissions data for EPA in accordance with 40 CFR 1036.235.

(iv) If a manufacturer uses an alternate test procedure under 40 CFR 1065.10 and subsequently the data is rejected by EPA, NHTSA will also reject the data.

(e) *Heavy-duty trailers.* This section describes the method for determining the fuel consumption performance rates for trailers. The NHTSA heavy-duty trailers fuel consumption performance rates correspond to the same requirements for EPA as specified in 40 CFR part 1037, subpart F.

(1) Select trailer family configurations that make up each of the manufacturer's regulatory subcategories of heavy-duty trailers in 40 CFR 1037.230 and § 535.4.

(2) Obtain preliminary approvals for trailer aerodynamic devices from EPA in accordance with 40 CFR 1037.150.

(3) For manufacturers voluntarily complying in model years 2018 through 2020, and for trailers complying with mandatory standards in model years 2021 and later, determine the CO_2 emissions and fuel consumption results for partial- and full-aero trailers using the equations and technologies specified in 40 CFR part 1037, subpart F. Use testing to determine input values in accordance with 40 CFR 1037.515.

(4) From the equation results, use the CO_2 family emissions level (FEL) to calculate equivalent fuel consumption FELs are expressed to the nearest 0.0001 gallons per 1000 ton-mile.

(i) For families containing multiple subfamilies, identify the FELs for each subfamily.

(ii) Calculate equivalent fuel consumption FEL values for trailer families. CO_2 FEL value (grams per 1000 ton-mile)/10,180 grams per 1000 ton-mile of diesel fuel) × (10^3) = Fuel consumption FEL value. The equivalent fuel consumption FELs are expressed to the nearest 0.0001 gallons per 1000 ton-mile.

§ 535.7 Averaging, banking, and trading (ABT) credit program.

(a) *General provisions.* After the end of each model year, manufacturers must comply with the fuel consumption standards in § 535.5 for averaging, banking and trading credits. Trailer manufacturers are excluded from this section except for those producing full-aero box trailers, which may comply with special provisions in paragraph (e) of this section. Manufacturers comply with standards if the sum of averaged, banked and traded credits generate a ''zero'' credit balance or a credit surplus within an averaging set of vehicles or engines. Manufacturers fail to comply with standards if the sum of the credit flexibilities generate a credit deficit (or shortfall) in an averaging set. Credit shortfalls must be offset by banked or traded credits within three model years after the shortfall is incurred. These processes are hereafter referenced as the NHTSA ABT credit program. The following provisions apply to all fuel consumption credits.

(1) *Credits (or fuel consumption credits (FCCs)).* Credits in this part mean a calculated weighted value representing the difference between the fuel consumption performance and the standard of a vehicle or engine family or fleet within a particular averaging set. Positive credits represent cases where a vehicle or engine family or fleets perform better than the applicable standard (the fuel consumption performance is less than the standard) whereas negative credits represent underperforming cases. The value of a credit is calculated according to paragraphs (b) through (e) of this section. FCCs are only considered earned or useable for averaging, banking or trading after EPA and NHTSA have verified the information in a manufacturer's final reports required in § 535.8. Types of FCCs include the following:

(i) *Conventional credits.* Credits generated by vehicle or engine families or fleets containing conventional vehicles (*i.e.,* gasoline, diesel and alternative fueled vehicles).

(ii) *Early credits.* Credits generated by vehicle or engine families or fleets produced for model year 2013. Early credits are multiplied by an incentive factor of 1.5 times.

(iii) *Advanced technology credits.* Credits generated by vehicle or engine families or subconfigurations containing vehicles with advanced technologies (*i.e.,* hybrids with regenerative braking, vehicles equipped with Rankine-cycle engines, electric and fuel cell vehicles) and incentivized under this ABT credit program in paragraph (f)(1) of this section and by EPA under 40 CFR 86.1819–14(d)(7), 1036.615, and 1037.615.

(iv) *Innovative and off-cycle technology credits.* Credits can be generated by vehicle or engine families or subconfigurations having fuel consumption reductions resulting from technologies not reflected in the GEM simulation tool or in the FTP chassis dynamometer and that were not in common use with heavy-duty vehicles or engines before model year 2010 that are not reflected in the specified test procedure. Manufacturers should prove that these technologies were not in common use in heavy-duty vehicles or engines before model year 2010 by demonstrating factors such as the penetration rates of the technology in the market. NHTSA will not approve any request if it determines that these technologies do not qualify. The approach for determining innovative and off-cycle technology credits under this fuel consumption program is described in paragraph (f)(2) of this section and by EPA under 40 CFR 86.1819–14(d)(13), 1036.610, and 1037.610.

(2) *Averaging.* Averaging is the summing of a manufacturer's positive and negative FCCs for engines or vehicle families or fleets within an averaging set. The principle averaging sets are defined in § 535.4.

(i) A credit surplus occurs when the net sum of the manufacturer's generated credits for engines or vehicle families or fleets within an averaging set is positive (a zero credit balance is when the sum equals zero).

(ii) A credit deficit occurs when the net sum of the manufacturer's generated credits for engines or vehicle families or fleets within an averaging set is negative.

(iii) Positive credits, other than advanced technology credits, generated and calculated within an averaging set may only be used to offset negative credits within the same averaging set.

(iv) Manufacturers may certify one or more vehicle families (or subfamilies) to an FEL above the applicable fuel consumption standard, subject to any applicable FEL caps and other provisions allowed by EPA in 40 CFR parts 1036 and 1037, if the manufacturer shows in its application for certification to EPA that its projected balance of all FCC transactions in that model year is greater than or equal to zero or that a negative balance is allowed by EPA under 40 CFR 1036.745 and 1037.745.

(v) If a manufacturer certifies a vehicle family to an FEL that exceeds the otherwise applicable standard, it must obtain enough FCC to offset the vehicle family's deficit by the due date of its final report required in § 535.8. The emission credits used to address the deficit may come from other vehicle families that generate FCCs in the same model year (or from the next three subsequent model years), from banked FCCs from previous model years, or from FCCs generated in the same or previous model years that it obtained through trading. Note that the option for using banked or traded credits does not apply for trailers.

(vi) Manufacturers may certify a vehicle or engine family using an FEL (as described in § 535.6) below the fuel consumption standard (as described in § 535.5) and choose not to generate conventional fuel consumption credits for that family. Manufacturers do not need to calculate fuel consumption credits for those families and do not need to submit or keep the associated records described in § 535.8 for these families. Manufacturers participating in NHTSA's FCC program must provide reports as specified in § 535.8.

(3) *Banking.* Banking is the retention of surplus FCC in an averaging set by the manufacturer for use in future model years for the purpose of averaging or trading.

(i) Surplus credits may be banked by the manufacturer for use in future model years, or traded, given the restriction that the credits have an expiration date of five model years after the year in which the credits are generated. For example, banked credits earned in model year 2014 may be utilized through model year 2019. Surplus credits will become banked credits unless a manufacturer contacts NHTSA to expire its credits.

(ii) Surplus credits become earned or usable banked FCCs when the manufacturer's final report is approved by both agencies. However, the agencies may revoke these FCCs at any time if they are unable to verify them after reviewing the manufacturer's reports or auditing its records.

(iii) Banked FCC retain the designation from the averaging set and model year in which they were generated.

(iv) Banked credits retain the designation of the averaging set in which they were generated.

(v) Trailer manufacturers generating credits in paragraph (e) of this section may not bank credits except to resolve credit deficits in the same model year or from up to three prior model years.

(4) *Trading.* Trading is a transaction that transfers banked FCCs between manufacturers or other entities in the same averaging set. A manufacturer may use traded FCCs for averaging, banking, or further trading transactions.

(i) Manufacturers may only trade banked credits to other manufacturers to use for compliance with fuel consumption standards. Traded FCCs, other than advanced technology credits, may be used only within the averaging set in which they were generated. Manufacturers may only trade credits to other entities for the purpose of expiring credits.

(ii) Advanced technology credits can be traded across different averaging sets.

(iii) The agencies may revoke traded FCCs at any time if they are unable to verify them after reviewing the manufacturer's reports or auditing its records.

(iv) If a negative FCC balance results from a transaction, both the buyer and seller are liable, except in cases the agencies deem to involve fraud. See § 535.9 for cases involving fraud. EPA also may void the certificates of all vehicle families participating in a trade that results in a manufacturer having a negative balance of emission credits. See 40 CFR 1037.745.

(v) Trailer manufacturers generating credits in paragraph (e) of this section starting in model year 2027 may not bank or trade credits. These manufacturers may only use credits for the purpose of averaging.

(vi) Manufacturers with deficits or projecting deficits before or during a production model year may not trade credits until its available credits exceed the deficit. Manufacturers with a deficit may not trade credits if the deadline to offset that credit deficit has passed.

(5) *Credit deficit (or credit shortfall).* A credit shortfall or deficit occurs when the sum of the manufacturer's generated credits for engines or vehicle families or fleets within an averaging set is negative. Credit shortfalls must be offset by an available credit surplus within three model years after the shortfall was incurred. If the shortfall cannot be offset, the manufacturer is liable for civil penalties as discussed in § 535.9.

(6) *FCC credit plan.* (i) Each model year manufacturers submit credit plan in their certificates of conformity as required in 40 CFR 1036.725(b)(2) and 40 CFR 1037.725(b)(2). The plan is required to contain equivalent fuel consumption information in accordance § 535.8(c). The plan must include:

(A) Detailed calculations of projected emission and fuel consumption credits (positive or negative) based on projected U.S.-directed production volumes. The agencies may require a manufacturer to include similar calculations from its other engine or vehicle families to project its net credit balances for the model year. If a manufacturer projects negative emission and/or fuel consumption credits for a family, it must state the source of positive emission and/or fuel consumption credits it expects to use to offset the negative credits demonstrating how it plans to resolve any credit deficits that might occur for a model year within a period of up to three model years after that deficit has occurred.

(B) Actual emissions and fuel consumption credit balances, credit transactions, and credit trades.

(ii) Manufacturers are required to provide updated credit plans after receiving their final verified reports from EPA and NHTSA after the end of each model year.

(iii) The agencies may determine that a manufacturer's plan is unreasonable or unrealistic based on a consideration of past and projected use of specific technologies, the historical sales mix of its vehicle models, subsequent failure to follow any submitted plans, and limited expected access to traded credits.

(iv) The agencies may also consider the plan unreasonable if the manufacturer's credit deficit increases from one model year to the next. The agencies may require that the manufacturers must send interim reports describing its progress toward resolving its credit deficit over the course of a model year.

(v) If NHTSA determines that a manufacturers plan is unreasonable or unrealistic, the manufacturer is deemed as not comply with fuel consumption standards as specified in § 535.10(c) and the manufacturer may be liable for civil penalties.

(7) *Revoked credits.* NHTSA may revoke fuel consumption credits if unable to verify any information after auditing reports or records or conducting confirmatory testing. In the cases where EPA revokes emissions CO_2 credits, NHTSA will revoke the equivalent amount of fuel consumption credits.

(8) *Transition to Phase 2 standards.* The following provisions allow for enhanced use of fuel consumption credits from Phase 1 tractors and vocational vehicles for meeting the Phase 2 standards:

(i) Fuel consumption credits a manufacturer generates for light and medium heavy-duty vocational vehicles in model years 2018 through 2021 may be used through model year 2027, instead of being limited to a five-year credit life as specified in this part.

(ii) The manufacturer may use the off-cycle provisions of paragraph (f) of this section to apply technologies to Phase 1 vehicles as follows:

(A) A manufacturer may apply an improvement factor of 0.988 for tractors and vocational vehicles with automatic tire inflation systems on all axles.

(B) For vocational vehicles with automatic engine shutdown systems that conform with 40 CFR 1037.660, a manufacturer may apply an improvement factor of 0.95.

(C) For vocational vehicles with stop-start systems that conform with 40 CFR 1037.660, a manufacturer may apply an improvement factor of 0.92.

(D) For vocational vehicles with neutral-idle systems conforming with 40 CFR 1037.660, manufacturers may apply an improvement factor of 0.98. Manufacturers may adjust this improvement factor if we approve a partial reduction under 40 CFR 1037.660(a)(2); for example, if the manufacturer's design reduces fuel consumption by half as much as shifting to neutral, it may apply an improvement factor of 0.99.

(9) *Credits for small business manufacturers.* Small manufacturers may generate fuel consumption credits for natural gas-fueled vocational vehicles as follows:

(i) Small manufacturers may certify their vehicles instead of relying on the exemption of § 535.3.

(ii) Use Phase 1 GEM to determine a fuel consumption level for vehicle, then multiply this value by the engine's FCL for fuel consumption and divide by the engine's applicable fuel consumption standard.

(iii) Use the value determined in paragraph (ii) in the credit equation specified in part (c) of this section in place of the term (Std − FEL).

(iv) The following provisions apply uniquely to small businesses under the custom-chassis standards of § 535.5(b)(6):

(A) Manufacturers may use fuel consumption credits generated under paragraph (c) of this section, including banked or traded credits from any averaging set. Such credits remain subject to other limitations that apply under this part.

(B) Manufacturers may produce up to 200 drayage tractors in a given model year to the standards described in § 535.5(b)(6) for ''other buses''. Treat these drayage tractors as being in their own averaging set.

(10) *Certifying non-gasoline engines.* A manufacturer producing non-gasoline engines complying with model year 2021 or later medium heavy-duty spark-ignition standards may not generate fuel consumption credits. Only manufacturers producing gasoline engines certifying to spark-ignition standards can generate fuel consumption credits under paragraph (d) of this part.

(b) *ABT provisions for heavy-duty pickup trucks and vans.* (1) Calculate fuel consumption credits in a model year for one fleet of conventional heavy-duty pickup trucks and vans and if designated by the manufacturer another consisting of advance technology vehicles for the averaging set as defined in § 535.4. Calculate credits for each fleet separately using the following equation:

$$\text{Total MY Fleet FCC (gallons)} = (\text{Std} - \text{Act}) \times (\text{Volume}) \times (\text{UL}) \times (10^2)$$

Where:

Std = Fleet average fuel consumption standard (gal/100 mile).

Act = Fleet average actual fuel consumption value (gal/100 mile).
Volume = the total U.S.-directed production of vehicles in the regulatory subcategory.
UL = the useful life for the regulatory subcategory. The useful life value for heavy-pickup trucks and vans manufactured for model years 2013 through 2020 is equal to the 120,000 miles. The useful life for model years 2021 and later is equal to 150,000 miles.

(2) Adjust the fuel consumption performance of subconfigurations with advanced technology for determining the fleet average actual fuel consumption value as specified in paragraph (f)(1) of this section and 40 CFR 86.1819–14(d)(7). Advanced technology vehicles can be separated in a different fleet for the purpose of applying credit incentives as described in paragraph (f)(1) of this section.

(3) Adjust the fuel consumption performance for subconfigurations with innovative technology. A manufacturer is eligible to increase the fuel consumption performance of heavy-duty pickup trucks and vans in accordance with procedures established by EPA set forth in 40 CFR part 600. The eligibility of a manufacturer to increase its fuel consumption performance through use of an off-cycle technology requires an application request made to EPA and NHTSA in accordance with 40 CFR 86.1869–12 and an approval granted by the agencies. For off-cycle technologies that are covered under 40 CFR 86.1869–12, NHTSA will collaborate with EPA regarding NHTSA's evaluation of the specific off-cycle technology to ensure its impact on fuel consumption and the suitability of using the off-cycle technology to adjust fuel consumption performance. NHTSA will provide its views on the suitability of the technology for that purpose to EPA. NHTSA will apply the criteria in section (f) of this section in granting or denying off-cycle requests.

(4) Fuel consumption credits may be generated for vehicles certified in model year 2013 to the model year 2014 standards in § 535.5(a). If a manufacturer chooses to generate CO_2 emission credits under EPA's provisions in 40 CFR part 86, it may also voluntarily generate early credits under the NHTSA fuel consumption program. To do so, a manufacturer must certify its entire U.S.-directed production volume of vehicles in its fleet. The same production volume restrictions specified in 40 CFR 1037.150(a)(2) relating to when test groups are certified apply to the NHTSA early credit provisions. Credits are calculated as specified in paragraph (b)(3) of this section relative to the fleet standard that would apply for model year 2014 using the model year 2013 production volumes. Surplus credits generated under this paragraph (b)(4) are available for banking or trading. Credit deficits for an averaging set prior to model year 2014 do not carry over to model year 2014. These credits may be used to show compliance with the standards of this part for 2014 and later model years. Once a manufacturer opts into the NHTSA program they must stay in the program for all of the optional model years and remain standardized with the same implementation approach being followed to meet the EPA CO_2 emission program.

(5) Calculate the averaging set credit value by summing together the fleet credits for conventional and advanced technology vehicles including any adjustments for innovative technologies. Manufacturers may sum conventional and innovative technology credits before adding any advanced technology credits in each averaging set.

(6) For credits that manufacturers calculate based on a useful life of 120,000 miles, multiply any banked credits carried forward for use in model year 2021 and later by 1.25. For credit deficits that a manufacturer calculates based on a useful life of 120,000 miles and that it offsets with credits originally earned in model year 2021 and later, it multiplies the credit deficit by 1.25.

(c) *ABT provisions for vocational vehicles and tractors.* (1) Calculate the fuel consumption credits in a model year for each participating family or subfamily consisting of conventional vehicles in each averaging set (as defined in § 535.4) using the equation in this section. Each designated vehicle family or subfamily has a ''family emissions limit'' (FEL) that is compared to the associated regulatory subcategory standard. An FEL that falls below the regulatory subcategory standard creates ''positive credits,'' while fuel consumption level of a family group above the standard creates a ''negative credits.'' The value of credits generated for each family or subfamily in a model year is calculated as follows and must be rounded to nearest whole number:

$$\text{Vehicle Family FCC (gallons)} = (\text{Std} - \text{FEL}) \times (\text{Payload}) \times (\text{Volume}) \times (\text{UL}) \times (10^3)$$

Where:

Std = the standard for the respective vehicle family regulatory subcategory (gal/1000 ton-mile).
FEL = family emissions limit for the vehicle family (gal/1000 ton-mile).
Payload = the prescribed payload in tons for each regulatory subcategory as shown in the following table:

Regulatory subcategory	Payload (tons)
Vocational LHD Vehicles	2.85
Vocational MHD Vehicles	5.60
Vocational HHD Vehicles	7.5
MDH Tractors	12.50
HHD Tractors, other than heavy-haul Tractors	19.00
Heavy-haul Tractors	43.00

Volume = the number of U.S.-directed production volume of vehicles in the corresponding vehicle family.
UL = the useful life for the regulatory subcategory (miles) as shown in the following table:

Regulatory subcategory	UL (miles)
LHD Vehicles	110,000 (Phase 1). 150,000 (Phase 2).
Vocational MHD Vehicles and tractors at or below 33,000 pounds GVWR.	185,000.
Vocation HHD Vehicles and tractors at or above 33,000 pounds GVWR.	435,000.

(i) Calculate the value of credits generated in a model year for each family or subfamily consisting of vehicles with advanced technology vehicles in each averaging set using the equation above and the guidelines provided in paragraph (f)(1) of this section. Manufacturers may generate credits for advanced technology vehicles using incentives specified in paragraph (f)(1) of this section.

(ii) Calculate the value of credits generated in a model year for each family or subfamily consisting of vehicles with off-cycle technology vehicles in each averaging set using the equation above and the guidelines provided in paragraph (f)(2) of this section.

(2) Manufacturers must sum all negative and positive credits for each vehicle family within each applicable averaging set to obtain the total credit balance for the model year before rounding. The sum of fuel consumptions credits must be rounded to the nearest gallon. Calculate the total credits generated in a model year for each averaging set using the following equation:

Total averaging set MY credits = Σ Vehicle family credits within each averaging set

(3) Manufacturers can sum conventional and innovative technology credits before adding any advanced technology credits in each averaging set.

(4) If a manufacturer chooses to generate CO_2 emission credits under

EPA provisions of 40 CFR 1037.150(a), it may also voluntarily generate early credits under the NHTSA fuel consumption program as follows:

(i) Fuel consumption credits may be generated for vehicles certified in model year 2013 to the model year 2014 standards in § 535.5(b) and (c). To do so, a manufacturer must certify its entire U.S.-directed production volume of vehicles. The same production volume restrictions specified in 40 CFR 1037.150(a)(1) relating to when test groups are certified apply to the NHTSA early credit provisions. Credits are calculated as specified in paragraph (c)(11) of this section relative to the standards that would apply for model year 2014. Surplus credits generated under this paragraph (c)(4) may be increased by a factor of 1.5 for determining total available credits for banking or trading. For example, if a manufacturer has 10 gallons of surplus credits for model year 2013, it may bank 15 gallons of credits. Credit deficits for an averaging set prior to model year 2014 do not carry over to model year 2014. These credits may be used to show compliance with the standards of this part for 2014 and later model years. Once a manufacturer opts into the NHTSA program they must stay in the program for all of the optional model years and remain standardized with the same implementation approach being followed to meet the EPA CO_2 emission program.

(ii) A tractor manufacturer may generate fuel consumption credits for the number of additional SmartWay designated tractors (relative to its MY 2012 production), provided that credits are not generated for those vehicles under paragraph (c)(4)(i) of this section. Calculate credits for each regulatory sub-category relative to the standard that would apply in model year 2014 using the equations in paragraph (c)(2) of this section. Use a production volume equal to the number of verified model year 2013 SmartWay tractors minus the number of verified model year 2012 SmartWay tractors. A manufacturer may bank credits equal to the surplus credits generated under this paragraph multiplied by 1.50. A manufacturer's 2012 and 2013 model years must be equivalent in length. Once a manufacturer opts into the NHTSA program they must stay in the program for all of the optional model years and remain standardized with the same implementation approach being followed to meet the EPA CO_2 emission program.

(5) If a manufacturer generates credits from vehicles certified for advanced technology in accordance with paragraph (e)(1) of this section, a multiplier of 1.5 can be used, but this multiplier cannot be used on the same credits for which the early credit multiplier is used.

(6) For model years 2012 and later, manufacturers may generate or use fuel consumption credits for averaging to demonstrate compliance with the alternative standards as described in § 535.5(b)(6) of this part. Manufacturers can specify a Family Emission Limit (FEL) for fuel consumption for each vehicle subfamily. The FEL may not be less than the result of emissions and fuel consumption modeling as described in 40 CFR 1037.520 and § 535.6. These FELs serve as the fuel consumption standards for the vehicle subfamily instead of the standards specified in this § 535.5(b)(6). Manufacturers may not use averaging for motor homes, coach buses, emergency vehicles or concrete mixers meeting standards under § 535.5(b)(5).

(7) Manufacturers may not use averaging for vehicles meeting standards § 535.5(b)(6)(iv) through (vi), and manufacturers may not use fuel consumption credits for banking or trading for any vehicles certified under § 535.5(b)(6).

(8) Manufacturers certifying any vehicles under § 535.5(b)(6) must consider each separate vehicle type (or group of vehicle types) as a separate averaging set.

(d) *ABT provisions for heavy-duty engines.* (1) Calculate the fuel consumption credits in a model year for each participating family or subfamily consisting of engines in each averaging set (as defined in § 535.4) using the equation in this section. Each designated engine family has a ''family certification level'' (FCL) which is compared to the associated regulatory subcategory standard. A FCL that falls below the regulatory subcategory standard creates ''positive credits,'' while fuel consumption level of a family group above the standard creates a ''credit shortfall.'' The value of credits generated in a model year for each engine family or subfamily is calculated as follows and must be rounded to nearest whole number:

$$\text{Engine Family FCC (gallons)} = (\text{Std} - \text{FCL}) \times (\text{CF}) \times (\text{Volume}) \times (\text{UL}) \times (10^2)$$

Where:

Std = the standard for the respective engine regulatory subcategory (gal/100 hp-hr).

FCL = family certification level for the engine family (gal/100 hp-hr).

CF = a transient cycle conversion factor in hp-hr/mile which is the integrated total cycle horsepower-hour divided by the equivalent mileage of the applicable test cycle. For engines subject to spark-ignition heavy-duty standards, the equivalent mileage is 6.3 miles. For engines subject to compression-ignition heavy-duty standards, the equivalent mileage is 6.5 miles.

Volume = the number of engines in the corresponding engine family.

UL = the useful life of the given engine family (miles) as shown in the following table:

Regulatory subcategory	UL (miles)
SI and CI LHD Engines	120,000 (Phase 1). 150,000 (Phase 2).
CI MHD Engines	185,000.
CI HHD Engines	435,000.

(i) Calculate the value of credits generated in a model year for each family or subfamily consisting of engines with advanced technology vehicles in each averaging set using the equation above and the guidelines provided in paragraph (f)(1) of this section. Manufacturers may generate credits for advanced technology vehicles using incentives specified in paragraph (f)(1) of this section.

(ii) Calculate the value of credits generated in a model year for each family or subfamily consisting of engines with off-cycle technology vehicles in each averaging set using the equation above and the guidelines provided in paragraph (f)(2) of this section.

(2) Manufacturers shall sum all negative and positive credits for each engine family within the applicable averaging set to obtain the total credit balance for the model year before rounding. The sum of fuel consumptions credits should be rounded to the nearest gallon.

Calculate the total credits generated in a model year for each averaging set using the following equation:

$$\text{Total averaging set MY credits} = \Sigma\ \text{Engine family credits within each averaging set}$$

(3) The provisions of this section apply to manufacturers utilizing the compression-ignition engine voluntary alternate standard provisions specified in § 535.5(d)(4) as follows:

(i) Manufacturers may not certify engines to the alternate standards if they are part of an averaging set in which they carry a balance of banked credits. For purposes of this section, manufacturers are deemed to carry credits in an averaging set if they carry credits from advance technology that are allowed to be used in that averaging set.

(ii) Manufacturers may not bank fuel consumption credits for any engine family in the same averaging set and model year in which it certifies engines to the alternate standards. This means a manufacturer may not bank advanced technology credits in a model year it certifies any engines to the alternate standards.

(iii) Note that the provisions of paragraph (d)(10) of this section apply with respect to credit deficits generated while utilizing alternate standards.

(4) Where a manufacturer has chosen to comply with the EPA alternative compression-ignition engine phase-in standard provisions in 40 CFR 1036.150(e), and has optionally decided to follow the same path under the NHTSA fuel consumption program, it must certify all of its model year 2013 compression-ignition engines within a given averaging set to the applicable alternative standards in § 535.5(d)(5). Engines certified to these standards are not eligible for early credits under paragraph (d)(14) of this section. Credits are calculated using the same equation provided in paragraph (d)(11) of this section.

(5) If a manufacturer chooses to generate early CO_2 emission credits under EPA provisions of 40 CFR 1036.150, it may also voluntarily generate early credits under the NHTSA fuel consumption program. Fuel consumption credits may be generated for engines certified in model year 2013 (2015 for spark-ignition engines) to the standards in § 535.5(d). To do so, a manufacturer must certify its entire U.S.-directed production volume of engines except as specified in 40 CFR 1036.150(a)(2). Credits are calculated as specified in paragraph (d)(11) of this section relative to the standards that would apply for model year 2014 (2016 for spark-ignition engines). Surplus credits generated under this paragraph (d)(3) may be increased by a factor of 1.5 for determining total available credits for banking or trading. For example, if a manufacturer has 10 gallons of surplus credits for model year 2013, it may bank 15 gallons of credits. Credit deficits for an averaging set prior to model year 2014 (2016 for spark-ignition engines) do not carry over to model year 2014 (2016 for spark-ignition engines). These credits may be used to show compliance with the standards of this part for 2014 and later model years. Once a manufacturer opts into the NHTSA program they must stay in the program for all of the optional model years and remain standardized with the same implementation approach being followed to meet the EPA CO_2 emission program.

(6) Manufacturers may generate fuel consumption credits from an engine family subject to spark-ignition standards for exchanging with other engine families only if the engines in the family are gasoline-fueled.

(7) Engine credits generated for compression-ignition engines in the 2020 and earlier model years may be used in model year 2021 and later only if the credit-generating engines were certified to the tractor standards in § 535.5(d) and 40 CFR 1036.108. Manufacturers may otherwise use fuel consumption credits generated in one model year without adjustment for certifying vehicles in a later model year, even if fuel consumption standards are different.

(8) Engine families manufacturers certify with a nonconformance penalty under 40 CFR part 86, subpart L, and may not generate fuel consumption credits.

(9) *Alternate transition option for Phase 2 engine standards.* The following provisions allow for enhanced generation and use of fuel consumption credits for manufacturers complying with engines standards in accordance with § 535.7(d)(11):

(i) If a manufacturer is eligible to certify all of its model year 2020 engines within the averaging set to the tractor and vocational vehicle engine standards in § 535.5(d)(11) and the requirements applicable to model year 2021 engines, the banked and traded fuel consumption credits generated for model year 2018 through 2024 engines may be used through model year 2030 as specified in paragraph (d)(9)(ii) of this section or through a five-year credit life, whichever is later.

(ii) Banked and traded fuel consumption credits generated under this paragraph (d)(9) for model year 2018 through 2024 engines may be used through model year 2030 with the extended credit life values shown in the table:

Model year	Credit life for transition option for phase 2 engine standards (years)
2018	12
2019	11
2020	10
2021	9
2022	8
2023	7
2024	6
2025 and later	5

(e) *ABT provisions for trailers.* (1) Manufacturers cannot use averaging for non-box trailers, partial-aero trailers, or non-aero trailers or cannot use fuel consumption credits for banking or trading. Starting in model year 2027, full aero box van manufactures may average, credits.

(2) Calculate the fuel consumption credits in a model year for each participating family or subfamily consisting of full aero box trailers (vehicles) in each averaging set (as defined in § 535.4) using the equation in this section. Each designated vehicle family or subfamily has a ''family emissions limit'' (FEL) which is compared to the associated regulatory subcategory standard. An FEL that falls below the regulatory subcategory standard creates ''positive credits,'' while fuel consumption level of a family group above the standard creates a ''negative credits.'' The value of credits generated for each family or subfamily in a model year is calculated as follows and must be rounded to nearest whole number:

$$\text{Vehicle Family FCC (gallons)} = (\text{Std} - \text{FEL}) \times (\text{Payload}) \times (\text{Volume}) \times (\text{UL}) \times (10^3)$$

Where:

Std = the standard for the respective vehicle family regulatory subcategory (gal/1000 ton-mile).
FEL = family emissions limit for the vehicle family (gal/1000 ton-mile).
Payload = 10 tons for short box vans and 19 tons for other trailers.
Volume = the number of U.S.-directed production volume of vehicles in the corresponding vehicle family.
UL = the useful life for the regulatory subcategory. The useful life value for heavy-duty trailers is equal to the 250,000 miles.

(3) Trailer manufacturers may not generate advanced technology credits.

(4) Manufacturers shall sum all negative and positive credits for each vehicle family within the applicable averaging set to obtain the total credit balance for the model year before rounding. Calculate the total credits generated in a model year for each averaging set using the following equation:

$$\text{Total averaging set MY credits} = \Sigma \text{ Vehicle family credits within each averaging set}$$

(5) Trailer manufacturers may not bank credits within an averaging set but surplus fuel consumption credits from a given model year may be used to offset deficits from earlier model years.

(f) *Additional credit provisions*—(1) *Advanced technology credits.* (i) For the Phase 1 program, manufacturers of heavy-duty pickup trucks and vans, vocational vehicles, tractors and the associated engines showing improvements in CO_2 emissions and fuel consumption using hybrid vehicles with regenerative braking, vehicles equipped with Rankine-cycle engines, electric vehicles and fuel cell vehicles are eligible for advanced technology credits. Manufacturers shall use sound engineering judgment to determine the performance of the vehicle or engine with advanced technology. Advanced technology credits for vehicles or engines complying with Phase 1 standards may be increased by a 1.5 multiplier. Manufacturers may not apply this multiplier in addition to any early-credit multipliers. The maximum amount of credits a manufacturer may bring into the service class group that contains the heavy-duty pickup and van averaging set is $5.89 \cdot 10^6$ gallons (for advanced technology credits based upon compression-ignition engines) or $6.76 \cdot 10^6$ gallons (for advanced technology credits based upon spark-ignition engines) per model year as specified in 40 CFR part 86 for heavy-duty pickup trucks and vans, 40 CFR 1036.740 for engines and 40 CFR 1037.740 for tractors and vocational vehicles. The specified limit does not cap the amount of advanced technology credits that can be used across averaging sets within the same service class group. Advanced technology credits can be used to offset negative credits in the same averaging set or other averaging sets. A manufacturer must first apply advanced technology credits to any deficits in the same averaging set before applying them to other averaging.

(A) *Heavy-duty pickup trucks and vans.* For advanced technology systems (hybrid vehicles with regenerative braking, vehicles equipped with Rankine-cycle engines and fuel cell vehicles), calculate fleet-average performance rates consistent with good engineering judgment and the provisions of 40 CFR 86.1819–14 and 86.1865.

(B) *Tractors and vocational vehicles.* For advanced technology system (hybrid vehicles with regenerative braking, vehicles equipped with Rankine-cycle engines and fuel cell vehicles), calculate the advanced technology credits as follows:

(*1*) Measure the effectiveness of the advanced system by conducting A to B testing a vehicle equipped with the advanced system and an equivalent conventional system in accordance with 40 CFR 1037.615.

(*2*) For purposes of this paragraph (f), a conventional vehicle is considered to be equivalent if it has the same footprint, intended vehicle service class, aerodynamic drag, and other relevant factors not directly related to the advanced system powertrain. If there is no equivalent vehicle, the manufacturer may create and test a prototype equivalent vehicle. The conventional vehicle is considered Vehicle A, and the advanced technology vehicle is considered Vehicle B.

(*3*) The benefit associated with the advanced system for fuel consumption is determined from the weighted fuel consumption results from the chassis tests of each vehicle using the following equation:

Benefit (gallon/1000 ton mile) = Improvement Factor × GEM Fuel Consumption Result_B

Where:

Improvement Factor = (Fuel Consumption_A − Fuel Consumption_B)/(Fuel Consumption_A).

Fuel Consumption Rates A and B are the gallons per 1000 ton-mile of the conventional and advanced vehicles, respectively as measured under the test procedures specified by EPA. GEM Fuel Consumption Result B is the estimated gallons per 1000 ton-mile rate resulting from emission modeling of the advanced vehicle as specified in 40 CFR 1037.520 and § 535.6(b).

(*4*) Calculate the benefit in credits using the equation in paragraph (c) of this section and replacing the term (Std-FEL) with the benefit.

(*5*) For electric vehicles calculate the fuel consumption credits using an FEL of 0 g/1000 ton-mile.

(C) *Heavy-duty engines.* This section specifies how to generate advanced technology-specific fuel consumption credits for hybrid powertrains that include energy storage systems and regenerative braking (including regenerative engine braking) and for engines that include Rankine-cycle (or other bottoming cycle) exhaust energy recovery systems.

(*1*) Pre-transmission hybrid powertrains are those engine systems that include features that recover and store energy during engine motoring operation but not from the vehicle wheels. These powertrains are tested using the hybrid engine test procedures of 40 CFR part 1065 or using the post-transmission test procedures.

(*2*) Post-transmission hybrid powertrains are those powertrains that include features that recover and store energy from braking at the vehicle wheels. These powertrains are tested by simulating the chassis test procedure applicable for hybrid vehicles under 40 CFR 1037.550.

(*3*) Test engines that include Rankine-cycle exhaust energy recovery systems according to the test procedures specified in 40 CFR part 1036, subpart F, unless EPA approves the manufacturer's alternate procedures.

(D) *Credit calculation.* Calculate credits as specified in paragraph (c) of this section. Credits generated from engines and powertrains certified under this section may be used in other averaging sets as described in 40 CFR 1036.740(d).

(ii) There are no separate credit allowances for advanced technology vehicles in the Phase 2 program. Instead, vehicle families containing plug-in battery electric hybrids, all-electric, and fuel cell vehicles certifying to Phase 2 vocational and tractor standards may multiply credits by a multiplier of:

(A) 3.5 times for plug-in hybrid electric vehicles;

(B) 4.5 times for all-electric vehicles; and

(C) 5.5 times for fuel cell vehicles.

(D) Incentivized credits for vehicles equipped with advanced technologies maintain the same credit flexibilities and restrictions as conventional credits specified in paragraph (a) of this section during the Phase 2 program.

(E) For vocational vehicles and tractors subject to Phase 2 standards, create separate vehicle families if there is a credit multiplier for advanced technology; group those vehicles together in a vehicle family if they use the same multiplier.

(F) For Phase 2 plug-in hybrid electric vehicles and for fuel cells powered by any fuel other than hydrogen, calculate fuel consumption credits using an FEL based on equivalent emission measurements from powertrain testing. Phase 2 advanced-technology credits do not apply for hybrid vehicles that have no plug-in capability.

(2) *Innovative and off-cycle technology credits.* This provision allows fuel saving innovative and off-cycle engine and vehicle technologies to generate fuel consumption credits comparable to CO_2 emission credits consistent with the provisions of 40 CFR 86.1819–14(d)(13) (for heavy-duty pickup trucks and vans), 40 CFR 1036.610 (for engines), and 40 CFR 1037.610 (for vocational vehicles and tractors).

(i) For model years 2013 through 2020, manufacturers may generate innovative technology credits for introducing technologies that were not in-common use for heavy-duty tractor, vocational vehicles or engines before model year 2010 and that are not reflected in the EPA specified test procedures. Upon identification and joint approval with EPA, NHTSA will allow equivalent fuel consumption credits into its program to those allowed by EPA for manufacturers seeking to obtain innovative technology credits in a given model year. Such credits must remain within the same regulatory subcategory in which the credits were generated. NHTSA will adopt fuel consumption credits depending upon whether—

(A) The technology has a direct impact upon reducing fuel consumption performance; and

(B) The manufacturer has provided sufficient information to make sound engineering judgments on the impact of the technology in reducing fuel consumption performance.

(ii) For model years 2021 and later, manufacturers may generate off-cycle technology credits for introducing technologies that are not reflected in the EPA specified test procedures. Upon identification and joint approval with EPA, NHTSA will allow equivalent fuel consumption credits into its program to those allowed by EPA for manufacturers seeking to obtain innovative technology credits in a given model year. Such credits must remain within the same regulatory subcategory in which the credits were generated. NHTSA will adopt fuel consumption credits depending upon whether—

(A) The technology meets paragraph (f)(2)(i)(A) and (B) of this section.

(B) For heavy-duty pickup trucks and vans, manufacturers using the 5-cycle test to quantify the benefit of a technology are not required to obtain approval from the agencies to generate results.

(iii) The following provisions apply to all innovative and off-cycle technologies:

(A) Technologies found to be defective, or identified as a part of NHTSA's safety defects program, and technologies that are not performing as intended will have the values of approved off-cycle credits removed from the manufacturer's credit balance.

(B) Approval granted for innovative and off-cycle technology credits under NHTSA's fuel efficiency program does not affect or relieve the obligation to comply with the Vehicle Safety Act (49 U.S.C. Chapter 301), including the ''make inoperative'' prohibition (49 U.S.C. 30122), and all applicable Federal motor vehicle safety standards issued thereunder (FMVSSs) (49 CFR part 571). In order to generate off-cycle or innovative technology credits manufacturers must state—

(*1*) That each vehicle equipped with the technology for which they are seeking credits will comply with all applicable FMVSS(s); and

(*2*) Whether or not the technology has a fail-safe provision. If no fail-safe provision exists, the manufacturer must explain why not and whether a failure of the innovative technology would affect the safety of the vehicle.

(C) Manufacturers requesting approval for innovative technology credits are required to provide documentation in accordance with 40 CFR 86.1869–12, 1036.610, and 1037.610.

(D) Credits will be accepted on a one-for-one basis expressed in terms of gallons in comparison to those approved by EPA.

(E) For the heavy-duty pickup trucks and vans, the average fuel consumption will be calculated as a separate credit amount (rounded to the nearest whole number) using the following equation:

$$\text{Off-cycle FC credits} = (CO_2\ \text{Credit}/CF) \times 100 \times \text{Production} \times VLM$$

Where:

CO_2 Credits = the credit value in grams per mile determined in 40 CFR 86.1869–12(c)(3), (d)(1), (d)(2) or (d)(3).
CF = conversion factor, which for spark-ignition engines is 8,887 and for compression-ignition engines is 10,180.
Production = the total production volume for the applicable category of vehicles.
VLM = vehicle lifetime miles, which for 2b–3 vehicles shall be 150,000 for the Phase 2 program.
The term (CO_2 Credit/CF) should be rounded to the nearest 0.0001.

(F) NHTSA will not approve innovative technology credits for technology that is related to crash-avoidance technologies, safety critical systems or systems affecting safety-critical functions, or technologies designed for the purpose of reducing the frequency of vehicle crashes.

(iv) Manufacturers normally may not calculate off-cycle credits or improvement factors under this section for technologies represented by GEM, but the agencies may allow a manufacturer to do so by averaging multiple GEM runs for special technologies for which a single GEM run cannot accurately reflect in-use performance. For example, if a manufacturer use an idle-reduction technology that is effective 80 percent of the time, the agencies may allow a manufacturer to run GEM with the technology active and with it inactive, and then apply an 80% weighting factor to calculate the off-cycle credit or improvement factor. A may need to perform testing to establish proper weighting factors or otherwise quantify the benefits of the special technologies.

(v) A manufacturer may apply the off-cycle provisions of this paragraph (2) and 40 CFR 1037.610 to trailers as early as model year 2018 as follows:

(A) A manufacturer may account for weight reduction based on measured values instead of using the weight reductions specified in 40 CFR 1037.515. Quantify the weight reduction by measuring the weight of a trailer in a certified configuration and comparing it to the weight of an equivalent trailer without weight-reduction technologies. This qualifies as A to B testing this part. Use good engineering judgment to select an equivalent trailer representing a baseline configuration. Use the calculated weight reduction in the equation specified in 40 CFR 1037.515 to calculate the trailer's CO_2 emission rate and calculate an equivalent fuel consumption rate.

(B) If a manufacturer's off-cycle technology reduces emissions and fuel consumption in a way that is proportional to measured rates as described in 40 CFR 1037.610(b)(1), multiply the trailer's CO_2 fuel consumption rate by the appropriate improvement factor.

(C) If a manufacturer's off-cycle technology does not yield emission and fuel consumption reductions that are proportional to measured rates, as described in 40 CFR 1037.610(b)(2), calculate an adjusted CO_2 fuel consumption rate for trailers by subtracting the appropriate off-cycle credit.

(vi) *Carry-over Approval.* Manufacturers may carry-over these credits into future model years as described below:

(A) For model years before 2021, manufacturers may continue to use an approved improvement factor or credit for any appropriate engine or vehicle family in future model years through 2020.

(B) For model years 2021 and later, manufacturers may not rely on an approval for model years before 2021. Manufacturers must separately request the agencies approval before applying an improvement factor or credit under this section for 2021 and later engines and vehicle, even if the agencies approve the improvement factor or credit for similar engine and vehicle models before model year 2021.

(C) The following restrictions also apply to manufacturers seeking to continue to carryover the improvement factor (not the credit value) if—

(*1*) The FEL is generated by GEM or 5-cycle testing;

(*2*) The technology is not changed or paired with any other off-cycle technology;

(*3*) The improvement factor only applies to approved vehicle or engine families;

(*4*) The agencies do not expect the technology to be incorporated into GEM at any point during the Phase 2 program; and

(D) The documentation to carryover credits that would primarily justify the difference in fuel efficiency between real world and compliance protocols is the same for both Phase 1 and Phase 2 compliance protocols. The agencies must approve the justification. If the agencies do not approve the justification, the manufacturer must recertify.

§ 535.8 Reporting and recordkeeping requirements.

(a) *General requirements.* Manufacturers producing heavy-duty vehicles and engines applicable to fuel consumption standards in § 535.5, for each given model year, must submit the required information as specified in paragraphs (b) through (h) of this section.

(1) The information required by this part must be submitted by the deadlines specified in this section and must be based upon all the information and data available to the manufacturer 30 days before submitting information.

(2) Manufacturers must submit information electronically through the EPA database system as the single point of entry for all information required for this national program and both agencies will have access to the information. In special circumstances, data may not be able to be received electronically (*i.e.,* during database system development work). The agencies will inform manufacturer of the alternatives can be used for submitting information. The format for the required information will be specified by EPA in coordination with NHTSA.

(3) Manufacturers providing incomplete reports missing any of the required information or providing untimely reports are considered as not complying with standards (*i.e.,* if good-faith estimates of U.S.-directed production volumes for EPA certificates of conformity are not provided) and are liable to pay civil penalties in accordance with 49 U.S.C. 32912.

(4) Manufacturers certifying a vehicle or engine family using an FEL or FCL below the applicable fuel consumption standard as described in § 535.5 may choose not to generate fuel consumption credits for that family. In which case, the manufacturer is not required to submit reporting or keep the associated records described in this part for that family.

(5) Manufacturers must use good engineering judgment and provide comparable fuel consumption information to that of the information or data provided to EPA under 40 CFR 86.1865, 1036.250, 1036.730, 1036.825 1037.250, 1037.730, and 1037.825.

(6) Any information that must be sent directly to NHTSA. In instances in which EPA has not created an electronic pathway to receive the information, the information should be sent through an electronic portal identified by NHTSA or through the NHTSA CAFE database (*i.e.,* information on fuel consumption credit transactions). If hardcopy documents must be sent, the information should be sent to the Associate Administrator of Enforcement at 1200 New Jersey Avenue, NVS–200, Office W45–306, SW., Washington, DC 20590.

(b) *Pre-model year reports.* Manufacturers producing heavy-duty pickup trucks and vans must submit reports in advance of the model year providing early estimates demonstrating how their fleet(s) would comply with GHG emissions and fuel consumption standards. Note, the agencies understand that early model year reports contain estimates that may change over the course of a model year and that compliance information manufacturers submit prior to the beginning of a new model year may not represent the final compliance outcome. The agencies view the necessity for requiring early model reports as a manufacturer's good faith projection for demonstrating compliance with emission and fuel consumption standards.

(1) *Report deadlines.* For model years 2013 and later, manufacturer of heavy-duty pickup trucks and vans complying with voluntary and mandatory standards must submit a pre-model year report for the given model year as early as the date of the manufacturer's annual certification preview meeting with EPA and NHTSA, or prior to submitting its first application for a certificate of conformity to EPA in accordance with 40 CFR 86.1819–14(d). For example, a manufacturer choosing to comply in model year 2014 could submit its pre-model year report during its precertification meeting which could occur before January 2, 2013, or could provide its pre-model year report any time prior to submitting its first application for certification for the given model year.

(2) *Contents.* Each pre-model year report must be submitted including the following information for each model year.

(i) A list of each unique subconfiguration in the manufacturer's fleet describing the make and model designations, attribute based-values (*i.e.,* GVWR, GCWR, Curb Weight and drive configurations) and standards;

(ii) The emission and fuel consumption fleet average standard derived from the unique vehicle configurations;

(iii) The estimated vehicle configuration, test group and fleet production volumes;

(iv) The expected emissions and fuel consumption test group results and fleet average performance;

(v) If complying with MY 2013 fuel consumption standards, a statement must be provided declaring that the manufacturer is voluntarily choosing to comply early with the EPA and NHTSA programs. The manufacturers must also acknowledge that once selected, the decision cannot be reversed and the manufacturer will continue to comply with the fuel consumption standards for subsequent model years for all the vehicles it manufacturers in each regulatory category for a given model year;

(vi) If complying with MYs 2014, 2015 or 2016 fuel consumption standards, a statement must be provided declaring whether the manufacturer will use fixed or increasing standards in accordance with § 535.5(a). The manufacturer must also acknowledge that once selected, the decision cannot be reversed and the manufacturer must continue to comply with the same alternative for subsequent model years for all the vehicles it manufacturers in each regulatory category for a given model year;

(vii) If complying with MYs 2014 or 2015 fuel consumption standards, a statement must be provided declaring that the manufacturer is voluntarily choosing to comply with NHTSA's voluntary fuel consumption standards in accordance with § 535.5(a)(4). The manufacturers must also acknowledge that once selected, the decision cannot be reversed and the manufacturer will continue to comply with the fuel consumption standards for subsequent model years for all the vehicles it manufacturers in each regulatory category for a given model year;

(viii) The list of Class 2b and 3 incomplete vehicles (cab-complete or chassis complete vehicles) and the method used to certify these vehicles as complete pickups and vans identifying the most similar complete sister- or other complete vehicles used to derive the target standards and performance test results;

(ix) The list of Class 4 and 5 incomplete and complete vehicles and the method use to certify these vehicles as complete pickups and vans identifying the most similar complete or sister vehicles used to derive the target standards and performance test results;

(x) List of loose engines included in the heavy-duty pickup and van category and the list of vehicles used to derive target standards and performance test results;

(xi) Copy of any notices a vehicle manufacturer sends to the engine manufacturer to notify the engine manufacturers that their engines are subject to emissions and fuel consumption standards and that it intends to use their engines in excluded vehicles;

(xii) A fuel consumption credit plan as specified § 535.7(a) identifying the manufacturers estimated credit balances, planned credit flexibilities (*i.e.,* credit balances, planned credit trading, innovative, advanced and early credits and etc.) and if needed a credit deficit plan demonstrating how it plans to resolve any credit deficits that might occur for a model year within a period of up to three model years after that deficit has occurred; and

(xiii) The supplemental information specified in paragraph (h) of this section.

Note to paragraph (b): NHTSA may also ask a manufacturer to provide additional information if necessary to verify compliance with the fuel consumption requirements of this section.

(c) *Applications for certificate of conformity.* Manufacturers producing vocational vehicles, tractors and heavy-duty engines are required to submit applications for certificates of conformity to EPA in accordance with 40 CFR 1036.205 and 1037.205 in advance of introducing vehicles for commercial sale. Applications contain early model year information demonstrating how manufacturers plan to comply with GHG emissions. For model years 2013 and later, manufacturers of vocational vehicles, tractors and engine complying with NHTSA's voluntary and mandatory standards must submit applications for certificates of conformity in accordance through the EPA database including both GHG emissions and fuel consumption information for each given model year.

(1) *Submission deadlines.* Applications are primarily submitted in advance of the given model year to EPA but cannot be submitted any later than December 31 of the given model year.

(2) *Contents.* Each application for certificates of conformity submitted to EPA must include the following equivalent fuel consumption.

(i) Equivalent fuel consumption values for emissions CO_2 FCLs values used to certify each engine family in accordance with 40 CFR 1036.205(e). This provision applies only to manufacturers producing heavy-duty engines.

(ii) Equivalent fuel consumption values for emission CO_2 data engines used to comply with emission standards in 40 CFR 1036.108. This provision applies only to manufacturers producing heavy-duty engines.

(iii) Equivalent fuel consumption values for emissions CO_2 FELs values used to certify each vehicle families or subfamilies in accordance with 40 CFR 1037.205(k). This provision applies only to manufacturers producing vocational vehicles and tractors.

(iv) Report modeling results for ten configurations in terms of CO_2 emissions and equivalent fuel consumption results in accordance with 40 CFR 1037.205(o). Include modeling inputs and detailed descriptions of how they were derived. This provision applies only to manufacturers producing vocational vehicles and tractors.

(v) Credit plans including the fuel consumption credit plan described in § 535.7(a).

(3) *Additional supplemental information.* Manufacturers are required to submit additional information as specified in paragraph (h) of this section for the NHTSA program before or at the same time it submits its first application for a certificate of conformity to EPA. Under limited conditions, NHTSA may also ask a manufacturer to provide additional information directly to the Administrator if necessary to verify the fuel consumption requirements of this regulation.

(d) *End of the Year (EOY) and Final reports.* Heavy-duty vehicle and engine manufacturers participating in the ABT program are required to submit EOY and final reports containing information for NHTSA as specified in paragraph (d)(2) of this section and in accordance with 40 CFR 86.1865, 1036.730, and 1037.730. Only manufacturers without credit deficits may decide not to participate in the ABT or may waive the requirement to send an EOY report. The EOY and final reports are used to review a manufacturer's preliminary or final compliance information and to identify manufacturers that might have a credit deficit for the given model year. For model years 2013 and later, heavy-duty vehicle and engine manufacturers complying with NHTSA's voluntary and mandatory standards must submit EOY and final reports through the EPA database including both GHG emissions and fuel consumption information for each given model year.

(1) *Report deadlines.* (i) For model year 2013 and later, heavy-duty vehicle and engine manufacturers complying with NHTSA voluntary and mandatory standards must submit EOY reports through the EPA database including both GHG emissions and fuel consumption information within 90 days after the end of the given model year and no later than March 31 of the next calendar year.

(ii) For model year 2013 and later, heavy-duty vehicle and engine manufacturers complying with NHTSA voluntary and mandatory standards must submit final reports through the EPA database including both GHG emissions and fuel consumption information within 270 days after the end of the given model year and no later than September 30 of the next calendar year.

(iii) A manufacturer may ask NHTSA and EPA to extend the deadline of a final report by up to 30 days. A manufacturer unable to provide, and requesting to omit an emissions rate or fuel consumption value from a final report must obtain approval from the agencies prior to the submission deadline of its final report.

(iv) If a manufacturer expects differences in the information reported between the EOY and the final year report specified in 40 CFR 1036.730 and 1037.730, it must provide the most up-to-date fuel consumption projections in its final report and identify the information as preliminary.

(v) If the manufacturer cannot provide any of the required fuel consumption information, it must state the specific reason for the insufficiency and identify the additional testing needed or explain what analytical methods are believed by the manufacturer will be necessary to eliminate the insufficiency and certify that the results will be available for the final report.

(2) *Contents.* Each EOY and final report must be submitted including the following fuel consumption information for each model year. EOY reports contain preliminary final estimates and final reports must include the manufacturer's final compliance information.

(i) Engine and vehicle family designations and averaging sets.

(ii) Engine and vehicle regulatory subcategory and fuel consumption standards including any alternative standards used.

(iii) Engine and vehicle family FCLs and FELs in terms of fuel consumption.

(iv) Production volumes for engines and vehicles.

(v) A summary as specified in paragraph (g)(7) of this section describing the vocational vehicles and vocational tractors that were exempted as heavy-duty off-road vehicles. This applies to manufacturers participating and not participating in the ABT program.

(vi) A summary describing any advanced or innovative technology engines or vehicles including alternative fueled vehicles that were produced for the model year identifying the approaches used to determinate compliance and the production volumes.

(vii) A list of each unique subconfiguration included in a manufacturer's fleet of heavy-duty pickup trucks and vans identifying the attribute based-values (GVWR, GCWR, Curb Weight, and drive configurations) and standards. This provision applies only to manufacturers producing heavy-duty pickup trucks and vans.

(viii) The fuel consumption fleet average standard derived from the unique vehicle configurations. This provision applies only to manufacturers producing heavy-duty pickup trucks and vans.

(ix) The subconfiguration and test group production volumes. This provision applies only to manufacturers producing heavy-duty pickup trucks and vans.

(x) The fuel consumption test group results and fleet average performance. This provision applies only to manufacturers producing heavy-duty pickup trucks and vans.

(xi) Manufacturers may correct errors in EOY and final reports as follows:

(A) Manufacturers may correct any errors in their end-of-year report when preparing the final report, as long as manufacturers send us the final report by the time it is due.

(B) If manufacturers or the agencies determine within 270 days after the end of the model year that errors mistakenly decreased he manufacturer's balance of fuel consumption credits, manufacturers may correct the errors and recalculate the balance of its fuel consumption credits. Manufacturers may not make any corrections for errors that are determined more than 270 days after the end of the model year. If manufacturers report a negative balance of fuel consumption credits, NHTSA may disallow corrections under this paragraph (d)(2)(xi)(B).

(C) If manufacturers or the agencies determine any time that errors mistakenly increased its balance of fuel consumption credits, manufacturers must correct the errors and recalculate the balance of fuel consumption credits.

(xii) Under limited conditions, NHTSA may also ask a manufacturer to provide additional information directly to the Administrator if necessary to verify the fuel consumption requirements of this regulation.

(e) *Amendments to applications for certification.* At any time, a manufacturer modifies an application for certification in accordance with 40 CFR 1036.225 and 1037.225, it must submit GHG emissions changes with equivalent fuel consumption values for the information required in paragraphs (b) through (e) and (h) of this section.

(f) *Confidential information.* Manufacturers must submit a request for confidentiality with each electronic submission specifying any part of the for information or data in a report that it believes should be withheld from *public* disclosure as trade secret or other confidential business information. Information submitted to EPA should follow EPA guidelines for treatment of confidentiality. Requests for confidential treatment for information submitted to NHTSA must be filed in accordance with the requirements of 49 CFR part 512, including submission of a request for confidential treatment and the information for which confidential treatment is requested as specified by part 512. For any information or data requested by the manufacturer to be withheld under 5 U.S.C. 552(b)(4) and 49 U.S.C. 32910(c), the manufacturer shall present arguments and provide evidence in its request for confidentiality demonstrating that—

(1) The item is within the scope of 5 U.S.C. 552(b)(4) and 49 U.S.C. 32910(c);

(2) The disclosure of the information at issue would cause significant competitive damage;

(3) The period during which the item must be withheld to avoid that damage; and

(4) How earlier disclosure would result in that damage.

(g) *Additional required information.* The following additional information is required to be submitted through the EPA database. NHTSA reserves the right to ask a manufacturer to provide additional information if necessary to verify the fuel consumption requirements of this regulation.

(1) *Small businesses.* For model years 2013 through 2020, vehicles and engines produced by small business manufacturers meeting the criteria in 13 CFR 121.201 are exempted from the requirements of this part. Qualifying small business manufacturers must notify EPA and NHTSA Administrators before importing or introducing into U.S. commerce exempted vehicles or engines. This notification must include a description of the manufacturer's qualification as a small business under 13 CFR 121.201. Manufacturers must submit this notification to EPA, and EPA will provide the notification to NHTSA. The agencies may review a manufacturer's qualification as a small business manufacturer under 13 CFR 121.201.

(2) *Emergency vehicles.* For model years 2021 and later, emergency vehicles produced by heavy-duty pickup truck and van manufacturers are exempted except those produced by manufacturers voluntarily complying with standards in § 535.5(a). Manufacturers must notify the agencies in writing if using the provisions in § 535.5(a) to produce exempted emergency vehicles in a given model year, either in the report specified in 40 CFR 86.1865 or in a separate submission.

(3) *Early introduction.* The provision applies to manufacturers seeking to comply early with the NHTSA's fuel consumption program prior to model year 2014. The manufacturer must send the request to EPA before submitting its first application for a certificate of conformity.

(4) *NHTSA voluntary compliance model years.* Manufacturers must submit a statement declaring whether the manufacturer chooses to comply voluntarily with NHTSA's fuel consumption standards for model years 2014 through 2015. The manufacturers must acknowledge that once selected, the decision cannot be reversed and the manufacturer will continue to comply with the fuel consumption standards for subsequent model years. The manufacturer must send the statement to EPA before submitting its first application for a certificate of conformity.

(5) *Alternative engine standards.* Manufacturers choosing to comply with the alternative engine standards must notify EPA and NHTSA of their choice and include in that notification a demonstration that it has exhausted all available credits and credit opportunities. The manufacturer must send the statement to EPA before submitting its EOY report.

(6) *Alternate phase-in.* Manufacturers choosing to comply with the alternative engine phase-in must notify EPA and NHTSA of their choice. The manufacturer must send the statement to EPA before submitting its first application for a certificate of conformity.

(7) *Off-road exclusion (tractors and vocational vehicles only).* (i) Tractors and vocational vehicles primarily designed to perform work in off-road environments such as forests, oil fields, and construction sites may be exempted without request from the requirements of this regulation as specified in 49 CFR 523.2 and § 535.5(b). Within 90 days after the end of each model year,

manufacturers must send EPA and NHTSA through the EPA database a report with the following information:

(A) A description of each excluded vehicle configuration, including an explanation of why it qualifies for this exclusion.

(B) The number of vehicles excluded for each vehicle configuration.

(ii) A manufacturer having an off-road vehicle failing to meet the criteria under the agencies' off-road exclusions will be allowed to request an exclusion of such a vehicle from EPA and NHTSA. The approval will be granted through the certification process for the vehicle family and will be done in collaboration between EPA and NHTSA in accordance with the provisions in 40 CFR 1037.150, 1037.210, and 1037.631.

(8) *Vocational tractors.* Tractors intended to be used as vocational tractors may comply with vocational vehicle standards in § 535.5(b). Manufacturers classifying tractors as vocational tractors must provide a description of how they meet the qualifications in their applications for certificates of conformity as specified in 40 CFR 1037.205.

(9) *Approval of alternate methods to determine drag coefficients (tractors only).* Manufacturers seeking to use alternative methods to determine aerodynamic drag coefficients must provide a request and gain approval by EPA in accordance with 40 CFR 1037.525. The manufacturer must send the request to EPA before submitting its first application for a certificate of conformity.

(10) *Innovative and off-cycle technology credits.* Manufacturers pursuing innovative and off-cycle technology credits must submit information to the agencies and may be subject to a public evaluation process in which the public would have opportunity for comment if the manufacturer is not using a test procedure in accordance with 40 CFR 1037.610(c). Whether the approach involves on-road testing, modeling, or some other analytical approach, the manufacturer would be required to present a final methodology to EPA and NHTSA. EPA and NHTSA would approve the methodology and credits only if certain criteria were met. Baseline emissions and fuel consumption and control emissions and fuel consumption would need to be clearly demonstrated over a wide range of real world driving conditions and over a sufficient number of vehicles to address issues of uncertainty with the data. Data would need to be on a vehicle model-specific basis unless a manufacturer demonstrated model-specific data was not necessary. The agencies may publish a notice of availability in the **Federal Register** notifying the public of a manufacturer's proposed alternative off-cycle credit calculation methodology and provide opportunity for comment. Any notice will include details regarding the methodology, but not include any Confidential Business Information.

(11) *Credit trades.* If a manufacturer trades fuel consumption credits, it must send EPA and NHTSA a fuel consumption credit plan as specified in § 535.7(a) and provide the following additional information:

(i) As the seller, the manufacturer must include the following information:

(A) The corporate names of the buyer and any brokers.

(B) A copy of any contracts related to the trade.

(C) The averaging set corresponding to the engine families that generated fuel consumption credits for the trade, including the number of fuel consumption credits from each averaging set.

(ii) As the buyer, the manufacturer or entity must include the following information in its report:

(A) The corporate names of the seller and any brokers.

(B) A copy of any contracts related to the trade.

(C) How the manufacturer or entity intends to use the fuel consumption credits, including the number of fuel consumption credits it intends to apply for each averaging set.

(D) A copy of the contract with signatures from both the buyer and the seller.

(12) *Production reports.* Within 90 days after the end of the model year and no later than March 31st, manufacturers participating and not-participating in the ABT program must send to EPA and NHTSA a report including the total U.S.-directed production volume of vehicles it produced in each vehicle and engine family during the model year (based on information available at the time of the report) as required by 40 CFR 1036.250 and 1037.250. Trailer manufacturers must include a separate report including the total U.S.-directed production volume of excluded trailers as allowed by § 535.3(e). Each manufacturer shall report by vehicle or engine identification number and by configuration and identify the subfamily identifier. Report uncertified vehicles sold to secondary vehicle manufacturers. Small business manufacturers may omit reporting. Identify any differences between volumes included for EPA but excluded for NHTSA.

(13) *Transition to engine-based model years.* The following provisions apply for production and ABT reports during the transition to engine-based model year determinations for tractors and vocational vehicles in 2020 and 2021:

(i) If a manufacturer installs model year 2020 or earlier engines in the manufacturer's vehicles in calendar year 2020, include all those Phase 1 vehicles in its production and ABT reports related to model year 2020 compliance, although the agencies may require the manufacturer to identify these separately from vehicles produced in calendar year 2019.

(ii) If a manufacturer installs model year 2020 engines in its vehicles in calendar year 2021, submit production and ABT reports for those Phase 1 vehicles separate from the reports it submits for Phase 2 vehicles with model year 2021 engines.

(h) *Public information.* Based upon information submitted by manufacturers and EPA, NHTSA will publish fuel consumption standards and performance results.

(i) *Information received from EPA.* NHTSA will receive information from EPA as specified in 40 CFR 1036.755 and 1037.755.

(j) *Recordkeeping.* NHTSA has the same recordkeeping requirements as the EPA, specified in 40 CFR 86.1865–12(k), 1036.250, 1036.735, 1036.825, 1037.250, 1037.735, and 1037.825. The agencies each reserve the right to request information contained in reports separately.

(1) Manufacturers must organize and maintain records for NHTSA as described in this section. NHTSA in conjunction or separately from EPA may review a manufacturers records at any time.

(2) Keep the records required by this section for at least eight years after the due date for the end-of-year report. Manufacturers may not use fuel consumption credits for any engines if it does not keep all the records required under this section. Manufacturers must therefore keep these records to continue to bank valid credits. Store these records in any electronic format and on any media, as long as the manufacturer can promptly send the agencies organized records in English if the agencies ask for them. Manufacturers must keep these records readily available. NHTSA may review them at any time.

(3) Keep a copy of the reports required in § 535.8 and 40 CFR 1036.725,1036.730, 1037.725 and 1037.730.

(4) Keep records of the vehicles and engine identification number (usually the serial number) for each vehicle and

engine produced that generates or uses fuel consumption credits under the ABT program. Manufacturers may identify these numbers as a range. If manufacturers change the FEL after the start of production, identify the date started using each FEL/FCL and the range of vehicles or engine identification numbers associated with each FEL/FCL. Manufacturers must also identify the purchaser and destination for each vehicle and engine produced to the extent this information is available.

(5) The agencies may require manufacturers to keep additional records or to send relevant information not required by this section in accordance with each agency's authority.

(6) If collected separately and NHTSA finds that information is provided fraudulent or grossly negligent or otherwise provided in bad faith, the manufacturer may be liable to civil penalties in accordance with each agency's authority.

§ 535.9 Enforcement approach.

(a) *Compliance.* (1) Each year NHTSA will assess compliance with fuel consumption standards as specified in § 535.10.

(i) NHTSA may conduct audits or verification testing prior to first sale throughout a given model year or after the model year in order to validate data received from manufacturers and will discuss any potential issues with EPA and the manufacturer. Audits may periodically be performed to confirm manufacturers credit balances or other credit transactions.

(ii) NHTSA may also conduct field inspections either at manufacturing plants or at new vehicle dealerships to validate data received from manufacturers. Field inspections will be carried out in order to validate the condition of vehicles, engines or technology prior to first commercial sale to verify each component's certified configuration as initially built. NHTSA reserves the right to conduct inspections at other locations but will target only those components for which a violation would apply to OEMs and not the fleets or vehicle owners. Compliance inspections could be carried out through a number of approaches including during safety inspections or during compliance safety testing.

(iii) NHTSA will conduct audits and inspections in the same manner and, when possible, in conjunction with EPA. NHTSA will also attempt to coordinate inspections with EPA and share results.

(iv) Documents collected under NHTSA safety authority may be used to support fuel efficiency audits and inspections.

(2) At the end of each model year NHTSA will confirm a manufacturer's fleet or family performance values against the applicable standards and, if a manufacturer uses a credit flexibility, the amount of credits in each averaging set. The averaging set balance is based upon the engines or vehicles performance above or below the applicable regulatory subcategory standards in each respective averaging set and any credits that are traded into or out of an averaging set during the model year.

(i) If the balance is positive, the manufacturer is designated as having a credit surplus.

(ii) If the balance is negative, the manufacturer is designated as having a credit deficit.

(iii) NHTSA will provide notification to each manufacturer confirming its credit balance(s) after the end of each model year directly or through EPA.

(3) Manufacturer are required to confirm the negative balance and submit a fuel consumption credit plan as specified in § 535.7(a) along with supporting documentation indicating how it will allocate existing credits or earn (providing information on future vehicles, engines or technologies), and/or acquire credits, or else be liable for a civil penalty as determined in paragraph (b) of this section. The manufacturer must submit the information within 60 days of receiving agency notification.

(4) Credit shortfall within an averaging set may be carried forward only three years, and if not offset by earned or traded credits, the manufacturer may be liable for a civil penalty as described in paragraph (b) of this section.

(5) Credit allocation plans received from a manufacturer will be reviewed and approved by NHTSA. NHTSA will approve a credit allocation plan unless it determines that the proposed credits are unavailable or that it is unlikely that the plan will result in the manufacturer earning or acquiring sufficient credits to offset the subject credit shortfall. In the case where a manufacturer submits a plan to acquire future model year credits earned by another manufacturer, NHTSA will require a signed agreement by both manufacturers to initiate a review of the plan. If a plan is approved, NHTSA will revise the respective manufacturer's credit account accordingly by identifying which existing or traded credits are being used to address the credit shortfall, or by identifying the manufacturer's plan to earn future credits for addressing the respective credit shortfall. If a plan is rejected, NHTSA will notify the respective manufacturer and request a revised plan. The manufacturer must submit a revised plan within 14 days of receiving agency notification. The agency will provide a manufacturer one opportunity to submit a revised credit allocation plan before it initiates civil penalty proceedings.

(6) For purposes of this regulation, NHTSA will treat the use of future credits for compliance, as through a credit allocation plan, as a deferral of civil penalties for non-compliance with an applicable fuel consumption standard.

(7) If NHTSA receives and approves a manufacturer's credit allocation plan to earn future credits within the following three model years in order to comply with regulatory obligations, NHTSA will defer levying civil penalties for non-compliance until the date(s) when the manufacturer's approved plan indicates that credits will be earned or acquired to achieve compliance, and upon receiving confirmed CO_2 emissions and fuel consumption data from EPA. If the manufacturer fails to acquire or earn sufficient credits by the plan dates, NHTSA will initiate civil penalty proceedings.

(8) In the event that NHTSA fails to receive or is unable to approve a plan for a non-compliant manufacturer due to insufficiency or untimeliness, NHTSA may initiate civil penalty proceedings.

(9) In the event that a manufacturer fails to report accurate fuel consumption data for vehicles or engines covered under this rule, noncompliance will be assumed until corrected by submission of the required data, and NHTSA may initiate civil penalty proceedings.

(10) If EPA suspends or revoke a certificate of conformity as specified in 40 CFR 1036.255 or 1037.255, and a manufacturer is unable to take a corrective action allowed by EPA, noncompliance will be assumed, and NHTSA may initiate civil penalty proceedings or revoke fuel consumption credits.

(b) *Civil penalties*—(1) *Generally.* NHTSA may assess a civil penalty for any violation of this part under 49 U.S.C. 32902(k). This section states the procedures for assessing civil penalties for violations of § 535.3(h). The provisions of 5 U.S.C. 554, 556, and 557 do not apply to any proceedings conducted pursuant to this section.

(2) *Initial determination of noncompliance.* An action for civil penalties is commenced by the execution of a Notice of Violation. A determination by NHTSA's Office of

Enforcement of noncompliance with applicable fuel consumption standards utilizing the certified and reported CO_2 emissions and fuel consumption data provided by the Environmental Protection Agency as described in this part, and after considering all the flexibilities available under § 535.7, underlies a Notice of Violation. If NHTSA Enforcement determines that a manufacturer's averaging set of vehicles or engines fails to comply with the applicable fuel consumption standard(s) by generating a credit shortfall, the incomplete vehicle, complete vehicle or engine manufacturer, as relevant, shall be subject to a civil penalty.

(3) *Numbers of violations and maximum civil penalties.* Any violation shall constitute a separate violation with respect to each vehicle or engine within the applicable regulatory averaging set. The maximum civil penalty is not more than $37,500.00 per vehicle or engine. The maximum civil penalty under this section for a related series of violations shall be determined by multiplying $37,500.00 times the vehicle or engine production volume for the model year in question within the regulatory averaging set. NHTSA may adjust this civil penalty amount to account for inflation.

(4) *Factors for determining penalty amount.* In determining the amount of any civil penalty proposed to be assessed or assessed under this section, NHTSA shall take into account the gravity of the violation, the size of the violator's business, the violator's history of compliance with applicable fuel consumption standards, the actual fuel consumption performance related to the applicable standards, the estimated cost to comply with the regulation and applicable standards, the quantity of vehicles or engines not complying, and the effect of the penalty on the violator's ability to continue in business. The ''estimated cost to comply with the regulation and applicable standards,'' will be used to ensure that penalties for non-compliance will not be less than the cost of compliance.

(5) *NHTSA enforcement report of determination of non-compliance.* (i) If NHTSA Enforcement determines that a violation has occurred, NHTSA Enforcement may prepare a report and send the report to the NHTSA Chief Counsel.

(ii) The NHTSA Chief Counsel will review the report prepared by NHTSA Enforcement to determine if there is sufficient information to establish a likely violation.

(iii) If the Chief Counsel determines that a violation has likely occurred, the Chief Counsel may issue a Notice of Violation to the party.

(iv) If the Chief Counsel issues a Notice of Violation, he or she will prepare a case file with recommended actions. A record of any prior violations by the same party shall be forwarded with the case file.

(6) *Notice of violation.* (i) The Notice of Violation will contain the following information:

(A) The name and address of the party;

(B) The alleged violation(s) and the applicable fuel consumption standard(s) violated;

(C) The amount of the proposed penalty and basis for that amount;

(D) The place to which, and the manner in which, payment is to be made;

(E) A statement that the party may decline the Notice of Violation and that if the Notice of Violation is declined within 30 days of the date shown on the Notice of Violation, the party has the right to a hearing, if requested within 30 days of the date shown on the Notice of Violation, prior to a final assessment of a penalty by a Hearing Officer; and

(F) A statement that failure to either pay the proposed penalty or to decline the Notice of Violation and request a hearing within 30 days of the date shown on the Notice of Violation will result in a finding of violation by default and that NHTSA will proceed with the civil penalty in the amount proposed on the Notice of Violation without processing the violation under the hearing procedures set forth in this subpart.

(ii) The Notice of Violation may be delivered to the party by—

(A) Mailing to the party (certified mail is not required);

(B) Use of an overnight or express courier service; or

(C) Facsimile transmission or electronic mail (with or without attachments) to the party or an employee of the party.

(iii) At any time after the Notice of Violation is issued, NHTSA and the party may agree to reach a compromise on the payment amount.

(iv) Once a penalty amount is paid in full, a finding of ''resolved with payment'' will be entered into the case file.

(v) If the party agrees to pay the proposed penalty, but has not made payment within 30 days of the date shown on the Notice of Violation, NHTSA will enter a finding of violation by default in the matter and NHTSA will proceed with the civil penalty in the amount proposed on the Notice of Violation without processing the violation under the hearing procedures set forth in this subpart.

(vi) If within 30 days of the date shown on the Notice of Violation a party fails to pay the proposed penalty on the Notice of Violation, and fails to request a hearing, then NHTSA will enter a finding of violation by default in the case file, and will assess the civil penalty in the amount set forth on the Notice of Violation without processing the violation under the hearing procedures set forth in this subpart.

(vii) NHTSA's order assessing the civil penalty following a party's default is a final agency action.

(7) *Hearing Officer.* (i) If a party timely requests a hearing after receiving a Notice of Violation, a Hearing Officer shall hear the case.

(ii) The Hearing Officer will be appointed by the NHTSA Administrator, and is solely responsible for the case referred to him or her. The Hearing Officer shall have no other responsibility, direct or supervisory, for the investigation of cases referred for the assessment of civil penalties. The Hearing Officer shall have no duties related to the light-duty fuel economy or medium- and heavy-duty fuel efficiency programs.

(iii) The Hearing Officer decides each case on the basis of the information before him or her.

(8) *Initiation of action before the Hearing Officer.* (i) After the Hearing Officer receives the case file from the Chief Counsel, the Hearing Officer notifies the party in writing of—

(A) The date, time, and location of the hearing and whether the hearing will be conducted telephonically or at the DOT Headquarters building in Washington, DC;

(B) The right to be represented at all stages of the proceeding by counsel as set forth in paragraph (b)(9) of this section; and

(C) The right to a free copy of all written evidence in the case file.

(ii) On the request of a party, or at the Hearing Officer's direction, multiple proceedings may be consolidated if at any time it appears that such consolidation is necessary or desirable.

(9) *Counsel.* A party has the right to be represented at all stages of the proceeding by counsel. A party electing to be represented by counsel must notify the Hearing Officer of this election in writing, after which point the Hearing Officer will direct all further communications to that counsel. A party represented by counsel bears all of its own attorneys' fees and costs.

(10) *Hearing location and costs.* (i) Unless the party requests a hearing at which the party appears before the

Hearing Officer in Washington, DC, the hearing may be held telephonically. In Washington, DC, the hearing is held at the headquarters of the U.S. Department of Transportation.

(ii) The Hearing Officer may transfer a case to another Hearing Officer at a party's request or at the Hearing Officer's direction.

(iii) A party is responsible for all fees and costs (including attorneys' fees and costs, and costs that may be associated with travel or accommodations) associated with attending a hearing.

(11) *Hearing procedures.* (i) There is no right to discovery in any proceedings conducted pursuant to this subpart.

(ii) The material in the case file pertinent to the issues to be determined by the Hearing Officer is presented by the Chief Counsel or his or her designee.

(iii) The Chief Counsel may supplement the case file with information prior to the hearing. A copy of such information will be provided to the party no later than three business days before the hearing.

(iv) At the close of the Chief Counsel's presentation of evidence, the party has the right to examine respond to and rebut material in the case file and other information presented by the Chief Counsel. In the case of witness testimony, both parties have the right of cross-examination.

(v) In receiving evidence, the Hearing Officer is not bound by strict rules of evidence. In evaluating the evidence presented, the Hearing Officer must give due consideration to the reliability and relevance of each item of evidence.

(vi) At the close of the party's presentation of evidence, the Hearing Officer may allow the introduction of rebuttal evidence that may be presented by the Chief Counsel.

(vii) The Hearing Officer may allow the party to respond to any rebuttal evidence submitted.

(viii) After the evidence in the case has been presented, the Chief Counsel and the party may present arguments on the issues in the case. The party may also request an opportunity to submit a written statement for consideration by the Hearing Officer and for further review. If granted, the Hearing Officer shall allow a reasonable time for submission of the statement and shall specify the date by which it must be received. If the statement is not received within the time prescribed, or within the limits of any extension of time granted by the Hearing Officer, it need not be considered by the Hearing Officer.

(ix) A verbatim transcript of the hearing will not normally be prepared. A party may, solely at its own expense, cause a verbatim transcript to be made. If a verbatim transcript is made, the party shall submit two copies to the Hearing Officer not later than 15 days after the hearing. The Hearing Officer shall include such transcript in the record.

(12) *Determination of violations and assessment of civil penalties.* (i) Not later than 30 days following the close of the hearing, the Hearing Officer shall issue a written decision on the Notice of Violation, based on the hearing record. This may be extended by the Hearing officer if the submissions by the Chief Counsel or the party are voluminous. The decision shall address each alleged violation, and may do so collectively. For each alleged violation, the decision shall find a violation or no violation and provide a basis for the finding. The decision shall set forth the basis for the Hearing Officer's assessment of a civil penalty, or decision not to assess a civil penalty. In determining the amount of the civil penalty, the gravity of the violation, the size of the violator's business, the violator's history of compliance with applicable fuel consumption standards, the actual fuel consumption performance related to the applicable standard, the estimated cost to comply with the regulation and applicable standard, the quantity of vehicles or engines not complying, and the effect of the penalty on the violator's ability to continue in business. The assessment of a civil penalty by the Hearing Officer shall be set forth in an accompanying final order. The Hearing Officer's written final order is a final agency action.

(ii) If the Hearing Officer assesses civil penalties in excess of $1,000,000, the Hearing Officer's decision shall contain a statement advising the party of the right to an administrative appeal to the Administrator within a specified period of time. The party is advised that failure to submit an appeal within the prescribed time will bar its consideration and that failure to appeal on the basis of a particular issue will constitute a waiver of that issue in its appeal before the Administrator.

(iii) The filing of a timely and complete appeal to the Administrator of a Hearing Officer's order assessing a civil penalty shall suspend the operation of the Hearing Officer's penalty, which shall no longer be a final agency action.

(iv) There shall be no administrative appeals of civil penalties assessed by a Hearing Officer of less than $1,000,000.

(13) *Appeals of civil penalties in excess of $1,000,000.* (i) A party may appeal the Hearing Officer's order assessing civil penalties over $1,000,000 to the Administrator within 21 days of the date of the issuance of the Hearing Officer's order.

(ii) The Administrator will review the decision of the Hearing Officer de novo, and may affirm the decision of the hearing officer and assess a civil penalty, or

(iii) The Administrator may—

(A) Modify a civil penalty;

(B) Rescind the Notice of Violation; or

(C) Remand the case back to the Hearing Officer for new or additional proceedings.

(iv) In the absence of a remand, the decision of the Administrator in an appeal is a final agency action.

(14) *Collection of assessed or compromised civil penalties.* (i) Payment of a civil penalty, whether assessed or compromised, shall be made by check, postal money order, or electronic transfer of funds, as provided in instructions by the agency. A payment of civil penalties shall not be considered a request for a hearing.

(ii) The party must remit payment of any assessed civil penalty to NHTSA within 30 days after receipt of the Hearing Officer's order assessing civil penalties, or, in the case of an appeal to the Administrator, within 30 days after receipt of the Administrator's decision on the appeal.

(iii) The party must remit payment of any compromised civil penalty to NHTSA on the date and under such terms and conditions as agreed to by the party and NHTSA. Failure to pay may result in NHTSA entering a finding of violation by default and assessing a civil penalty in the amount proposed in the Notice of Violation without processing the violation under the hearing procedures set forth in this part.

(c) *Changes in corporate ownership and control.* Manufacturers must inform NHTSA of corporate relationship changes to ensure that credit accounts are identified correctly and credits are assigned and allocated properly.

(1) In general, if two manufacturers merge in any way, they must inform NHTSA how they plan to merge their credit accounts. NHTSA will subsequently assess corporate fuel consumption and compliance status of the merged fleet instead of the original separate fleets.

(2) If a manufacturer divides or divests itself of a portion of its automobile manufacturing business, it must inform NHTSA how it plans to divide the manufacturer's credit holdings into two or more accounts. NHTSA will subsequently distribute holdings as directed by the manufacturer, subject to provision for

reasonably anticipated compliance obligations.

(3) If a manufacturer is a successor to another manufacturer's business, it must inform NHTSA how it plans to allocate credits and resolve liabilities per 49 CFR part 534.

§ 535.10 How do manufacturers comply with fuel consumption standards?

(a) *Pre-certification process.* (1) Regulated manufacturers determine eligibility to use exemptions or exclusions in accordance with § 535.3.

(2) Manufacturers may seek preliminary approvals as specified in 40 CFR 1036.210 and 40 CFR 1037.210 from EPA and NHTSA, if needed. Manufacturers may request to schedule pre-certification meetings with EPA and NHTSA prior to submitting approval requests for certificates of conformity to address any joint compliance issues and gain informal feedback from the agencies.

(3) The requirements and prohibitions required by EPA in special circumstances in accordance with 40 CFR 1037.601 and 40 CFR part 1068 apply to manufacturers for the purpose of complying with fuel consumption standards. Manufacturers should use good judgment when determining how EPA requirements apply in complying with the NHTSA program. Manufacturers may contact NHTSA and EPA for clarification about how these requirements apply to them.

(4) In circumstances in which EPA provides multiple compliance approaches manufacturers must choose the same compliance path to comply with NHTSA's fuel consumption standards that they choose to comply with EPA's greenhouse gas emission standards.

(5) Manufacturers may not introduce new vehicles into commerce without a certificate of conformity from EPA. Manufacturers must attest to several compliance standards in order to obtain a certificate of conformity. This includes stating comparable fuel consumption results for all required CO_2 emissions rates. Manufacturers not completing these steps do not comply with the NHTSA fuel consumption standards.

(6) Manufacturers apply the fuel consumption standards specified in § 535.5 to vehicles, engines and components that represent production units and components for vehicle and engine families, sub-families and configurations consistent with the EPA specifications in 40 CFR 86.1819, 1036.230, and 1037.230.

(7) Only certain vehicles and engines are allowed to comply differently between the NHTSA and EPA programs as detailed in this section. These vehicles and engines must be identified by manufacturers in the ABT and production reports required in § 535.8.

(b) *Model year compliance.* Manufacturers are required to conduct testing to demonstrate compliance with CO_2 exhaust emissions standards in accordance with EPA's provisions in 40 CFR part 600, subpart B, 40 CFR 1036, subpart F, 40 CFR part 1037, subpart R, and 40 CFR part 1066. Manufacturers determine equivalent fuel consumption performance values for CO_2 results as specified in § 535.6 and demonstrate compliance by comparing equivalent results to the applicable fuel consumption standards in § 535.5.

(c) *End-of-the-year process.* Manufacturers comply with fuel consumption standards after the end of each model year, if—

(1) For heavy-duty pickup trucks and vans, the manufacturer's fleet average performance, as determined in § 535.6, is less than the fleet average standard; or

(2) For truck tractors, vocational vehicles, engines and box trailers the manufacturer's fuel consumption performance for each vehicle or engine family (or sub-family), as determined in § 535.6, is lower than the applicable regulatory subcategory standards in § 535.5.

(3) For non-box and non-aero trailers, a manufacturer is considered in compliance with fuel consumption standards if all trailers meet the specified standards in § 535.5(e)(1)(i).

(4) NHTSA will use the EPA final verified values as specified in 40 CFR 86.1819, 40 CFR 1036.755, and 1037.755 for making final determinations on whether vehicles and engines comply with fuel consumption standards.

(5) A manufacturer fails to comply with fuel consumption standards if its final reports are not provided in accordance with § 535.8 and 40 CFR 86.1865, 1036.730, and 1037.730. Manufacturers not providing complete or accurate final reports or any plans by the required deadlines do not comply with fuel consumption standards. A manufacturer that is unable to provide any emissions results along with comparable fuel consumption values must obtain permission for EPA to exclude the results prior to the deadline for submitting final reports.

(6) A manufacturer that would otherwise fail to directly comply with fuel consumption standards as described in paragraphs (c)(1) through (3) of this section may use one or more of the credit flexibilities provided under the NHTSA averaging, banking and trading program, as specified in § 535.7, but must offset all credit deficits in its averaging sets to achieve compliance.

(7) A manufacturer failing to comply with the provisions specified in this part may be liable to pay civil penalties in accordance with § 535.9.

(8) A manufacturer may also be liable to pay civil penalties if found by EPA or NHTSA to have provided false information as identified through NHTSA or EPA enforcement audits or new vehicle verification testing as specified in § 535.9 and 40 CFR parts 86, 1036, and 1037.

PART 538—MANUFACTURING INCENTIVES FOR ALTERNATIVE FUEL VEHICLES

■ 382. Revise the authority citation for part 538 to read as follows:

Authority: 49 U.S.C. 32901, 32905, and 32906; delegation of authority at 49 CFR 1.95.

■ 383. Revise § 538.5 to read as follows:

§ 538.5 Minimum driving range.

(a) The minimum driving range that a passenger automobile must have in order to be treated as a dual fueled automobile pursuant to 49 U.S.C. 32901(c) is 200 miles when operating on its nominal useable fuel tank capacity of the alternative fuel, except when the alternative fuel is electricity or compressed natural gas. Beginning model year 2016, a natural gas passenger automobile must have a minimum driving range of 150 miles when operating on its nominal useable fuel tank capacity of the alternative fuel to be treated as a dual fueled automobile, pursuant to 49 U.S.C. 32901(c)(2).

(b) The minimum driving range that a passenger automobile using electricity as an alternative fuel must have in order to be treated as a dual fueled automobile pursuant to 49 U.S.C. 32901(c) is 7.5 miles on its nominal storage capacity of electricity when operated on the EPA urban test cycle and 10.2 miles on its nominal storage capacity of electricity when operated on the EPA highway test cycle.

Dated: August 16, 2016.

Anthony Foxx,

Secretary,Department of Transportation.

Dated: August 16, 2016.

Gina McCarthy,

Administrator, Environmental Protection Agency.

[FR Doc. 2016–21203 Filed 10–24–16; 8:45 am]

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Technical Support Document for

Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act

December 7, 2009

Climate Change Division, Office of Atmospheric Programs
U.S. Environmental Protection Agency
Washington, DC

Appendix B: Greenhouse Gas Emissions From Section 202(a) Source Categories

This Appendix provides greenhouse gas (GHG) emission information from Clean Air Act Section 202(a) source categories. It includes an overview of the respective source categories with a description of how the emission data from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* map to these source categories. Then, relevant emission data are presented and comparisons are made between U.S. GHG emissions from Section 202(a) source categories and domestic and global emission data. To inform the Administrator's assessment, the following types of comparisons for both the collective and individual emissions of GHGs from Section 202(a) source categories are provided:

- As a share of total global aggregate emissions of the well-mixed GHGs
- As a share of total U.S. aggregate emissions of the six GHGs
- As a share of the total global transportation emissions of the six GHGs

In addition, for each individual GHG, the following comparisons were also calculated:

- As a share of total U.S. Section 202(a) GHG emissions
- As a share of U.S. emissions of that individual GHG, including comparisons to the magnitude of emissions of that GHG from non-transport related source categories
- As a share of global emissions of that individual GHG
- As a share of global transport GHG emissions
- As a share of all global GHG emissions

(A) Overview of Section 202(a) Source Categories

To inform the Administrator's cause or contribute finding, EPA analyzed historical GHG emission data for motor vehicles and motor vehicle engines in the United States from 1990 to 2007 (the most recent year for which official EPA estimates are available). The motor vehicles and motor vehicle engines addressed include:

- Passenger cars
- Light-duty trucks
- Motorcycles
- Buses
- Medium/heavy-duty trucks

The source of the emissions data is the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 (U.S. EPA, 2009).* The *U.S. Inventory* is organized around the source classification scheme put forth by the Intergovernmental Panel on Climate Change, in which emissions from motor vehicles and motor vehicle engines are reported within two different sectors: Energy and Industrial Processes. Table B.1 describes the correspondence between Section 202(a) GHG emission source categories and IPCC source categories:

Table B.1:Source Categories Included Under Section 202(a)

Section 202(a) Source Category	IPCC Sector	IPCC Source Category	Greenhouse Gases
Passenger Cars	Energy	1A3b (i) Cars	CO_2, CH_4, N_2O
Light-Duty Trucks	Energy	1A3b (ii) Light-duty trucks	CO_2, CH_4, N_2O
Motorcycles	Energy	1A3b (iv) Motorcycles	CO_2, CH_4, N_2O
Buses	Energy	1A3b (iii) Heavy-duty trucks and buses	CO_2, CH_4, N_2O
Medium/Heavy-Duty Trucks	Energy	1A3b (iii) Heavy-duty trucks and buses	CO_2, CH_4, N_2O
Cooling (from section 202(a) sources)	Industrial Processes	2F1 Refrigeration and Air Conditioning Equipment	Hydrofluorocarbons (HFCs)

GHG emissions from aviation, pipelines, railways, and marine transport are included in the IPCC Energy Sector under 1A3 but are not included within Section 202(a).

(B) GHG Emissions from Section 202(a) Source Categories

(1) Total, combined GHG emissions from Section 202(a) source categories

Table B.2 presents historical emissions of all GHGs (CO_2, CH_4, N_2O, and HFCs) from Section 202(a) source categories from 1990-2007 in carbon dioxide equivalent units ($TgCO_2e$).[105] Passenger cars (38.7. percent), light-duty trucks (32.4 percent), and medium/heavy-duty trucks (24.8 percent) emitted the largest shares of GHG emissions in 2007, followed by cooling (from section 202(a) sources) (3.2 percent), buses (0.7 percent), and motorcycles (0.1 percent). From 1990 to 2007, GHG emissions from Section 202(a) source categories grew by 33.9 %due in part to increased demand for travel and the stagnation of fuel efficiency across the U.S. vehicle fleet. Since the 1970s, the number of highway vehicles registered in the United States has increased faster than the overall population, according to the Federal Highway Administration (FHWA).[106] Likewise, the number of miles driven (up 41.3% from 1990 to 2007) and the gallons of gasoline consumed each year in the United States have increased steadily since the 1980s, according to the FHWA and Energy Information

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[105] A Tg is one teragram, or one million metric tons.

[106] FHWA (1996 through 2008) Highway Statistics. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Report FHWA-PL-96-023-annual. Available online at <http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.htm>.

Administration, respectively.[107] These increases in motor vehicle use are the result of a confluence of factors, including population growth, economic growth, urban sprawl, low fuel prices, and increasing popularity of sport utility vehicles and other light-duty trucks that tend to have lower fuel efficiency.

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[107] DOE (1993 through 2008) Transportation Energy Data Book. Office of Transportation Technologies, Center for Transportation Analysis, Energy Division, Oak Ridge National Laboratory. ORNL-5198.

Table B.2: Total Greenhouse Gas Emissions by Section 202(a) Source Category (Tg CO_2e)

Section 202(a) Sources	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Passenger Cars	656.9	633.9	670.3	673.1	686.5	664.4	660.7	677.3	651.1	639.6
Light-Duty Trucks	336.2	428.6	489.7	492.9	502.9	536.5	557.3	517.1	528.8	533.8
Motorcycles	1.8	1.8	1.9	1.7	1.7	1.7	1.8	1.7	1.9	2.1
Buses	8.3	9.0	10.9	10.0	9.7	10.5	14.7	11.8	12.1	12.1
Medium/Heavy-Duty Trucks	228.8	272.4	342.7	341.8	355.9	352.3	365.0	392.9	402.3	408.6
Cooling (from section 202(a) sources)	0.0	16.2	43.0	46.7	49.9	52.4	55.1	56.5	55.9	53.2
Total	1231.9	1362.1	1558.5	1566.3	1606.6	1617.7	1654.6	1657.3	1652.1	1649.3

Between 1990 and 2007, GHG emissions from passenger cars decreased 2.6%, though there was some growth in GHG emissions from 2000 to 2002, and again from 2004 to 2005. Emissions from light-duty trucks increased 58.8% from 1990 to2007, largely due to the increased use of sport-utility vehicles and other light-duty trucks. Meanwhile, GHG emissions from heavy-duty trucks increased 78.6%, reflecting the increased volume of total freight movement and an increasing share transported by trucks. In 1990, there were no hydrofluorocarbons (HFCs) used in vehicle cooling systems. HFCs were gradually introduced into motor vehicle air conditioning and refrigerating systems during the 1990s as chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs) started to phase out of production as required under the Montreal Protocol and Title VI of the Clean Air Act.

Table B.3 presents GHG emissions from Section 202(a) source categories alongside total U.S. emissions. The table also presents emissions from the electricity generation and industrial sectors for comparison. In 1990, Section 202(a) source categories emitted 20.2% of total U.S. emissions, behind the electricity generation sector (30.5%) and the industrial sector (24.5%). By 2007, Section 202(a) source categories collectively were the second largest sector with 23.1% of total U.S. emissions, due both to growth in vehicle emissions and a decline in emissions from industry.

TECHNOLOGIES AND APPROACHES TO REDUCING THE FUEL CONSUMPTION OF MEDIUM- AND HEAVY-DUTY VEHICLES

Committee to Assess Fuel Economy Technologies for
Medium- and Heavy-Duty Vehicles

Board on Energy and Environmental Systems
Division on Engineering and Physical Sciences

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Summary

Liquid fuel consumption by medium- and heavy-duty vehicles (MHDVs) represents 26 percent of all U.S. liquid transportation fuels consumed and has increased more rapidly—in both absolute and percentage terms—than consumption by other sectors. In early recognition of these trends, which are forecast to continue until 2035 (DOE, EIA, 2009), the Energy Independence and Security Act of 2007 (EISA; Public Law 110-140, Dec. 19, 2007), Section 108, was passed, requiring the U.S. Department of Transportation (DOT), for the first time in history, to establish fuel economy standards for MHDVs. In December 2009 the U.S. Environmental Protection Agency (EPA) formally declared that greenhouse gas (GHG) emissions endanger public health and the environment within the meaning of the Clean Air Act, a decision that compels EPA to consider establishing first-ever GHG emission standards for new motor vehicles, including MHDVs. If the United States is to reduce its reliance on foreign sources of oil, and reduce GHG emissions from the transportation sector, it is important to consider how the fuel consumption of MHDVs can be reduced.

Following the passage of EISA, the National Research Council appointed the Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles. The committee considered approaches to measuring fuel economy (the committee uses fuel consumption), assessed current and future technologies for reducing fuel consumption, addressed how such technologies may be practically implemented in vehicles, discussed the pros and cons of approaches to improving the fuel efficiency of moving goods as opposed to setting vehicle fuel consumption standards, and identified potential costs and other impacts on the operation of MHDVs (see Chapter 1 and Appendix A for the complete statement of task).

The legislation also requires DOT's National Highway Traffic Safety Administration (NHTSA) to conduct its own study on the fuel consumption of commercial medium- and heavy-duty highway vehicles and work trucks and then to establish a rulemaking to implement a commercial medium- and heavy-duty on-highway and work-truck fuel efficiency improvement program.

The organization of this Summary follows that of the report's chapters: Chapter 1 provides background; Chapter 2 provides vehicle fundamentals; Chapter 3 surveys the current U.S., European, and Asian approaches to fuel economy and regulations; Chapters 4 and 5 review and assess technologies to reduce fuel consumption; Chapter 6 assesses direct and indirect costs and benefits of integrating fuel consumption reduction technologies into vehicles; Chapter 7 presents a review of potential unintended consequences and the alternative nontechnology approaches to reducing fuel consumption; and Chapter 8 reviews options for regulatory design. The Summary presents the committee's major findings and recommendations from each chapter; fuller discussion and additional findings are found in the report.

VEHICLE FUNDAMENTALS, FUEL CONSUMPTION, AND EMISSIONS

Medium- and heavy-duty trucks, motor coaches, and transit buses, Class 2b through Class 8, are used in every sector of the economy. The purposes of these vehicles range from carrying passengers to moving goods. For some vehicles and driving cycles this simple relationship breaks down (as with a bucket truck, which carries one or two passengers but delivers no freight). It brings services and capability (the bucket, tools, and spare parts) to a job site. This results in a broad range of varying duty cycles, from high-speed operation on highways with few stops to lower-speed urban operation with many stops per mile. For the purposes of estimating fuel consumption benefits of various technologies in this report, the committee examined seven different types of vehicles and made assumptions about the duty cycles that would characterize their operations: (1) tractor trailer, (2) Class 6 box truck, (3) Class 6 bucket truck, (4) refuse truck, (5) transit bus, (6) motor coach, and (7) pickup/van. When DOT promulgates standards for fuel consumption, it will have to address the duty cycles that characterize different types of vehicles and their wide range of applications.

The fundamental engineering metric for measuring the fuel efficiency of a vehicle is fuel consumption, the amount of fuel used, assuming some standard duty or driving cycle, to deliver a given transportation service, for example, the amount of fuel a vehicle needs to go a mile or the amount of fuel needed to transport a ton of goods a mile. For light-duty vehicles (cars and light trucks), the corporate average fuel economy (CAFE) program uses miles per gallon (mpg). This measure, although derived from measurements of fuel consumption in gallons/mile, is not the appropriate measure for MHDVs, since these vehicles are designed to carry loads in an efficient and timely manner. A partially loaded tractor trailer would consume less fuel per mile than a fully loaded truck, but this would not be an accurate measure of the fuel efficiency of moving goods. However, normalizing fuel consumption by the payload and using the calculation of gallon/ton-mile—the load-specific fuel consumption (LSFC)—the fully loaded truck would have a much lower LSFC number than the partially loaded truck, reflecting the ability of the truck to accomplish the task of delivering goods.

Major Findings and Recommendations—
Chapters 1 and 2: Introduction and Fundamentals

Finding 2-1. Fuel consumption (fuel used per distance traveled; e.g., gallons per mile) has been shown to be the fundamental metric to properly judge fuel efficiency improvements from both engineering and regulatory viewpoints, including yearly fuel savings for different technology vehicles.

Finding 2-2. The relationship between the percent improvement in fuel economy (FE) and the percent reduction in fuel consumption (FC) is nonlinear; e.g., a 10 percent increase in FE (miles per gallon) corresponds to a 9.1 percent decrease in FC, whereas a 100 percent increase in FE corresponds to a 50 percent decrease in FC. This nonlinearity leads to widespread consumer confusion as to the fuel-savings potential of the various technologies, especially at low absolute values of FE.

Finding 2-3. MHDVs are designed as load-carrying vehicles, and consequently their most meaningful metric of fuel efficiency will be in relation to the work performed, such as fuel consumption per unit payload carried, which is load-specific fuel consumption (LSFC). Methods to increase payload may be combined with technology to reduce fuel consumption to improve LSFC. Future standards might require different values to accurately reflect the applications of the various vehicle classes (e.g., buses, utility, line haul, pickup, and delivery).

Recommendation 2-1. Any regulation of medium- and heavy-duty vehicle fuel consumption should use LSFC as the metric and be based on using an average (or typical) payload based on national data representative of the classes and duty cycle of the vehicle. Standards might require different values of LSFC due to the various functions of the vehicle classes e.g., buses, utility, line haul, pickup, and delivery. Regulators need to use a common procedure to develop baseline LSFC data for various applications, to determine if separate standards are required for different vehicles that have a common function. Any data reporting or labeling should state an LSFC value at specified tons of payload.

COMPARING THE REGULATORY APPROACHES OF THE UNITED STATES, JAPAN, AND EUROPEAN COMMUNITY

Although a CAFE regulatory program has been implemented for light-duty vehicles, where the responsibility for the manufacture and certification of vehicles is well defined and the configurations of cars and light trucks for sale are well defined and of limited number, the MHDV world is much more complicated. There are literally thousands of different configurations for vehicles, including bucket trucks, pickup trucks, garbage trucks, delivery vehicles, and long-haul tractor trailers. Their duty cycles vary greatly. Some stop and go every few seconds; others spend most of their time at highway speeds. Furthermore, the party responsible for the final truck configuration is often not well defined. For example, a body builder (vehicle integrator) may be the manufacturer of record, but the body builder may not design or even specify the chassis and power train. For tractor-trailer combinations, the tractor and trailer are always made and often owned by different companies, and a given tractor may pull hundreds of different trailers of different configurations over its life. Many trucks are custom made, literally one of a kind.

Even though the regulation of such vehicles will be much more complicated than it is for light-duty vehicles, the barriers are not insurmountable. Safety and emission regulations have been implemented, and regulations for fuel consumption in medium- and heavy-duty trucks already exist in Japan and are under development by the European Commission. California is building on the EPA's SmartWay Partnership to implement its own approach to regulating truck fuel consumption.

Major Findings and Recommendations—
Chapter 3: Current Regulatory Approaches

Finding 3-1. Although it took years of development and substantial effort, regulators have dealt effectively with the diversity and complexity of the vehicle industry for current laws on fuel consumption and emissions for light-duty vehicles. Engine-based certification procedures have been applied to address emissions from heavy-duty vehicles and the myriad of nontransportation engines.

Finding 3-2. The heavy-duty-truck fuel consumption regulations in Japan, and those under consideration and study by the European Commission, provide valuable input and experience to the U.S. plans. In Japan the complexity of MHDV configurations and duty cycles was determined to lend itself to the use of computer simulation as a cost-effectives means to calculate fuel efficiency, and Japan is not using extensive full-vehicle testing in the certification process.

TECHNOLOGIES AND COSTS OF REDUCING FUEL CONSUMPTION

The committee has evaluated a wide range of fuel-saving technologies for medium- and heavy-duty vehicles. Some technologies, such as certain aerodynamic features, automated manual transmissions, and wide-base single low-rolling-resistance tires, are already available in production. Some of the technologies are in varying stages of development, while others have only been studied using simulation models. Reliable, peer-reviewed data on fuel-saving performance is available only for a few technologies in a few applications. As a result, the committee had to rely on information from a wide range of sources, (e.g., information gathered from vehicle manufacturers, component suppliers, research labs, and major fleets during site visits by the committee), including many results that have not been duplicated by other researchers or verified over a range of duty cycles.

There is a tendency among researchers to evaluate technologies under conditions which are best suited to that specific technology. This can be a serious issue in situations where performance is strongly dependent on duty cycle, as is the case for many of the technologies evaluated in this report. One result is that the reported performance of a specific technology may be better than what would be achieved by the overall vehicle fleet in actual operation. Another issue with technologies that are not fully developed is a tendency to underestimate the problems that could emerge as the technology matures to commercial application. Such issues often result in implementation delays as well as a loss of performance compared to initial projections. As a result of these issues, some of the technologies evaluated in this report may be available later than expected, or at a lower level of performance than expected. Extensive additional research would be needed to quantify these issues, and regulators will need to allow for the fact that some technologies may not mature as expected.

The fuel-saving technologies that are already available on the market generally result in increased vehicle cost, and purchasers must weigh the additional cost against the fuel savings that will accrue. In most cases, market penetration is low at this time. Most fuel-saving technologies that are under development will also result in increased vehicle cost, and in some cases, the cost increases will be substantial. As a result, many technologies may struggle to achieve market acceptance, despite the sometimes substantial fuel savings, unless driven by regulation or by higher fuel prices. Powertrain technologies (for diesel engines, gasoline engines, transmissions, and hybrids) as well as vehicle technologies (for aerodynamics, rolling resistance, mass/weight reduction, idle reduction, and intelligent vehicles) are analyzed in Chapters 4 and 5. Tables S-1 and S-2 provide the committee's estimate of the range of fuel consumption reduction that is potentially achievable with new technologies in the period 2015 to 2020, compared to a 2008 baseline.[1] Figure S-1 provides estimates for potential fuel consumption reductions for typical new vehicles in the 2015 to 2020 time frame.

The technologies were grouped into time periods based on the committee's estimate of when the technologies would be proven and available. In practice, the timing of their introduction will vary by manufacturer, based in large part on individual company product development cycles. In order to manage product development costs, manufacturers must consider the overall product life cycle and the timing of new product introductions. As a result, widespread availability of some technologies may not occur in the time frames shown.

The percent fuel consumption reduction (% FCR) numbers shown for individual technologies and other options are not additive. For each vehicle class, the % FCR associated with combined options is as follows:

$$\%\ \mathrm{FCR}_{\mathrm{package}} = 100\ [1 - (1 - \{\%\ \mathrm{FCR}_{\mathrm{tech1}}/100\})\ (1 - \{\%\ \mathrm{FCR}_{\mathrm{tech2}}/100\})\ \ldots\ \{(1 - \{\%\ \mathrm{FCR}_{\mathrm{techN}}/100\})]$$

where $\%\ \mathrm{FCR}_{\mathrm{techx}}$ is the percent benefit of an individual technology.

The major enabling technologies necessary to achieve these reductions are hybridization, advanced diesel engines, and aerodynamics. Hybridization is particularly important in those applications with the stop-and-go duty cycles characteristic of many MHDVs, such as refuse trucks and transit buses, as well as bucket trucks. Diesel and gasoline engine advancements are helpful in all applications and will include continuing improvements to fuel injection systems, emissions control, and air handling systems, in addition to commercialization of waste heat recovery systems. Essentially all Class 8 vehicles will continue with diesel engines as the prime mover. The third major technology improvement is total vehicle aerodynamics, especially in over-the-road applications like tractor trailers and motor coaches. Other technologies that will play a role in reducing fuel consumption in all vehicle segments include low-rolling-resistance tires, improved transmissions, idle-reduction technologies, weight reduction, and driver management and coaching.

The applications of these technologies can be put into packages and then applied to the seven types of MHDVs analyzed. The resulting fuel consumption reduction for each

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[1] More information on the baseline can be found in Chapter 6 and in TIAX (2009).

manufacturers. Trailers, which present an important opportunity for fuel consumption reduction, can benefit from improvements in aerodynamics and tires.

Recommendation 8-1. When NHTSA regulates, it should regulate the final-stage vehicle manufacturers since they have the greatest control over the design of the vehicle and its major subsystems that affect fuel consumption. Component manufacturers will have to provide consistent component performance data. As the components are generally tested at this time, there is a need for a standardized test protocol and safeguards for the confidentiality of the data and information. It may be necessary for the vehicle manufacturers to provide the same level of data to the tier suppliers of the engines, transmissions, and after-treatment and hybrid systems.

Recommendation 8-3. NHTSA should establish fuel consumption metrics tied to the task associated with a particular type of MHDV and set targets based on potential improvements in vehicle efficiency and vehicle or trailer changes to increase cargo-carrying capacity. NHTSA should determine whether a system of standards for full but lightly loaded (cubed-out) vehicles can be developed using only the LSFC metric or whether these vehicles need a different metric to properly measure fuel efficiency without compromising the design of the vehicles.

Finding 8-7. Some certification and compliance methods seem more practical than others, and the committee acknowledges that there may be other options or variations that have yet to be identified. Regulating total vehicle fuel consumption of MHDVs will be a formidable task due to the complexity of the fleet, the various work tasks performed, and the variations in fuel-consumption-related technologies within given classes, including vehicles of the same model and manufacturer.

Finding 8-9. Using the process and results from existing engine dynamometer testing for criteria emissions to certify fuel economy standards for MHDVs would build on proven, accurate, and repeatable methods and put less additional administrative burden on the industry. However, to account for the fuel consumption benefits of hybrid power trains and transmission technology, the present engine-only tests for emissions certification will need to be augmented with other power train components added to the engine test cell, either as real hardware or as simulated components. Similarly, the vehicle attributes (aerodynamics, tires, mass) will need to be accounted for, one approach being to use vehicle-specific prescribed loads (via models) in the test cycle. This will require close cooperation among component manufacturers and vehicle manufacturers.

Recommendation 8-4. Simulation modeling should be used with component test data and additional tested inputs from power train tests, which could lower the cost and administrative burden yet achieve the needed accuracy of results. This is similar to the approach taken in Japan, but with the important clarification that the program would represent all of the parameters of the vehicle (power train, aerodynamics, and tires) and relate fuel consumption to the vehicle task.

Finding 8-13. There is an immediate need to take the findings and recommendations in this report and begin the development of a regulatory approach. Significant engineering work is needed to produce an approach that results in fuel efficiency standards that are cost-effective and that accurately represent the effects of fuel-consumption-reducing technologies. The regulations should fit into the engineering and development cycle of the industry and provide meaningful data to vehicle purchasers.

Recommendation 8-5. Congress should appropriate money for and NHTSA should implement as soon as possible a major engineering contract that would analyze several actual vehicles covering several applications and develop an approach to component testing and related data collection in conjunction with vehicle simulation modeling to arrive at LSFC data for these vehicles. The actual vehicles should also be tested by appropriate full-scale test procedures to confirm the actual LSFC values and the reductions measured with fuel consumption reduction technologies in order to validate the evaluation method.

Recommendation 8-6. NHTSA should conduct a pilot program to "test drive" the certification process and validate the regulatory instrument proof of concept. It should have these elements:

- Gain experience with certification testing, data gathering, compiling, and reporting. There needs to be a concerted effort to determine the accuracy and repeatability of all the test methods and simulation strategies that will be used with any proposed regulatory standards and a willingness to fix issues that are found.
- Gather data on fuel consumption from several representative fleets of vehicles. This should continue to provide a real-world check on the effectiveness of the regulatory design on the fuel consumption of trucking fleets in various parts of the marketplace and in various regions of the country.

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TABLE 2-7 Truck Sales, by Manufacturer, 2004-2008

	Calendar Year				
	2004	2005	2006	2007	2008
Class 3					
Chrysler	29,859	35,038	36,057	46,553	29,638
Ford	68,615	122,903	105,955	81,155	60,139
Freightliner[a]	270	14	0	0	0
General Motors	2,471	2,788	2,578	33,507	41,559
International	0	0	0	0	609
Isuzu	4,992	5,167	4,929	4,350	2568
Mitsubishi-Fuso	720	670	93	52	202
Nissan Diesel	352	276	232	279	112
Sterling	0	0	0	0	12
Total	107,279	166,856	149,844	165,896	134,839
Classes 4-7					
Chrysler	0	0	0	588	5,386
Ford	60,538	61,358	69,070	70,836	46,454
Freightliner[a]	51,814	51,639	51,357	42,061	30,809
General Motors	34,351	45,144	41,340	34,164	24,828
Hino	2,387	4,290	6,203	5,448	4,917
Navistar/ International	52,278	54,895	61,814	40,268	35,022
Isuzu	10,715	10,620	10,822	9,639	6,157
Kenworth	5,020	3,874	5040	4,239	3,710
Mack	21	0	0	0	0
Mitsubishi-Fuso	4,384	4,842	5,967	5,218	2,136
Nissan	0	0	0	0	0
Nissan Diesel	2,453	2,382	2,551	2,080	1,273
Peterbilt	4,495	4,739	6,307	5009	3,792
Sterling	0	0	102	578	467
Total	228,456	243,783	260,573	220,128	164,951
Class 8					
Freightliner[a]	73,731	94,900	98,603	51,706	42,639
Navistar/ International	38,242	46,093	53,373	29,675	32,399
Kenworth	23,294	27,153	33,091	19,299	15,855
Mack	20,670	27,303	29,524	13,438	11,794
Peterbilt	26,145	30,274	37,322	19,948	17,613
Volvo Truck	20,323	26,446	30,716	16,064	13,061
Other	792	623	1,379	835	112
Total	203,197	252,792	284,008	150,965	133,473
Grand Total	538,932	663,431	694,425	536,989	433,263

[a] Freightliner/Western Star/Sterling(domestic).

SOURCE: DOE/EERE (2009), pp. 21-22, based on *Ward's Motor Vehicle Facts and Figures*, available at http://www.wardsauto.com/about/facts figures.

TABLE 2-8 Engines Manufactured for Class 2b Through Class 8 Trucks, 2004-2008

	2004	2005	2006	2007	2008
Engines Manufactured for Heavy-Duty Trucks					
Cummins	64,630	79,100	91,317	65,228	75,307
Detroit Diesel	48,060	61,074	63,809	29,506	35,174
Caterpillar	74,224	86,806	97,544	33,232	20,099
Mack	25,158	36,211	36,198	18,544	16,794
Mercedes Benz	17,178	24,414	24,584	17,048	10,925
Volvo	12,567	19,298	23,455	9,850	8,822
Navistar	0	0	0	4	927
PACCAR	0	0	0	52	20
Total	241,817	306,913	336,907	173,464	168,068
Engines Manufactured for Medium-Duty Trucks					
Navistar	373,842	382, 143	357,470	335,046	264,317
GM	74,328	77,056	83,355	87,749	72,729
Cummins	14,900	15,162	16,400	20,615	27,664
Mercedes Benz	16,075	20,038	27,155	19,330	9,066
Caterpillar	42,535	42,350	45,069	14,693	6,269
PACCAR	0	0	0	9,020	5,694
Hino	671	5,001	7,489	6,230	3,062
Detroit Diesel	0	958	8	0	0
Total	522,351	542,708	536,946	492,683	388,801
Engines Manufactured for Medium- and Heavy-Duty Trucks					
Navistar	373,842	382,143	357,470	335,050	265,244
Cummins	79,530	94,262	107,717	85,843	102,971
GM	74,328	77,056	83,355	87,749	72,729
Detroit Diesel	48,060	62,032	63,817	29,506	35,174
Caterpillar	116,759	129,156	142,613	47,295	26,368
Mercedes Benz	33,253	44,452	51,739	36,378	19,991
Mack	25,158	36,221	36,198	18,544	16,794
Volvo	12,567	19,298	23,455	9,850	8,822
PACCAR	0	0	0	9,072	5,714
Hino	671	5,001	7,489	6,230	3,062
Total	764,168	849,621	873,853	666,147	556,869

The CAFE for light-duty vehicles is calculated from fuel consumption data using a "harmonic average."[2] The harmonic average in the CAFE standards is determined as the sales weighted average of the fuel consumption for the Urban and Highway schedules, converted into fuel economy. The average is calculated using the fuel consumption of individual vehicles times the number of vehicles sold of each model, summed over the whole fleet and divided by the total fleet.

Because fuel economy and fuel consumption are reciprocal, each of the two metrics can be computed in a straightforward manner if the other is known. In mathematical terms, if fuel economy is X and fuel consumption is Y, their relationship is expressed by $XY = 1$. This relationship is not linear, as illustrated by Figure 2-2. In this figure, fuel consumption is shown in units of gallons/100 miles, and fuel economy is shown in units of miles/gallon. The figure also shows that a given percentage improvement in fuel economy saves less and less fuel as the baseline fuel economy increases. Each bar represents an increase in fuel economy by 100 percent, which corresponds to a decrease in fuel consumption by 50 percent. The data on the graph show the resulting decrease in fuel consumption per 100 miles and the total fuel saved in driving 10,000 miles. The dramatic decrease in the impact of increasing fuel economy by 100 percent for a high fuel economy vehicle is most visible in the case of increasing the fuel economy from 40 to 80 mpg, where the total fuel saved in driving 10,000 miles is only 125 gallons, compared to

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[2] Harmonic average weighted CAFE = $\dfrac{\sum_1^n N_n}{\sum_1^n N_n \dfrac{1}{FE_1} + \ldots + N_n \dfrac{1}{FE_n}}$

where N_n = number of vehicles in class n, FE_n = fuel economy of class n vehicles and n = number of separate classes of vehicles.

F

Details of Aerodynamic Trailer Device Technology

Tables F-1 through F-3 report results from a collection of suppliers that provided trailer aerodynamic device results in more detail for trailer skirts, trailer base devices, and trailer face devices, three of the areas identified in Figure 5-9 (Chapter 5) as prime for aerodynamic device improvement in tractor-trailer combination trucks. These data are principally those returned by nine manufacturers responding to a committee questionnaire. Those responses were supplemented by information from the Web sites of four other manufacturers.

Interestingly, these most recent data on reduction of fuel consumption received from developers/manufacturers for trailer skirts (Table F-1) substantially group around 7 percent.

TABLE F-1 Trailer Skirt Information from Manufacturers

Item	Manufacturer	Qualified for SmartWay (Y/N)	Fuel Consumption Reduction (gal/mile) (%)	Evaluation Method (provide details)	Weight to Equip 53-ft Trailer, (lb)	Retail Price Equivalent for One Trailer (US$)	Estimated Annual Maintenance Cost (USD)	Other Useful Information
1	Laydon	Y	6	J1321	300	1,900	0	Very flexible meeting systems
2	FreightWing	Y	7	J1321, 62 mph	160	1,599	$50	Impact resistant; small road clearance
3	AdamWorks	Y	7	self truck test	<200	2,400	$400	Automatically deploys to 6-inch ground clearance
4	TransTex[a]	[a]	7.4	J1321, 61 mph	[a]	[a]	[a]	[a]
5	Windyne[a]	Y	6.9	J1321	[a]	[a]	[a]	Improved handling in side winds
6	ATDynamics	Y	7.4	J1321, 60 mph	175	2,200	0	Reduced road spray, 5-year warranty
7	Wabash	Y	5.6	J1321, 65 mph	250	1,625	0	12-inch ground clearance

[a] Committee questionnaire not responded to.

TABLE F-2 Trailer Base Device Information from Manufacturers

Item	Manufacturer	Qualified for SmartWay (Y/N)	Fuel Consumption Reduction (gal/ mile) (%)	Evaluation Method	Weight to Equip 53-ft Trailer (lb)	Retail Price Equivalent for One Trailer (US$)	Estimated Annual Maintenance Cost (US%)	Other Useful Information
1	ATDynamics boat tail	Y	5.1	J1321, 62 mph	175	2,800	0	Folds flat in 6 sec; improves stability
2	AeroTrailerSys[a] inflatable tail	[a]	3	[a]	[a]	[a]	[a]	Automatically deploys
3	TransTex[a] boat tail	[a]	2.9	[a]	[a]	[a]	[a]	Reduces road spray
4	AirTab vortex generators	N	2-3	Truck test, 47 mph	1	220	0	Reduces road spray

[a] Committee questionnaire not responded to.

SOURCE: Data from responses to committee questionnaire and from manufacturers' websites.

TABLE F-3 Trailer Face Device Information from Manufacturers

Item	Manufacturer	Qualified for SmartWay (Y/N)	Fuel Consumption Reduction (gal/mile) (%)	Evaluation Method	Weight to Equip 53-ft Trailer (lb)	Retail Price Equivalent for One Trailer (US$)	Estimated Annual Maintenance Cost (USD)	Other Useful Information
1	Laydon Vortex Stabilizer	N	1	J1321	40	495	0	Better performance in yaw
2	Laydon Nose Fairing	Y	2	J1321	95	795	0	No tractor interference
3	FreightWing Gap Fairing	Y	2	J1321, 65 mph	75	849	$50	Better performance with low aerodynamic tractor
4	NoseCone Eyebrow	Y?	>3	J1321?	30	—	—	For high tractor roof fairing
5	NoseCone	Y?	>4	J1321?	75	1,264	$35	No yaw effect in J1321

U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

NHTSA
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DOT HS 811 XXX October 2010

Factors and Considerations for Establishing a Fuel Efficiency Regulatory Program for Commercial Medium- and Heavy-Duty Vehicles

II. EISA's framework for developing MD/HD fuel efficiency regulations

With the passage of EISA in December 2007, Congress laid out a framework for developing the first fuel efficiency regulations for MD/HD vehicles. As codified at 49 U.S.C. § 32902(k), EISA requires NHTSA to develop a regulatory system for the fuel economy of commercial MD/HD on-highway vehicles and work trucks in three steps: a study by the NAS, a study by NHTSA, and a rulemaking to develop the regulations themselves. Although the text of the statute does not clearly mandate that the steps occur in sequence, they are most straightforwardly explained in turn.

A. NAS Study

Section 108 of EISA states that the Department of Transportation (by delegation, NHTSA) must execute an agreement with the NAS "to develop a report evaluating MD/HD truck fuel economy standards, including—

(1) an assessment of technologies and costs to evaluate fuel economy for MD/HD trucks;

(2) an analysis of existing and potential technologies that may be used practically to improve MD/HD truck fuel economy;

(3) an analysis of how such technologies may be practically integrated into the MD/HD truck manufacturing process;

(4) an assessment of how such technologies may be used to meet fuel economy standards to be prescribed under 49 U.S.C. § 32902(k); and

(5) associated costs and other impacts on the operation of MD/HD trucks, including congestion."

EISA further states that the NAS must submit the report to DOT, the Senate Committee on Commerce, Science, and Transportation, and the House Committee on Energy and Commerce not later than one year after the date on which the Secretary of Transportation executed the agreement with the NAS. NAS requested and was granted an additional six months to complete its report; thus, based on the date of execution of the ultimate agreement, the deadline for the NAS report was determined to be March 2010.[2]

The NAS Report, "Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles" (the "March 2010 NAS report" or "NAS report"), was delivered to NHTSA in pre-publication form in mid-March 2010, to

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[2] The modification to the contract is available at Docket No. NHTSA-2010-0079.

Congress in late March 2010, and was released to the public on March 31, 2010.[3] The contents of the NAS MD/HD study will be discussed below.

B. NHTSA Study

Section 102 of EISA, codified at 49 U.S.C. § 32902(k)(1), states that not later than one year after the NAS MD/HD study is published, DOT (by delegation, NHTSA), in consultation with DOE and EPA, "shall examine the fuel efficiency of commercial MD/HD on-highway vehicles and work trucks and determine

> **(A)** the appropriate test procedures and methodologies for measuring the fuel efficiency of such vehicles and work trucks;
>
> **(B)** the appropriate metric for measuring and expressing commercial MD/HD on-highway vehicle and work truck fuel efficiency performance, taking into consideration, among other things, the work performed by such vehicles and types of operations in which they are used;
>
> **(C)** the range of factors, including, without limitation, design, functionality, use, duty cycle, infrastructure, and total overall energy consumption and operating costs that affect commercial MD/HD on-highway vehicle and work truck fuel efficiency; and
>
> **(D)** such other factors and conditions that could have an impact on a program to improve commercial MD/HD on-highway vehicle and work truck fuel efficiency."

In response to the request from Senator Daniel Inouye that NHTSA complete its study within 24 months,[4] NHTSA determined that its study would need to be completed by September 2010.[5] This document constitutes the NHTSA study, in fulfillment of 49 U.S.C. § 32902(k)(1).

C. Rulemaking to Develop Regulations

Section 102 of EISA, codified at 49 U.S.C. § 32902(k)(2), states that not later than two years after completion of the NHTSA study, DOT (by delegation, NHTSA), in consultation with DOE and EPA, shall develop a regulation to implement a "commercial

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[3] National Academy of Science, Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles, "Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles," March 2010 (hereafter, "March 2010 NAS report" or "NAS report"). Available at www.nap.edu/catalog.php?record_id=12845 (last accessed Sept. 19, 2010).

[4] *See* letter from Senator Inouye to DOT Secretary Peters, October 28, 2008. Available at Docket No. NHTSA-2010-0079.

[5] The study itself was fundamentally complete by the end of September, but the agency took an additional two weeks for clean-up and finalization of the document.

MD/HD on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement." NHTSA interprets the timing requirements as permitting a regulation to be developed earlier, rather than as requiring the agency to wait a specified period of time.

Congress specified that as part of the "MD/HD fuel efficiency improvement program designed to achieve the maximum feasible improvement," NHTSA must adopt and implement

(1) appropriate test methods;

(2) measurement metrics;

(3) fuel economy standards;[6] and

(4) compliance and enforcement protocols.

Congress emphasized that the test methods, measurement metrics, standards, and compliance and enforcement protocols must all be *appropriate, cost-effective*, and *technologically feasible* for commercial MD/HD on-highway vehicles and work trucks. These criteria are different from the "four factors" of § 32902(f)[7] that have long governed NHTSA's setting of fuel economy standards for passenger cars and light trucks, so we have italicized them here for emphasis.

Congress also stated that NHTSA may set separate standards for different classes of MD/HD vehicles, and provided requirements new to § 32902 in terms of timing of regulations, stating that the MD/HD standards adopted as a result of the agency's rulemaking shall provide not less than four full model years of regulatory lead time, and three full model years of regulatory stability.

II. What were the major findings and recommendations of the March 2010 NAS report?

As discussed above, Section 108 of EISA required that NHTSA contract with the NAS to undertake a study and develop a report that evaluated medium- and heavy-duty truck fuel economy. The National Research Council (NRC) Committee to Assess Fuel

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[6] In the context of § 32902(k), NHTSA interprets "fuel economy standards" as referring not specifically to miles per gallon, as in the light-duty vehicle context, but instead more broadly to account as accurately as possible for MD/HD fuel *efficiency*. While it is a metric that NHTSA considered for setting MD/HD fuel efficiency standards, the agency recognizes that it may not be an appropriate one given the work that MD/HD vehicles are manufactured to do, and thus is proposing alternative metrics in the NPRM that this report accompanies. This issue will be discussed further below.

[7] 49 U.S.C. § 32902(f) states that "When deciding maximum feasible average fuel economy under this section, [NHTSA] shall consider technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy."

Chapter 5 considered vehicle technologies for reducing load-specific fuel consumption. The committee emphasized that the technologies that can be used to reduce fuel consumption in MD/HD vehicles vary by vehicle type, duty cycle, and the year that the technology becomes available – for example, a Class 8 tractor operating on the interstate will benefit from technologies that improve aerodynamic performance and reduce rolling resistance, but a Class 2b pickup truck will benefit little from these technologies. The chapter discusses vehicle energy balances and how energy is lost in the operation of MD/HD vehicles, and then reviews technologies and techniques for reducing the fuel consumption of these vehicles, including technologies that improve aerodynamic performance and that reduce rolling resistance, auxiliary loads, and idle. The chapter also covers mass/weight reduction, and intelligent vehicle technologies.[137]

The committee presented an energy balance for a Class 8 vehicle to map out how the energy contained in the fuel is used by the vehicle.[138] The committee discussed how energy is consumed (lost) by the engine through heat rejection to the coolant and heat loss through the exhaust, with the remaining energy being used to propel the vehicle down the road, including the energy required to overcome frictional and aerodynamic losses, and supply auxiliary loads such as the air compressor, cooling fans, air-conditioning compressor, power take-off (PTO), etc.[139] The committee also explained that the energy consumed by the different loss mechanisms and the energy required to propel the vehicle and supply auxiliary loads can vary based on the vehicle type and application.[140]

Aerodynamics: The committee stated that at highway speeds, aerodynamic loads consume more power than any other load on current tractor-trailer vehicles.[141] Aerodynamic features can significantly reduce these loads, but their value diminishes rapidly as average vehicle speed goes down, and in low-speed operation, aerodynamic features have little value.[142] The committee identified four areas of the tractor-trailer combination as critical for aerodynamic improvements: (1) tractor streamlining, (2) management of airflow around the tractor-to-trailer gap, (3) management of airflow under the trailer, and (4) management of airflow at the rear of the trailer.[143] The committee suggested that by the 2015-2020 timeframe, the use of aerodynamic features could provide fuel consumption reductions of about 15 percent for tractor-van trailer vehicles operating at 65 mph, but that the potential benefits for other classes of vehicles are significantly less.[144] The committee also cautioned that many tractor and trailer aerodynamic features are damage-prone in low-speed operation, and that the cost of repairing these features as they break may be a significant barrier to implementation for

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[137] Id. at 91.
[138] Id. at 91-92.
[139] Id.
[140] Id. at 92.
[141] Id. at 128, Finding 5-1.
[142] Id.
[143] Id., Finding 5-2.
[144] Id., Finding 5-3.

some applications, while broken aero components could also become road hazards.[145] The committee recommended that regulators require aerodynamic features to be evaluated on a wind-averaged basis that takes into account the effects of yaw, and that tractor and trailer manufacturers should be required to certify their drag coefficient results using a common industry standard.[146]

Below is a summary table of the aerodynamic feature technologies and their costs and effectiveness considered by the committee as presented in the TIAX report.

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[145] Id., Finding 5-4.
[146] Id., Recommendation 5-1.

Table II.C.6: Aerodynamic Technology Matrix

Category	Technology	FC Benefit	Cd/Crr/Wt Change	Capital cost (RPE)	Intro Year	Sales Pen.	Vocation	Baseline
Tractor	Roof top fairing, sleeper cab	7 to 10% 1	5 to 20%	(Standard) $500 to $1,000	pre-2008	63%	Van TT only	No cab aero
	Roof top deflector, day cab	4 to 7%	13%	$1,000 to $1,300	pre-2008	Most	Day cabs only	No cab aero
	Cab Side extension (aka, "side fairing")	2 to 3%	4 to 5%	$300 to $500; (Standard on some vehicles)	pre-2008	80 to 90%	Any	No cab aero
	Chassis Skirts (aka, "chassis fairing", "fuel tank fairing") -— full length	3 to 4%	4 to 7%	$1,500 to $2,000	pre-2008	45 to 60%	Long Haul, sleeper cabs	No cab aero
	Chassis Skirts (aka, "chassis fairing", "fuel tank fairing") — partial length	2 to 3%	4 to 6%	$500 to $1,200	pre-2008		Day cabs primarily	No cab aero
	Baseline Package - Smartway Aero Cab: Aero mirrors, cab side extenders, integrated sleeper cab roof fairing, aero bumper, full fuel tank fairings;	4 to 6%	22 to 25%	$2,750 to $3,500	2008 to 2010	~60%	Van TT, primarily	Compared to no aero (CD of 0.8)
	"Next generation" Smartway aero cab: Current Smartway cab, PLUS aero bumper w/underbody treatment; improved streamlining; wheel skirts	3 to 4% beyond Smartway	6 to 8%	$2,750	2012	—	Van TT, primarily	Smartway cab
Trailer	Partial Skirts (4 to 6 m)	2 to 3%	2 to 6%	$1,500 to $2,000	2010 to 2012	Demos	Many types of trailers	53' box trailer
	Full Skirts (7 to 9 m)	4 to 5%	5 to 11%	$2,000 to $4,000	2010 to 2012	Demos	Many types of trailers	53' box trailer
	Partial Gap Fairing	1 to 2%	2 to 4%	$800 to $1,000	2010 to 2012	Demos	Van TT	53' box trailer; 42" gap
	Full Gap fairing	2 to 3%	4 to 6%	$1,000 to $1,500	2010 to 2012	Demos	Van TT	53' box trailer; 42" gap
	Boat tail — structural or inflatable	4 to 6%	6.5 to 9%	$1,500 to $2,000	2010 to 2012	Demos	Van TT	53' box trailer
	Bogie Fairing – fairing for the trailer rear wheel assembly	1%	~2%	$500	2010 to 2012	Demos	Any	53' box trailer
	Hub caps	0 to 0.5%	~1%	?	2010 to 2012	Demos	Any	53' Box trailer
	Pneumatic Aero Drag Reduction - Unproven	3.5 to 4.0%	?	$2,500 - $5,250	Post-2015	Demos	Van TT	53' box trailer
	Smartway trailer – partial skirts + partial gap fairing or boat tail	5 to 6%	10 to 12%	$3,000 per trailer	2010 to 2012	Demos	Van TT	53' box trailer
	Full next-generation trailer aero – full skirts, boat tail, and full gap fairing	8 to 9%	17 to 19%	$4,000 per trailer	2013 to 2015	—	Van TT	53' box trailer
Tractor + Trailer Aero Pkgs	No aero	-10 to -12%	-22 to -25%	-	Pre-2008	—	Van TT	Smartway Tractor, 53' trailer
	Smartway Tractor	-	CD ~ 0.59	-	Pre-2008	~60%	Van TT	Smartway Tractor, 53'
	Smartway Tractor + Smartway Trailer	5 to 6%	10 to 12%	$3,000 per trailer	2010 to 2012	Demos	Van TT	Smartway Tractor, 53' trailer
	Improved Smartway Tractor + Smartway Trailer	7 to 9%	5 to 17%	$2,750 + $3,000 per trailer	2012 to 2013	Demos	Van TT	Smartway Tractor, 53' trailer
	Full Aero Tractor & Trailer	11 to 12%	22 to 24%	$2,750 + $4,000 per trailer	2013 to 2014	—	Van TT	Smartway Tractor, 53' trailer
Tractor Trailer Aero Penalties	Flat-nose Trailer	3 to 4%	7%	-	-	~20%		Smartway Tractor
	Double trailer		-10%	-	-	-		53' single
	Fender-mounted mirrors, bug deflector, etc.	-1.5 to -3%		-	-	-		53' box trailer
	Cattle hauler, car hauler, flatbed	-5 to -13%	-10 to -30%	-	-	-		53' box trailer
Class 3-6 Box and Bucket	Roof Deflector	2 to 3%	7 to 7.5%	$500 to $800	2008	<1%		No aero add-on devices;
	Fuel Tank/Chassis fairings	0.5 to 1%	2.5 to 3%	$400 to $500	2010-2012	—		
	Box Skirts	2 to 3%	4.5 to 5%	$500 to $1,000	2010-2012	Demos		
	Cab side extension or Cab/Box Gap fairing (e.g., Nosecone)	0.5 to 1%	2.4 to 2.7%	$500 to $650	2010-2012	Demos		
	Aft Box Taper	1.5 to 3%	7.6 to 8%	$1,000	2014-2015	—		
	Cab streamlining: aero mirrors, aero bumper, streamlined shape	1 to 2%	5 to 6%	$750	2010-2012	—		
	Straight Truck aero combination package	5 to 8%	20%	$3,000 to $3,500	2015	—		
Class 2b	10% Reduction in aero drag	2 to 3%	10%	$60 to $120	Continuous	-	-	
Motor Coach-Bus	Boat Tail	4 to 6%	6.5 to 9%	$1,500 to $2,000	2012-2014	-		No aero features
	Streamlining - no cost estimate	3 to 4%	6 to 8%	$2,750	2012-2014	-		No aero features
	Motor Coach Aero Combination (boat tail + streamlining	7 to 10%	13 to 15%	$4,250 to $4,750	2014-2015	-		No aero features

Auxiliary loads: The committee stated that auxiliary loads – such as compressed air needed for the braking systems, air conditioners, power-steering systems, and the alternator to charge the vehicle's battery – can consume up to 2.5 percent of fuel, so fuel consumption reductions of 1-2.5 percent are feasible.[147] The committee suggested that electrification of these auxiliaries, mostly in hybrid vehicles, will reduce some of this loss.[148]

Rolling resistance: The committee stated that technological advances have lowered the coefficient of rolling resistance of tires by roughly 50 percent since 1990, but that further reductions are expected to be less dramatic.[149] The use of low rolling resistance tires, such as wide-based singles, show 4-11 percent reductions in fuel consumption with computer models and on-road tests, depending on terrain, weight, and choice of baseline tire.[150] The committee noted, however, that very advanced low rolling resistance tires are presently not available in tire dimensions used on many Class 3-6 vehicles, and that tires with the very lowest rolling resistance levels may not be practical for all applications,[151] which will make it very challenging to have uniformly low rolling resistance for all vehicle applications.[152]

That said, the committee noted that tire pressure monitoring, automatic inflation systems, and nitrogen inflation are all effective in avoiding wasting fuel due to underinflation and improve vehicle safety.[153] The committee recommended that since there are numerous variables that contribute to the range of results of test programs, an industry standard (SAE) protocol for measuring and reporting the coefficient of rolling resistance should be developed to aid consumer selection, similar to that proposed for passenger cars.[154]

Vehicle mass (weight): Based on results from tests and computer models, the committee found that the impact of weight on truck fuel consumption will range from 0.5-1.0 percent per 1,000 lbs on level roads to over 2 percent per 1,000 lbs on hilly terrain and for driving cycles with frequent accelerations.[155] The committee stressed that these results are primarily for Class 8 combination trucks, and that for these trucks at full weight capacity, the payload-specific fuel consumption is reduced by about 2 percent per 1,000 lbs.[156] In terms of how (and how much) weight can be reduced, the committee stated that design progress and the use of lightweight materials for major components, such as the engine, drivetrain, wheels and tires, and chassis, have been estimated to save

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[147] Id., Finding 5-5.
[148] Id.
[149] Id., Finding 5-6.
[150] Id.
[151] The committee noted that tires must satisfy a range of performance criteria (besides rolling resistance, also wear, noise, traction, durability, and cost), and cited the example of tires designed for optimal mud or snow traction which typically have more void in the tread pattern as an example of a tire that generally cannot have low rolling resistance. Id. at 111-112.
[152] Id. at 112.
[153] Id. at 128, Finding 5-7.
[154] Id., Recommendation 5-2.
[155] Id., Finding 5-8.
[156] Id.

weight up to 20 percent beyond current technology – which could amount to as much as 5,000 lbs over the next decade – by the 21st Century Truck Partnership and separately by one manufacturer.[157] The committee suggested that a fuel consumption reduction of about 5 percent could be achieved.[158]

Below is a summary table of the weight reduction technologies and their costs and effectiveness considered by the committee as presented in the TIAX report.

Table II.C.7: Weight Reduction Technology Matrix

Category	Technology	FC Benefit	Cd/Crr/Wt Change	Capital cost (RPE)	Intro Year	Sales Pen.	Baseline Section No.
Tractor Trailer	WBS + aluminum wheels — benefit is included in WBS line item under tires	0 to 0.3%	100 lbs per tire	$225 per wheel + tire	2008	10%	aluminum duals
	Volume-constrained 0 to 1,000 lbs 1,000 to 2,000 lbs 2,000 to 3,000 lbs	0.4 to 0.6%	Per 1,000 lbs	$2 to $4/lb $4 to $8/lb $8 to $10/lb	Continuous	—	65K lb GVW
	Weight-constrained 0 to 1,000 lbs 1,000 to 2,000 lbs 2,000 to 3,000 lbs	2.20%	Per 1,000 lbs	$2 to $4/lb $4 to $8/lb $8 to $10/lb	Continuous	—	80K lb GVW
Refuse Hauler	0 to 1,000 lbs 1,000 to 2,000 lbs	1.4 to 2.3%	Per 1,000 lbs	$4 to $8/lb $8 to $10/lb	Continuous	—	80K lb GVW
Transit Bus	0 to 800 lbs 800 to 1,600 lbs 1,600 to 2,800 lbs	2 to 3%	Per 1,000 lbs	$2 to $4/lb $4 to $8/lb $8 to $10/lb	Continuous	—	28.5K lb GVW 4.4.3
Class 3-6 Box and Bucket	WBS + aluminum wheels -- benefit is included in WBS line item under tires	0.1% for 4 wheels	~100 lbs per tire+wheel	See WBS under tires	2008	?	steel duals
	0 to 470 lbs 470 to 940 lbs 940 to 1,650 lbs	3 to 5%	Per 1,000 lbs	$2 to $4/lb $4 to $8/lb $8 to $10/lb	Continuous	—	16.5K lb GVW
Class 2b	Weight reduction via materials substitution, up to 2%	0.6 to 0.9% per 3% saved	1 to 2%	$1 to $2/lb	2012	-	No weight reduction
	Materials substitution - Weight Reduction - 5%	0.6 to 0.9% per 3% saved	2 to 5%	$2 to $4/lb	2014	-	incremental to 2% weight
Motor Coach	0 to 1,000 lbs 1,000 to 2,000 lbs 2,000 to 3,500 lbs	0.70%	Per 1,000 lbs	$2 to $4/lb $4 to $8/lb $8 to $10/lb	Continuous	—	36K lb GVW

Idle reduction: The committee stated that there are a number of technologies and products available for reducing idle fuel use in Class 8 HD vehicles, such as automatic shut-down/start-up systems, battery-powered idle reduction systems, fuel-operated heaters (or direct-fired heaters), auxiliary power units (APUs), and truck stop electrification.[159] It is reported that up to 9 percent fuel consumption reduction is available, but it is dependent on the hotel power load factor.[160] The committee stated that it had used 5-9 percent, and TIAX had used an average of 6 percent fuel consumption reduction potential.[161]

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[157] Id., Finding 5-9.
[158] Id.
[159] Id., Finding 5-10.
[160] Id.
[161] Id.

Table II.C.8: Idle Reduction Technology Matrix

Category	Technology	FC Benefit	Cd/Crr/Wt Change	Capital cost (RPE)	Intro Year	Sales Pen.	Baseline
Tractor Trailer - Long Haul	Automatic Engine Idle Management - 0.5 gal/hr, 1,500 to 2,400 hrs/yr	3%	—	$1,000 to $4,000	2008	?	1,500 to 2,400 hours per year idling; 0.8 gal/hr
	Direct fire heater - saves 0.2 to 0.3 gal/hr 500 to 800 hrs/yr	1.3 to 2.3%	—	$1,000 - $3,000	2008	?	1,500 to 2,400 hours per year idling; 0.8 gal/hr
	Battery System – 0 gal/hr, ~10 hours of life; requires off-board charging	5 to 9%	400 to 500 lbs	$3,000 to $8,000	2008	?	1,500 to 2,400 hours per year idling; 0.8 gal/hr
	APU – 0.2 to 0.3 gal/hr, 1,500 to 2,400 hrs/yr	4 to 7%	400 to 500 lbs	$6,000 to $8,000	2009	?	1,500 to 2,400 hours per year idling; 0.8 gal/hr

Intelligent vehicle technologies: The committee found that, in general, intelligent vehicle technologies provide fuel consumption reductions by taking advantage of knowledge of the vehicle's location, terrain in the vicinity of the vehicle, congestion, location of leading vehicles, historical traffic data, and so forth, and altering the speed of the vehicle, the route the vehicle travels, or, in the case of hybrid electric vehicles, altering the power split ratio.[162] The committee cautioned, however, that these fuel savings may not show up in any fuel consumption test, but noted that a number of the technologies, such as adaptive cruise control, predictive cruise control, and navigation and route optimization, are being applied by the trucking industry even without regulation because the owners and operators view the reduction in fuel costs as good business practice.[163] The committee stated that based on experiments to date, the electronic tow bar concept of trucks traveling closely spaced in tandem can provide significantly lower fuel consumption, 8 to 15 percent, compared with the same vehicles traveling separately.

Table II.C.9: Intelligent Vehicle Technology (IVT) Matrix

Category	Technology	FC Benefit	Cd/Crr/Wt Change	Capital cost (RPE)	Intro Year	Sales Pen.	Vocation	Baseline
Driver Management and Coaching	Route Management – telematics for congestion & weather avoidance	0 to 1%	—	$400 to $800	2010	—	Any	No route management
	Engine & Driveline Management (load-based speed control, multi-torque)	1 to 2%	—	—	2009	?	Long haul	Non-controlled engine
	Adaptive cruise control — Slows according to traffic	0 to 1%	—	$2,000 to $3,000	pre-2008	10%	Long Haul	basic cruise control
	Predictive cruise control — adjusts vehicle according to topology, conditions	1 to 2%	—	$100	2012	—	Long Haul	basic cruise control +Telematic GPS system
	Speed Governor - 60 MPH	0.4 to 0.5% per MPH	—	—	pre-2008	25 to 50%	Long Haul	70MPH speed
	Training & Feedback — driving training, sweet-spot indicator, rewards, etc	1 to 4%	—	$0 to $1,600	Continuous	25 to 50%	Long Haul	No coaching

Chapter 6 considered the costs and benefits of integrating the fuel consumption reduction technologies discussed in Chapters 4 and 5 into MD/HD vehicles. The

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[162] Id. at 129, Finding 5-11.

[163] Id., Findings 5-11 and 5-12.

committee noted that while some technologies are already available in production, others are not, so reliable, peer-reviewed data on fuel-saving performance are available only for a few technologies in a few applications.[164] The committee explained that as a result, it had relied on information from a wide range of sources (including information gathered directly from manufacturers, suppliers, research labs, and major fleets), including many results that have not been duplicated by other researchers or verified over a range of duty cycles.[165] The committee also cautioned against over-reliance on unduplicated results or extrapolation to other classes of vehicles or duty cycles, and against the tendency to underestimate the problems that could emerge with pre-production technologies as they mature to commercial application.[166] The committee emphasized that extensive additional research would be needed to quantify the extent to which some technologies may be available later or at a lower level of performance than expected, and stated that regulators will need to allow for the fact that some technologies may not mature as expected.[167]

In considering technology costs, the committee discussed the fact that purchasers must weigh the cost of adding the technologies against the fuel savings that will accrue, and that as a result, many technologies may struggle to achieve market acceptance, despite the sometimes substantial fuel savings, unless driven by regulation or by higher fuel prices to push through the barriers associated with R&D and investing in new technologies.[168] The committee's methodology for evaluating the potential limits of costs and effectiveness was to group technologies into time periods based on the committee's estimate of when the technologies would be proven and available.[169]

Tractor-trailers: The committee stated that since tractor-trailer trucks have relatively high fuel consumption, very high average vehicle miles traveled, and a large share of the overall truck market, it makes sense to put a priority on fuel consumption reduction from these vehicles.[170] The committee indicated that a given percentage reduction in this vehicle category will save more fuel than a matching percent improvement in any other vehicle category, and that in fact, the potential fuel savings in tractor-trailer trucks represents about half of the total possible fuel savings in all categories of MD/HD vehicles.[171] The committee found the fuel consumption reduction potential for the tractor-trailer application in the 2015-2020 timeframe is 50.5 percent at a cost of $84,600, which results in a capital cost per percent reduction ("CCPPR") of $1,674/1 percent fuel consumption reduction.[172]

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[164] Id. at 131. In presentations to NHTSA, the committee emphasized that this situation contrasts greatly with light-duty fuel consumption reducing technologies, which have been studied extensively over the last several decades, and the committee stressed that the estimates presented in the March 2010 report should be considered with that in mind.

[165] Id.

[166] Id.

[167] Id.

[168] Id.

[169] Id.

[170] Id. at 155, Finding 6-1.

[171] Id.

[172] Id., Finding 6-2.

REDUCING THE FUEL CONSUMPTION AND GREENHOUSE GAS EMISSIONS OF MEDIUM- AND HEAVY-DUTY VEHICLES, PHASE TWO

FIRST REPORT

Committee on Assessment of Technologies and Approaches for Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles, Phase Two

Board on Energy and Environmental Systems

Division on Engineering and Physical Sciences

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6

Review of Options to Reduce Energy Use of Trailers

This chapter addresses the opportunities to reduce the energy consumed by Class 8 tractors pulling, particularly, van trailers. Following some background information, three government programs that deal with tractor-trailer fuel consumption are summarized. Next, the technologies associated with tractor and trailer aerodynamics as well as tires for both components are discussed. The contribution to life-cycle costs of tire pressure monitoring (and maintenance) systems (TPMS) and greenhouse gas (GHG) emissions will also be considered. Finally, the findings and appropriate recommendations are presented.

Because the tractor and trailer act as a system, with each part affecting the energy use of the other, options to reduce energy use of the tractor are also briefly discussed. While tractors are built for the weight Classes of 8, 7, and 6, the most populous and versatile and the default industry workhorses are Class 8 tractors. Reduced tare weight is noted as a contributor to reduced energy consumption (or, alternatively, to marginally increased payload) and is not discussed further.

A fully loaded Class 8 tractor-trailer combination operating on the interstate at a constant 65 mph typically demands over 200 hp from the engine. This power demand is principally to drive the wheels at freeway speeds to overcome aerodynamic drag and tire rolling resistance. The remaining power demand, in the absence of grade or headwinds, is to overcome drivetrain friction and to power auxiliary devices. Table 6-1 details these demands.

Class 8 tractor-trailers account for 60 percent of the fuel used by all on-road heavy-duty trucks (ICCT, 2013). The disproportionate fuel use notwithstanding, Class 8 tractor-trailers are relatively small in number because of the just-mentioned high power demands at freeway speeds (65 mph) and the high annual mileages accumulated by these vehicles (a median of about 100,000). By comparison, Class 3 to Class 6 fully loaded delivery trucks require less than a third of the power to operate at a constant urban speed of 40 mph, and they each accumulate fewer miles per year (a median of about 40,000) (NRC, 2010, Tables 2-1 and 5-2). Therefore, straight trucks with these predominately urban duty cycles will not be further considered in this chapter.

In addition to trailers towed by tractors, some trailers are also transported by rail. “Intermodal transport” refers to the movement of goods by more than one mode on a single journey (Corbett and Winebrake, 2007; Winebrake et al., 2008). Commonly, intermodal transport combines a truck mode with either ship or rail to improve shipping efficiency, reduce costs, or achieve some other desirable performance attribute. Because rail and ship are significantly less energy-intensive than truck, incentivizing the movement of goods from truck to rail or ship is one way to improve the overall efficiency of the freight transportation system (NRC, 2010, p. 175).

Containers are transported at each end of their route by truck tractors. These final segments are typically much shorter than the total journey of the container. The container is on- and off-loaded to a chassis, which completes the trailer configuration (sometimes standard van trailers are also rail transported). When the notion of adding trailer aerodynamic devices is considered later in this chapter, the potential interference of those devices with container handling must be considered.

TABLE 6-1 Operational Power Demands from Class 8 Tractor with Sleeper Cab-Van Trailer at 65 mph on a Level Road and Having a Gross Vehicle Weight (GVW) of 80,000 lb

Operating Load	Power Consumed (hp)	Power Consumed (%)
Aerodynamic	114	53
Rolling resistance	68	32
Auxiliaries	20	9
Drivetrain	12	6
Total	214	100

SOURCE: NRC, 2010, Table 5-4.

vehicles. That would give fleets direction as to which type of products they should or must use to better monitor and maintain their tires.

The author concluded that by integrating tire monitoring and inflation systems with telematics[24] systems, fleets will greatly improve their tire maintenance, fuel economy, and safety and will reduce their tire costs-per-mile and in-route breakdowns.

A recent response from NHTSA is its solicitation of input on truck tire maintenance practices to help determine the impact of TPS on commercial vehicle fuel economy. This information solicitation is to support its study on feasible fuel-economy standards for medium and heavy-duty trucks for MY2019 and beyond. [25]

FINDINGS AND RECOMMENDATIONS

Trailers

Finding: When a trailer is not owned by the tractor owner-operator (who pays for fuel), there is no incentive for the trailer owner to purchase fuel-saving devices.

Finding: In a survey of trailer manufacturers responsible for two-thirds of industry sales, it was found that only 40 percent of new van trailers come equipped with fuel-saving aerodynamic devices such as side skirts, which suggests that fuel saving is not a dominant consideration in purchasing a new van trailer.

Finding: Only a few van trailer manufacturers promote use of aerodynamic-device-equipped trailers on their websites; others will install devices if requested by the customer, who chooses from an option list.

Finding: The benefits and favorable return on investment that result from more efficient van trailers have been demonstrated by testing and fleet feedback. Use of trailer aerodynamic devices on van trailers, in particular side skirts, provides a full return on investment through fuel savings in about 1 year, on average. Yet the majority of both new and in-use van trailers currently do not use these fuel-saving devices.

Finding: A California regulation requires operators of van trailers to use aerodynamic devices to reduce the energy required to pull them. Observations made in California and Arizona showed a greater proportion of trailers with aerodynamic devices than did those observations made in Oregon, Texas, Michigan, Pennsylvania, and Maryland. Side skirts were overwhelmingly the predominant aerodynamic devices strategy. Other strategies (underbody fairings and rear fairings) were observed in relatively few instances.

Finding: Trailer manufacturers report that compliance with California's regulation is of greater interest than fuel savings when decisions are made on new van trailer purchases. This suggests it is doubtful that the U.S. fleet's use of fuel-efficient trailers will become universal in the absence of a regulation or other strong incentive.

Recommendation 6.1: NHTSA, in coordination with EPA, should adopt a regulation requiring that all new, 53 ft and longer dry van and refrigerated van trailers meet performance standards that will reduce their fuel consumption and CO_2 emissions. The lead time to implement this regulation should be evaluated independently from lead time requirements applicable to the next set of standards for new engines and tractors, because less time is needed to perform compliance testing and install aerodynamic devices on new trailers. The agencies should also collect real-world data on fleet use of aerodynamic trailers to help inform the regulation.

Finding: The current SmartWay program and CARB regulation address only the most commonly used trailer, the 53 ft or longer van trailer, which, among those manufacturers surveyed by the committee, accounts for about 60 percent of the trailers that could benefit from the use of aerodynamic devices. Use of aerodynamic devices on other types of trailers, such as container/chassis and shorter vans, including dual trailers ("pups"), could provide additional fuel savings of 4 to 9 percent per tractor-trailer, according to industry estimates. Fuel savings from the use of side skirts have also been demonstrated on flatbed trailers. The cost-effectiveness of using aerodynamic devices on these additional categories of trailers depends on their annual mileage and average speed, among other considerations such as access to the trailer underbody, and needs further assessment and quantification.

Recommendation 6.2: NHTSA, in coordination with EPA, should determine whether it would be practical and cost-effective to include along with the regulation of van trailers the regulation of other types of trailers such as pups, flatbeds, and container carriers, as doing so could substantially increase overall fuel savings.

Finding: Both trailer and aerodevice manufacturers report that based on replicate tests and testing across different facilities, fuel consumption results determined by the SAE J1321 test procedure lack the necessary precision for accurately assessing the small incremental improvements provided by aerodynamic devices. Depending on the device evaluated, the procedure-specified precision range can be as much as 100 percent of the result.

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[24] Denotes the use of devices that incorporate both telecommunications and informatics. See, for example, www.telematics.com.

[25] TireBusiness.com, "NHTSA to Study Mileage Impact of Truck TPMS," December 14, 2012.

Peer Review of the Greenhouse Gas Emissions Model (GEM) and EPA's Response to Comments

Phase II

United States
Environmental Protection
Agency

Peer Review of the Greenhouse Gas Emissions Model (GEM) and EPA's Response to Comments

Phase II

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Prepared for EPA by
Versar, Inc.
EPA Contract No. EP-C-12-045
Work Assignment No. 44

EPA United States Environmental Protection Agency

EPA-420-R-15-009
June 2015

A. INTRODUCTION

EPA, the National Highway Traffic Safety Administration (NHTSA), and the California Air Resources Board (CARB), in looking to reduce greenhouse gas emissions (GHG) and to improve fuel efficiency in medium- (MD) and heavy-duty (HD) vehicles, are considering recognizing the efficiency of various powertrain technologies within the context of any new full vehicle emission standard(s). For this option, it becomes critical to develop methods that assess the expected real world performance of those technologies, including vehicle engine, transmission and axle technologies.

Enhancements have also been made to their HD vehicle simulation software tool, GEM (Greenhouse Gas Emission Model). At present, GEM is used by vehicle manufacturers to certify the expected GHG emissions of their products. With the enhancements, GEM could potentially have the ability to model a majority of the advanced technologies being incorporated into these vehicles and their engines and that are being recognized by engine and chassis dynamometer emission testing today.

EPA and the other agencies consider the GEM tool as a principal support for the second round of HD GHG emissions regulations which are under development at the present time in both NHTSA and EPA. The model has undergone a formal peer review in an earlier iteration of the GEM tool (Phase I) and this newest version of GEM (Phase II) is the subject of this peer review.

EPA is looking to assure the regulated community of the high quality of the agencies' predictive tool and that the proposed structure (and overall development process) of the GEM model results in a tool that is simple, accurate and well-suited for the diversity of vehicles to which it may be applied. The purpose of the requested peer review is for EPA to receive written comments from experts on the concepts and methodologies upon which GEM relies and whether or not the model can be expected to execute these algorithms correctly.

The purpose of the requested letter review is for EPA to receive written comments from individual experts on GEM Phase II tool and supporting documentation ("Vehicle Simulation Model").

Versar selected four senior scientists with expertise/experience in the following areas to serve as peer reviewers. The reviewers are familiar with the use of models to characterize vehicle simulations/operations; specifically, model design and model code and logic. Additionally, reviewers have expertise in one or more of the following areas:

- vehicle operations and analysis, including the physical process of generating and controlling vehicle emissions;
- linkages between mobile source emission modeling and transportation modeling and planning; and
- application of current mobile source emissions models, w.r.t., heavy-duty vehicles, for analysis for regulatory purposes and/or policy evaluation, e.g., HD GHG Notice of Proposed Rulemaking.

Peer Reviewers:

Christopher M. Atkinson, Sc.D.
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Table 3. Charge Question 2

Charge Question 2: Please comment on the appropriateness and completeness of the contents of the overall model structure and its individual systems and their component models (i.e., using the MATLAB/Simulink version), if applicable, and considering the following:

a) Elements in each system used to describe different vehicle categories;

Reviewer Name	Reviewer Comment	EPA Response to Comment
Reviewer 1	The proposed GEM Phase II model represents a substantial advance over the model used to implement the first phase of truck efficiency legislation, and encourages more technology advances from manufacturers in consequence. Improvements in truck efficiency are based primarily on reductions in aerodynamic drag, tire rolling resistance and engine brake specific fuel consumption, and this was recognized in the first GEM model. Practically, there is less to be gained from aerodynamic improvements in most vocational truck operation than in long haul trucking and the GEM model as presented neglects vocational truck aerodynamics, and the modelers are right to exclude aerodynamic parameter entries for low speed trucks. However, the overall GEM structure is capable of modeling aerodynamic improvements for niche vocational designs, and has the flexibility to extend beyond the present exclusion of the drag coefficient. In this way, the capabilities of the model, as received, will be far greater than the executable version that is finally used for compliance. A major theme in the industry is that efficiency gains are significant from design integration, particularly powertrain integration. But it is understood that combined powertrain control is proprietary. The supporting language might address this more clearly, noting that the GEM model employs just steady-state maps and a defined set of gear ratios, and cannot predict the benefits of more sophisticated integration. In a	The comments on gasoline and natural gas engines are well taken. The agencies are currently conducting a program at SwRI to address gasoline engine performance related to the rulemaking. We are also actively collecting the engine performance data on both types of engines from manufacturers. The GEM Phase 2 shift algorithm is based on the torque curve and fuel map of the engine and such will adapt shift points uniquely for every engine map provided, regardless of fuel type. Manufacturers will have the option to perform powertrain testing to account for improvements, such as those mentioned by the reviewer. The agencies are seeking comment on whether to include GEM inputs for vocational vehicle aerodynamics in the preamble to the HD Phase 2 NPRM.

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	similar fashion GEM cannot predict the benefits of learning algorithms, look-ahead strategies and intelligent vehicle systems for the optimization of powertrain efficiency on specific routes. These are emerging approaches, but it is acknowledged that it would take great effort to configure GEM to deal with these details and it would be difficult to assure their generic benefit in revenue service. GEM has some check-a-box options proposed for features that cannot be modeled. The model, as provided, was oriented to diesel engines. The shift strategies also considered the engine torque curve for execution. Naturally aspirated gasoline, boosted gasoline and natural gas engines are likely players in the next five years and may warrant separate and careful consideration because their characteristics, torque curves and efficiency maps differ substantially from the diesel engine properties.	
Reviewer 2	Overall the model structure and its systems are appropriate and, in large part, complete. Generally, the performance of each component model and the underlying equations and physical principles are valid throughout (see some finer details below). The input and output structures interact with the model to obtain the expected result in a way that is sound. The following sub-sections comment on specific issues regarding model structure, individual systems, as well as default values, in no particular order of importance. <u>Fixed payloads</u> Phase 1 GEM had predefined engines, driveline parameters, and payloads for every category. An issue that may arise when	Fixed Payload The agencies are fully aware of the technical issues related to payload. However, allowing payload as a variable means that agencies must develop a standard that varies with payload, which would complicate the rulemaking, specifically the process of certification. Furthermore, it would be challenging to verify the in-use payload of a vehicle application, making audit challenging. In addition, this approach would force tractors running without trailer, or bobtail, to be considered

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<tr><td></td><td>using user-defined engine fueling maps in combination with predefined payloads is that some simulated vehicles, with lower power-to-weight ratios, will show higher deviations from the target speed-distance trace. This affects the simulation results since these underpowered vehicles will take more time to complete the assigned route and will show a lower average speed. This could lead to underpowered vehicles being improperly credited.

Appropriate matching of engine, transmission gear ratios, axle ratios, and tire radius is only going to be promoted if the GEM payloads closely match actual vehicle operation. Right sizing of powertrains to application does not seem to be promoted when payloads are predefined for a particular vehicle category. In order to recognize engine power matching to vehicle road load, payload needs to be a user input rather than a predefined parameter. The regulatory approach and modeling would ideally recognize and promote market diversity and identify potential discrepancies between actual payloads and GEM payloads. There is an existing trend towards smaller engines, but also some applications require larger engines. On the other hand, if the truck manufacturer is allowed to input vehicle-specific payloads, some issues may arise in terms of enforceability (How do the regulatory agencies ensure that the vehicles are operated close to the payload values at which they were certified?), that may also open the door for the manufacturers to report numbers for their own benefit, and adds complexity.</td><td>out of compliance because they are not carrying the declared payload. Therefore, the agencies simplify the process by proposing fixed payload values.

Pull-Down Technologies

Pull-down technologies are also known as the technology improvement inputs for the rulemaking. The supporting document, "Vehicle Simulation Model" and the HD Phase 2 NPRM preamble describe many aspects of the pull-down technologies. We also seek comment on whether the technology improvement inputs should be in terms of percent reduction or absolute grams of CO_2 per ton-mile. Basically, the agencies have been actively talking to all relevant manufacturers regarding these technologies as selectable items. We proposed a conservative approach recognizing these potential technologies. All the technologies considered as pull-downs would be those that GEM would not be able to model or are not fully recognized over the limited certification drive cycles. Technologies mentioned by this reviewer, such as electric coolant pumps would only show a partial benefit in the engine fuel mapping process, and therefore the pull-down item associated with it accounts for the other remainder of the benefit seen on the road.</td></tr>
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	An option could be to adjust the payload on a few pre-defined bins based on certain parameters that are indicative of vehicle road load (e.g. engine displacement, engine power, final drive ratio). Under this option, a performance criterion that captures the trace-following capabilities of the simulated truck (e.g. a set threshold of percent difference between target speed and simulated speed) can be used to force certain engine-vehicle combinations to switch to a lower payload bin if they don't follow the trace according to the specified criterion. Another option would be to impose a CO2 penalty based on the ratio of simulated average speed to target average speed. Ideally, the allowed deviations from the target trace should be minimized for the simulations to be considered valid and allow comparisons between them. Drop-down technologies The agencies have identified a list of technologies that provide fuel consumption benefits but are difficult to simulate accurately. They are developing feature-based drop-down menus that make post-simulation adjustments (percent reductions) to the results. It appears that manufacturers have not taken much advantage of the Phase 1 advanced technology structure to earn credits so it is important to try to include most of the technologies in some way. However, drop-down menus inherently assume that all the technology variants within a technology category provide the same fuel consumption benefits. Not all the models and brands of a certain technology feature would provide the same fuel consumption benefits. There is the risk of giving artificial credits to products that	Although these values used by GEM are fixed as default values, the user does have the option to use off-cycle credit proposed by the rule, similar to the innovative credits in Phase 1, to quantify the additional benefits of individual technology. Driver Subsystem All the driver model related constants are not tunable. We tested these pre-selected PI controller related constants against over 130 vehicle variants without any noticeable issues. In addition, the driver controller constants are scaled by vehicle mass and therefore adjust automatically for each simulation run. Transmission The auto-shifting tables for all three types of transmissions are different in the form of internal constants which are not user-tunable. The supporting document, "Vehicle Simulation Model", and HD Phase 2 NPRM Draft RIA Chapter 4 includes a table to show the impacts of the shift algorithm on overall vehicle performance as opposed to using manufacturer-supplied shift tables. We agree with the reviewer that we need to provide a clearer description of this subject and it will be clarified in Draft RIA Chapter 4.

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	perform at a lower level than the value that is selected from the drop- down menu, thus rewarding poor performers. Also, technology products with better than average levels of performance would not get additional credits, which is a disincentive to make investments in the development of such technologies. The default improvement values (percent reductions) developed by the agencies were not shared for this peer review but they are of relevance and need to be determined with care. Currently, the users have no flexibility to enter their own values. Giving the users the flexibility to enter their own values (after testing and with proper documentation) could offer a way to reward good performers. It seems that applying adjustment factors in terms of percent reductions rather than applying predefined credits in units of go2/ton-mile or gal/ton-mile may punish good performers. Assuming that truck A emits 90 go2/ton-mile and truck B emits 100 gCO2/ton-mile. If a certain technology improvement value is set at 5%, and both trucks use such technology, truck A would get 4.5 gCO2/ton-mile credit and truck B would get 5 gCO2/ton-mile credit. This discrepancy of incentives can exacerbate if the trucks use more than one drop-down technology and the agencies decide that the percent improvements are additive. So it would be good for the agencies to support whether and why percentage-based (versus gCO2/ton-mile based) are most appropriate. Also the agencies might address, in such drop-down menus whether such technology improvements are indeed additive or not. Another issue with drop-down technologies is that there is the	We fully agree with the reviewer's comments on the powertrain test. As a matter of fact, the powertrain test is one of the options that manufacturers can use to address benefits GEM is unable to fully capture. Engine Fuel maps The proposed engine fuel mapping procedure is detailed in the proposed regulations in 40 CFR part 1036. It is always challenging to use a steady state map approach to account for transient operation. While there are many ways that the vehicle model can be improved for those behaviors, there are always trade-offs in terms of computational speed and accuracy. Furthermore, including more advanced models, such as model based control could substantially improve accuracy, but the collection of test data plus calibration of the model against the data would be beyond the agencies' capabilities, and could be expensive, time consuming and error-prone. This kind of advanced modeling could take much longer to run as opposed to the proposed executable version of GEM, which only takes a few seconds to complete one certification vehicle. It is very typical for a vehicle manufacturer to run thousands of

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	potential for double counting of technology benefits. As an example, an electric coolant pump is listed as a drop-down technology. Depending on the engine mapping process, the resultant engine fuel map may already capture the benefits from that technology. Running a simulation with such a map, and later improving the results using a drop-down menu will double count the benefits. If EPA could respond to how potential double-counting situations are minimal, that would be helpful. Driver subsystem In vehicle simulation modeling, it would seem that the driver ideally would be excluded entirely as a factor that could influence the GEM regulatory compliance results. Using the same driver model for all the vehicles seems to be an appropriate choice. However, additional documentation is needed for this subsystem. There are no details about how the proportional and integral gains of the PI controller have been selected. Are they representative of current drivers? Are they tuned to enhance the trace-following capabilities of the model? The look- ahead feature also lacks documentation. Is it bringing any advantage to the trace-following capabilities of the model? How was the time span value for such feature selected? Ideally EPA would provide some consideration and discussion of such factors to provide greater assurance that no anomalies occur in compliance results from company-to-company technology strategies as well as tested-versus-real-world results for the relative technology benefits. Transmission subsystem	simulations for certification. It is not practical to introduce such complicated modeling processes to perform certification at this time. We propose a single transient factor in the HD Phase 2 NPRM, as the reviewer recommended. We are also seeking comment on the transient correction factor. Modeling of idle cycle The HD Phase 2 NPRM described in Chapter 2 of the Draft RIA and Preamble Section V provides more detailed description on modeling of the idle cycle. Regarding "trace following" and the idle calculation, for tractor-trailers the idle weight is zero and the simulation grams/mile are multiplied by target mph and also divided by target mph so what remains is simulation grams/mile which will reflect the modeled performance (or under-performance) of the vehicle. For vocational vehicles the same is true with regards to the simulation grams/mile over the drive cycles. Idle consumption takes places at zero speed and is measured in grams/hour so there is a

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	There are some transmission-related features that are confusing and need to be clarified. The report mentions that the different transmission models: manual (MT), automated manual (AMT), and torque converter automatic (AT) are built of similar components, but each features a unique control algorithm. However, the model seems to use the same "auto shift algorithm" to determine the operating gear for any transmission type. The differences in the control algorithm of the three different transmissions are not clear and need to be provided. Since transmissions are an important new addition for Phase 2 GEM, it is important to let the reader know that the control strategy (e.g. shift points) or the selection of predefined transmission parameters (e.g. efficiencies and inertias at different gears) are not creating any artificial advantage of one technology type over the others. I suggest presenting a comparison of the same simulated truck with different transmission types. It is also important to highlight in the report that the new transmission controller is based on both speed and throttle position, and differs from the Phase 1 transmission controller, which was solely based on vehicle speed. The rule-based approach of the "auto shift algorithm" would ideally be documented. It would be appropriate for the agencies to acknowledge that Phase 2 GEM simulations can capture some but not all of the benefits of powertrain integration. The simulation would adequately capture engine down speeding since the users have to input specific transmission gear ratios, final drive ratio, and tire radius. However, there are many complexities in the control	conversion factor required to obtain grams/mile. The target weighted average speed represents that conversion factor and does not alter the modeled vehicle performance (or under-performance) over the drive cycles. <u>Trailer</u> The HD Phase 2 NPRM described in Chapter 2 of the Draft RIA and Preamble Section VI provides more detailed description on how trailers are handled. Tractor manufacturers determine the coefficient of drag area for a tractor-trailer combination. The trailer used in this determination is a "reference trailer" that is specified in the regulations (40 CFR part 1037). Details of the test procedures for the tractors are included in the HD Phase 2 NPRM Section III. <u>Accessories</u> The agencies chose the same approach as Phase 1 to model accessories, mainly because it is not an easy task to model accessory improvements, which requires time consuming and expensive testing and validation of the model. Allowing user input of accessory loads would require each user to know ahead of time the expected load for each vehicle in use and while potentially providing more accurate

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<tr><td></td><td>strategy when it comes to integrating engine and transmission. Integrated engine-transmission powertrain approaches with advanced controls and shifting algorithms that many companies are developing could result in significantly more (or less) benefit than the agencies determine as the appropriate default emission-reduction effect.

As an example, if two different vehicles have the same driveline parameters (tire radius, final drive ratio, transmission gear ratios, transmission inertias, and transmission efficiencies) and AMT transmissions from different manufacturers, they will obtain the same simulation results in GEM but, due to differing control strategies and other design characteristics, they will show different fuel consumption benefits in reality. It cannot be expected that all the AMT transmissions bring the same fuel consumption benefits. The drop-down menu option won't handle these differences unless there is an option to choose manufacturer-specific transmissions or otherwise input such data.

As a result, there is an opportunity here to leverage the powertrain testing and provide the option for manufacturers to better capture the fuel efficiency gains coming from the control strategies and other complexities that are not adequately captured in GEM. Another advantage of powertrain testing is that the manufacturers would not need to disclose confidential information. The results from powertrain testing can then be implemented as correction factors for the GEM results. Using correction factors, GEM results could be multiplied by a fixed</td><td>results would place an unreasonable burden on the user and manufacturers. If the accessory is normally part of the engine, the engine mapping conducted on the dynamometer should be able to account for some of those losses, thus being modeled through the engine fuel map. If accessory improvement comes from the vehicle, and GEM is unable to model it, manufacturers can either use pull-down technology or use innovative credit to recognize these accessories.</td></tr>
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<tr><td></td><td>percent improvement obtained by comparing the results of powertrain test and GEM simulations under the same torque-speed trace.[4] The default benefits for transmission improvements would ideally be set to be appropriately conservative (i.e., lowest expected value based on various industry results) in GEM. The drop-down menu could still then be offered as a default, for the manufacturers that decide not to use the powertrain testing. Then, for the powertrain option, companies would ideally be provided clear testing procedures and guidance to demonstrate the emission-reduction impact of their advanced powertrain approaches with physical vehicle testing in simulated real-world conditions.

<u>Engine fueling maps</u>
The inclusion of manufacturer-specific engine maps is a critical feature to reflect company differences and detailed engine-specific characteristics that reflect real-world fuel consumption and emissions. This is an important addition to GEM, but there is lack of documentation of the engine mapping procedure. I imagine that a fairly prescriptive procedure (including number of points, preconditioning and warming procedures, fuel properties, etc.) is described somewhere else in the larger regulatory development document but this chapter would ideally include a brief description of the procedure so the reader knows which engine accessories are included or excluded during the engine mapping procedure.

It is noted that there are many advanced features that may affect fueling but are not captured by using a steady-state fuel</td><td></td></tr>
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	map. Manufacturers are going away from traditional map-based strategies and are going towards model-based controls. Diverse thermal management strategies are utilized, and some engines use dual torque curves. Have the agencies considered how to handle these technologies? This could have important implications for how tested steady-state engine maps, and GEM modeling, and real-world emissions characteristics could differ. As a result, we recommend that the agencies discuss such industry approaches in the rulemaking and investigate ways to ensure that tested results are aligned with real-world engine and vehicle operation the results in fuel consumption and emissions. The approach used to quantify the transient correction factor (run GEM with the engine map, then use the torque-speed points in the engine dynamometer and compare measured versus simulated results) is appropriate. Ideally the transient correction factor may be obtained for each individual engine. However, since there is a need for selection of a vehicle in GEM in order to get the torque-speed trace. It would become a hard task for the agencies to try and run a transient correction factor for each vehicle-engine configuration. For practicality, I recommend provisionally using a single correction factor and maintaining the option to refine it over the years with additional testing. <u>Modeling of idle cycle</u> The idle cycle modeling would gain from increased documentation. Using a gCO2/mile value for an idle cycle at	

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<tr><td></td><td>first seems counterintuitive (i.e., there are no miles traveled) so a complete description of the calculation method would clarify. It would be desirable to present some validation results for the idle cycle modeled in GEM compared to experimental results. Some of the engine auxiliaries may not be enabled while doing the test, and the map could be underestimating actual idle speed fueling rates. There are also engine thermal management strategies that are used to keep appropriate after treatment system temperatures. These strategies vary from manufacturer to manufacturer and could increase idle fueling substantially.

The "trace following" issue discussed above also has implications in the calculation of idle cycle g/mile value. For this calculation the fuel rate in units of grams per hour [g/h] is converted to units of grams per mile [g/mile] using the weighted average speed over the three non-idle cycles. The target speed is used for this calculation and not the actual simulated speed, which may penalize smaller engines. I suggest EPA to consider if this issue might be significant.

<u>Trailers</u>
Although there is a parameter in GEM for trailer tires' rolling resistance, it is not clear how trailer aerodynamics is going to be modeled in GEM. Trailer aerodynamics can bring about two-thirds of tractor-trailer aerodynamic benefits, so this is a critical area that requires documentation and specification of the procedures for the vetting, binning, and including the input data. My understanding is that the Coda input parameter is for the tractor only (mid-roof and low roof tractors are tested in its</td><td></td></tr>
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	bobtail configuration), or for the tractor using a "reference" 53-ft dry van trailer (for high-roof tractors coast-down test). Trailer aerodynamic devices can reduce the overall tractor-trailer combination aerodynamic drag and ideally the Coda used in simulation should represent the combination. It seems that there is no current provision to include the effect of trailer aerodynamics as an input in GEM. The report needs to clarify how the GEM model is handling trailer parameters (including aerodynamics, tires rolling resistance, and weight reduction) and if the model is going to use a predefined "reference" trailer for all the tractors. Ideally agencies would give credit to tractor-trailer integrated designs although it would be difficult for the agencies to ensure in-use compliance of matching of tractors and trailers. <u>Accessories</u> There are opportunities for fuel savings from mechanical accessories and electric accessories but the agencies decided to keep with the Phase 1 approach of having pre-defined and not customizable power from accessories. If these parameters are assigned default values, there are no incentives to implement new technologies that could have greater impact. Allowing accessories power consumption to be user-defined inputs can be used to promote developments in technologies that reduce the power requirements of accessories such as the alternator, air-conditioning compressor, power steering pump, or cooling fan. There are other opportunities for engine accessories such as oil, coolant, and fuel pumps, but is not clear at this point if all those savings are going to be captured by the engine	

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	mapping process. References: [4] See Sharpe, Delgado, Muncrief (2015) Comparative assessment of heavy-duty vehicle regulatory design options for U.S. greenhouse gas and efficiency regulation. http://www.theicct.org/us-phase2-hdv- regulation-design-options	
Reviewer 3	The elements in each of the systems (engine, transmission, axle, vehicle attributes etc.) seem appropriate and complete. The specific selection of the engines and transmissions chosen will cover a large portion of the current heavy-duty vehicle fleet, although of course any specific, single selection of powertrain hardware or powertrain hardware attributes necessarily limits the range of vehicles that can be simulated with that same selection.	Non-conventional or alternative powertrains can be certified through powertrain testing.
Reviewer 4	The three main powertrain components that can affect fuel economy and greenhouse gas emissions in a vehicle are: engine fuel map, transmission type and efficiency map, and vehicle aerodynamic improvements (including tire rolling friction improvements and weight reduction technologies). In this regard, GEM-II addresses all the aforementioned components by providing steady state maps for each powertrain component, which an informed user can change to represent specific technology improvements. GEM-II comes with certain standard transmission models, namely: manual, automatic, and automated manual transmissions. The user would select the appropriate transmission and GEM-II would automatically select the user-specified transmission.	The proposed Phase 2 version of GEM for certification is an executable version code, which does not require Matlab/Simulink license. In additional, a plain text formatted file will be used for user inputs. There is no need for user to understand the coding structure of GEM in a Matlab/Simulink format. Neither manufacturers nor users will be able to modify the structure of GEM in any way. The Phase 2 GEM User Guide, provided with the NPRM, will provide details on how to use GEM. A technology improvement such as a proprietary

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 9, 22, 85, 86, 600, 1033, 1036, 1037, 1039, 1042, 1043, 1065, 1066, and 1068

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 512, 523, 534, 535, 537, and 538

[EPA–HQ–OAR–2014–0827; NHTSA–2014–0132; FRL–9927–21–OAR]

RIN 2060–AS16; RIN 2127–AL52

Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2

AGENCY: Environmental Protection Agency (EPA) and Department of Transportation (DOT) National Highway Traffic Safety Administration (NHTSA)

ACTION: Proposed rule.

SUMMARY: EPA and NHTSA, on behalf of the Department of Transportation, are each proposing rules to establish a comprehensive Phase 2 Heavy-Duty (HD) National Program that will reduce greenhouse gas (GHG) emissions and fuel consumption for new on-road heavy-duty vehicles. This technology-advancing program would phase in over the long-term, beginning in the 2018 model year and culminating in standards for model year 2027, responding to the President's directive on February 18, 2014, to develop new standards that will take us well into the next decade. NHTSA's proposed fuel consumption standards and EPA's proposed carbon dioxide (CO_2) emission standards are tailored to each of four regulatory categories of heavy-duty vehicles: Combination tractors; trailers used in combination with those tractors; heavy-duty pickup trucks and vans; and vocational vehicles. The proposal also includes separate standards for the engines that power combination tractors and vocational vehicles. Certain proposed requirements for control of GHG emissions are exclusive to EPA programs. These include EPA's proposed hydrofluorocarbon standards to control leakage from air conditioning systems in vocational vehicles, and EPA's proposed nitrous oxide (N_2O) and methane (CH_4) standards for heavy-duty engines. Additionally, NHTSA is addressing misalignment in the Phase 1 standards between EPA and NHTSA to ensure there are no differences in compliance standards between the agencies. In an effort to promote efficiency, the agencies are also proposing to amend their rules to modify reporting requirements, such as the method by which manufacturers submit pre-model, mid-model, and supplemental reports. EPA's proposed HD Phase 2 GHG emission standards are authorized under the Clean Air Act and NHTSA's proposed HD Phase 2 fuel consumption standards authorized under the Energy Independence and Security Act of 2007. These standards would begin with model year 2018 for trailers under EPA standards and 2021 for all of the other heavy-duty vehicle and engine categories. The agencies estimate that the combined standards would reduce CO_2 emissions by approximately 1 billion metric tons and save 1.8 billion barrels of oil over the life of vehicles and engines sold during the Phase 2 program, providing over $200 billion in net societal benefits. As noted, the proposal also includes certain EPA-specific provisions relating to control of emissions of pollutants other than GHGs. EPA is seeking comment on non-GHG emission standards relating to the use of auxiliary power units installed in tractors. In addition, EPA is proposing to clarify the classification of natural gas engines and other gaseous-fueled heavy-duty engines, and is proposing closed crankcase standards for emissions of all pollutants from natural gas heavy-duty engines. EPA is also proposing technical amendments to EPA rules that apply to emissions of non-GHG pollutants from light-duty motor vehicles, marine diesel engines, and other nonroad engines and equipment. Finally, EPA is proposing to require that rebuilt engines installed in new incomplete vehicles meet the emission standards applicable in the year of assembly, including all applicable standards for criteria pollutants.

DATES: Comments on all aspects of this proposal must be received on or before September 11, 2015. Under the Paperwork Reduction Act (PRA), comments on the information collection provisions are best assured of consideration if the Office of Management and Budget (OMB) receives a copy of your comments on or before August 12, 2015.

EPA and NHTSA will announce the public hearing dates and locations for this proposal in a supplemental **Federal Register** document.

ADDRESSES: Submit your comments, identified by Docket ID No. EPA–HQ–OAR–2014–0827 (for EPA's docket) and NHTSA–2014–0132 (for NHTSA's docket) by one of the following methods:

- *Online: www.regulations.gov:* Follow the on-line instructions for submitting comments.
- *Email: a-and-r-docket@epa.gov.*
- *Mail:*

EPA: Air and Radiation Docket and Information Center, Environmental Protection Agency, Mail code: 28221T, 1200 Pennsylvania Ave. NW., Washington, DC 20460.

NHTSA: Docket Management Facility, M–30, U.S. Department of Transportation, West Building, Ground Floor, Rm. W12–140, 1200 New Jersey Avenue SE., Washington, DC 20590.

- *Hand Delivery:*

EPA: EPA Docket Center, EPA WJC West Building, Room 3334, 1301 Constitution Ave. NW., Washington, DC 20460. Such deliveries are only accepted during the Docket's normal hours of operation, and special arrangements should be made for deliveries of boxed information.

NHTSA: West Building, Ground Floor, Rm. W12–140, 1200 New Jersey Avenue SE., Washington, DC 20590, between 9 a.m. and 4 p.m. Eastern Time, Monday through Friday, except Federal holidays.

Instructions: EPA and NHTSA have established dockets for this action under Direct your comments to Docket ID No. EPA–HQ–OAR–2014–0827 and/or NHTSA–2014–0132, respectively. See the **SUPPLEMENTARY INFORMATION** section on ''Public Participation'' for more information about submitting written comments.

Docket: All documents in the docket are listed on the *www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.,* confidential business information or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available either electronically through *www.regulations.gov* or in hard copy at the following locations:

EPA: Air and Radiation Docket and Information Center, EPA Docket Center, EPA/DC, EPA WJC West Building, 1301 Constitution Ave. NW., Room 3334, Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742.

NHTSA: Docket Management Facility, M–30, U.S. Department of

TABLE I–3—SUMMARY OF PHASE 1 AND PROPOSED PHASE 2 REQUIREMENTS FOR CLASS 7 AND CLASS 8 COMBINATION TRACTORS

	Phase 1 program	Alternative 3—2027 (proposed standard)	Alternative 4—2024 (also under consideration)
Covered in this category	Tractors that are designed to pull trailers and move freight.		
Share of HDV fuel consumption and GHG emissions.	Combination tractors and their engines account for approximately two thirds of fuel use and GHG emissions in the medium and heavy duty truck sector.		
Per vehicle fuel consumption and CO_2 improvement.	10%–23% improvement over MY 2010 baseline, depending on tractor category. Improvements are in addition to improvements from engine standards.	18%–24% improvement over MY 2017 standards.	
Form of the standard	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons of fuel/1,000 ton payload mile.		
Example technology options available to help manufacturers meet standards.	Aerodynamic drag improvements; low rolling resistance tires; high strength steel and aluminum weight reduction; extended idle reduction; and speed limiters.	Further technology improvements and increased use of all Phase 1 technologies, plus engine improvements, improved and automated transmissions and axles, powertrain optimization, tire inflation systems, and predictive cruise control (depending on tractor type).	
Flexibilities	ABT program which allows emissions and fuel consumption credits to be averaged, banked, or traded (five year credit life). Manufacturers allowed to carry-forward credit deficits for up to three model years. Interim incentives for advanced technologies, recognition of innovative (off-cycle) technologies not accounted for by the HD Phase 1 test procedures, and credits for certifying early.	Same as Phase 1, except no extra credits for advanced technologies or early certification.	

(c) Summary of the Proposed Trailer Standards

This proposed rule is a set of GHG emission and fuel consumption standards for manufacturers of new trailers that are used in combination with tractors that would significantly reduce CO_2 and fuel consumption from combination tractor-trailers nationwide over a period of several years. As described in Section IV, there are numerous aerodynamic and tire technologies available to manufacturers to accomplish these proposed standards. For the most part, these technologies have already been introduced into the market to some extent through EPA's voluntary SmartWay program. However, adoption is still somewhat limited.

The agencies are proposing incremental levels of Phase 2 standards that would apply beginning in MY 2018 and be fully phased-in by 2027. These standards are predicated on use of aerodynamic and tire improvements, with trailer OEMs making incrementally greater improvements in MYs 2021 and 2024 as standard stringency increases in each of those model years. EPA's GHG emission standards would be mandatory beginning in MY 2018, while NHTSA's fuel consumption standards would be voluntary beginning in MY 2018, and be mandatory beginning in MY 2021.

As described in Section XV.D and Chapter 12 of the draft RIA, the agencies are proposing special provisions to minimize the impacts on small trailer manufacturers. These provisions have been informed by and are largely consistent with recommendations coming from the SBAR Panel that EPA conducted pursuant to Section 609(b) of the Regulatory Flexibility Act (RFA). Broadly, these provisions provide additional lead time for small manufacturers, as well as simplified testing and compliance requirements. The agencies are also requesting comment on whether there is a need for additional provisions to address small business issues.

TABLE I–4—SUMMARY OF PROPOSED PHASE 2 REQUIREMENTS FOR TRAILERS

	Phase 1 program	Alternative 3—2027 (proposed standard)	Alternative 4—2024 (also under consideration)
Covered in this category	Trailers hauled by low, mid, and high roof day and sleeper cab tractors, except those qualified as logging, mining, stationary or heavy-haul.		
Share of HDV fuel consumption and GHG emissions.	Trailers are modeled together with combination tractors and their engines. Together, they account for approximately two thirds of fuel use and GHG emissions in the medium and heavy duty truck sector.		
Per vehicle fuel consumption and CO_2 improvement.	N/A	Between 3% and 8% improvement over MY 2017 baseline, depending on the trailer type.	

TABLE I–4—SUMMARY OF PROPOSED PHASE 2 REQUIREMENTS FOR TRAILERS—Continued

	Phase 1 program	Alternative 3—2027 (proposed standard)	Alternative 4—2024 (also under consideration)
Form of the standard	N/A	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons/1,000 ton payload mile.	
Example technology options available to help manufacturers meet standards.	N/A	Low rolling resistance tires, automatic tire inflation systems, weight reduction for most trailers, aerodynamic improvements such as side and rear fairings, gap closing devices, and undercarriage treatment for box-type trailers (*e.g.,* dry and refrigerated vans).	
Flexibilities	N/A	One year delay in implementation for small businesses, trailer manufacturers may use pre-approved devices to avoid testing, averaging program for manufacturers of dry and refrigerated box trailers.	

(d) Summary of the Proposed Vocational Vehicle Standards

As explained in Section V, the agencies are proposing to revise the Phase 1 vocational vehicle program and to propose new standards. These proposed standards also reflect further sub-categorization from Phase 1, with separate proposed standards based on mode of operation: Urban, regional, and multi-purpose. The agencies are also proposing alternative standards for emergency vehicles.

The agencies project that the proposed vocational vehicle standards could be met through improvements in the engine, transmission, driveline, lower rolling resistance tires, workday idle reduction technologies, and weight reduction, plus some application of hybrid technology. These are described in Section V of this preamble and in Chapter 2.9 of the draft RIA. These MY 2027 standards would achieve up to 16 percent lower CO_2 emissions and fuel consumption than MY 2017 Phase 1 standards. The agencies are also proposing revisions to the compliance regime for vocational vehicles. These include: The addition of an idle cycle that would be weighted along with the other drive cycles; and revisions to the vehicle simulation tool to reflect specific improvements to the engine, transmission, and driveline.

Similar to the tractor program, we have determined that there is sufficient lead time to introduce many of these new technologies into the fleet starting in MY 2021. Therefore, we are proposing new standards for MY 2021 and 2024. Based on our analysis, the MY 2021 standards for vocational vehicles would achieve up to 7 percent lower CO_2 emissions and fuel consumption than a MY 2017 Phase 1 vehicle, on average, and the MY 2024 standards would achieve up to 11 percent lower CO_2 emissions and fuel consumption.

In Phase 1, EPA adopted air conditioning (A/C) refrigerant leakage standards for tractors, as well as for heavy-duty pickups and vans, but not for vocational vehicles. For Phase 2, EPA believes that it would be feasible to apply similar A/C refrigerant leakage standards for vocational vehicles, beginning with the 2021 model year. The process for certifying that low leakage components are used would follow the system currently in place for comparable systems in tractors.

TABLE I–5—SUMMARY OF PHASE 1 AND PROPOSED PHASE 2 REQUIREMENTS FOR VOCATIONAL VEHICLE CHASSIS

	Phase 1 program	Alternative 3—2027 (proposed standard)	Alternative 4—2024 (also under consideration)
Covered in this category	Class 2b–8 chassis that are intended for vocational services such as delivery vehicles, emergency vehicles, dump truck, tow trucks, cement mixer, refuse trucks, etc., except those qualified as off-highway vehicles.		
	Because of sector diversity, vocational vehicle chassis are segmented into Light, Medium and Heavy Duty vehicle categories and for Phase 2 each of these segments are further subdivided using three duty cycles: Regional, Multi-purpose, and Urban.		
Share of HDV fuel consumption and GHG emissions.	Vocational vehicles account for approximately 20 percent of fuel use and GHG emissions in the medium and heavy duty truck sector categories.		
Per vehicle fuel consumption and CO_2 improvement.	2% improvement over MY 2010 baseline. Improvements are in addition to improvements from engine standards.	Up to 16% improvement over MY 2017 standards.	
Form of the standard	EPA: CO_2 grams/ton payload mile and NHTSA: Gallons of fuel/1,000 ton payload mile.		
Example technology options available to help manufacturers meet standards.	Low rolling resistance tires	Further technology improvements and increased use of Phase 1 technologies, plus improved engines, transmissions and axles, powertrain optimization, weight reduction, hybrids, and workday idle reduction systems.	

proposed standards using the same approaches employed in HD Phase 1. Together, the agencies have considered the following three ratios of cost effectiveness:

1. Total costs per gallon of fuel conserved.
2. Technology costs per ton of GHG emissions reduced.
3. Technology costs minus fuel savings per ton of GHG emissions reduced.

By all three of these measures, the proposed standards would be highly cost effective.

As discussed below, the agencies estimate that over the lifetime of heavy-duty vehicles produced for sale in the U.S. during model years 2018–2029, the proposed standards would cost about $30 billion and conserve about 75 billion gallons of fuel, such that the first measure of cost effectiveness would be about 40 cents per gallon. Relative to fuel prices underlying the agencies' analysis, the agencies have concluded that today's proposed standards would be cost effective.

With respect to the second measure, which is useful for comparisons to other GHG rules, the proposed standards would have overall $/ton costs similar to the HD Phase 1 rule. As Chapter 7 of the draft RIA shows, technology costs by themselves would amount to less than $50 per metric ton of GHG (CO_2 eq) for the entire HD Phase 2 program. This compares well to both the HD Phase 1 rule, which was estimated to cost about $30 per metric ton of GHG (without fuel savings), and to the agencies' estimates of the social cost of carbon. Thus, even without accounting for fuel savings, the proposed standards would be cost-effective.

The third measure deducts fuel savings from technology costs, which also is useful for comparisons to other GHG rules. On this basis, net costs per ton of GHG emissions reduced would be negative under the proposed standards. This means that the value of the fuel savings would be greater than the technology costs, and there would be a net cost saving for vehicle owners. In other words, the technologies would pay for themselves (indeed, more than pay for themselves) in fuel savings.

In addition, while the net economic benefits (*i.e.,* total benefits minus total costs) of the proposed standards is not a traditional measure of their cost-effectiveness, the agencies have concluded that the total costs of the proposed standards are justified in part by their significant economic benefits. As discussed in the previous subsection and in Section IX, this rule would provide benefits beyond the fuel conserved and GHG emissions avoided. The rule's net benefits is a measure that quantifies each of its various benefits in economic terms, including the economic value of the fuel it saves and the climate-related damages it avoids, and compares their sum to the rule's estimated costs. The agencies estimate that the proposed standards would result in net economic benefits exceeding $100 billion, making this a highly beneficial rule.

Our current analysis of Alternative 4 also shows that, if technologically feasible, it would have similar cost-effectiveness but with greater net benefits (see Chapter 11 of the draft RIA). For example, the agencies estimate costs under Alternative 4 could be about $40 billion and about 85 billion gallons of fuel could be conserved, such that the first measure of cost effectiveness would be about 47 cents per gallon. However, the agencies considered all of the relevant factors, not just relative cost-effectiveness, when selecting the proposed standards from among the alternatives considered. Relative cost-effectiveness was not a limiting factor for the agencies in selecting the proposed standards. It is also worth noting that the proposed standards and the Alternative 4 standards appear very cost effective, regardless of which reference case is used for the baseline, such that all of the analyses reinforced the agencies' findings.

E. EPA and NHTSA Statutory Authorities

This section briefly summarizes the respective statutory authority for EPA and NHTSA to promulgate the Phase 1 and proposed Phase 2 programs. For additional details of the agencies' authority, see Section XV of this notice as well as the Phase 1 rule.[63]

(1) EPA Authority

Statutory authority for the vehicle controls in this proposal is found in CAA section 202(a)(1) and (2) (which requires EPA to establish standards for emissions of pollutants from new motor vehicles and engines which emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare), and in CAA sections 202(d), 203–209, 216, and 301 (42 U.S.C. 7521 (a)(1) and (2), 7521(d), 7522–7543, 7550, and 7601).

Title II of the CAA provides for comprehensive regulation of mobile sources, authorizing EPA to regulate emissions of air pollutants from all mobile source categories. When acting under Title II of the CAA, EPA considers such issues as technology effectiveness, its cost (both per vehicle, per manufacturer, and per consumer), the lead time necessary to implement the technology, and based on this the feasibility and practicability of potential standards; the impacts of potential standards on emissions reductions of both GHGs and non-GHG emissions; the impacts of standards on oil conservation and energy security; the impacts of standards on fuel savings by customers; the impacts of standards on the truck industry; other energy impacts; as well as other relevant factors such as impacts on safety.

This proposed action implements a specific provision from Title II, Section 202(a). Section 202(a)(1) of the CAA states that ''the Administrator shall by regulation prescribe (and from time to time revise) . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles . . ., which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.'' With EPA's December 2009 final findings that certain greenhouse gases may reasonably be anticipated to endanger public health and welfare and that emissions of GHGs from Section 202(a) sources cause or contribute to that endangerment, Section 202(a) requires EPA to issue standards applicable to emissions of those pollutants from new motor vehicles. See *Coalition for Responsible Regulation* v. *EPA,* 684 F. 3d at 116–125, 126–27 cert. granted by, in part Util. Air Regulatory Group v. EPA, 134 S. Ct. 418, 187 L. Ed. 2d 278, 2013 U.S. LEXIS 7380 (U.S., 2013), affirmed in part and reversed in part on unrelated grounds by Util. Air Regulatory Group v. EPA, 134 S. Ct. 2427, 189 L. Ed. 2d 372, 2014 U.S. LEXIS 4377 (U.S., 2014) (upholding EPA's endangerment and cause and contribute findings, and further affirming EPA's conclusion that it is legally compelled to issue standards under Section 202 (a) to address emission of the pollutant which endangers after making the endangerment and cause of contribute findings); see also id. at 127–29 (upholding EPA's light-duty GHG emission standards for MYs 2012–2016 in their entirety).

Other aspects of EPA's legal authority, including it authority under Section 202(a), its testing authority under Section 203 of the Act, and its enforcement authorities under Section 207 of the Act are discussed fully in the Phase 1 rule, and need not be repeated here. See 76 FR 57129–57130.

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[63] 76 FR 57106—57129, September 15, 2011.

The proposed rule includes GHG emission and fuel efficiency standards applicable to trailers—an essential part of the tractor-trailer motor vehicle. Class 7/8 heavy-duty vehicles are composed of three major components:—The engine, the cab-chassis (*i.e.* the tractor), and the trailer. The fact that the vehicle consists of two detachable parts does not mean that either of the parts is not a motor vehicle. The trailer's sole purpose is to serve as the cargo-hauling part of the vehicle. Without the tractor, the trailer cannot transport property. The tractor is likewise incomplete without the trailer. The motor vehicle needs both parts, plus the engine, to accomplish its intended use. Connected together, a tractor and trailer constitute ''a self-propelled vehicle designed for transporting . . . property on a street or highway,'' and thus meet the definition of ''motor vehicle'' under Section 216(2) of the CAA. Thus, as EPA has previously explained, we interpret our authority to regulate motor vehicles to include authority to regulate such trailers. See 79 FR 46259 (August 7, 2014).[64]

This analysis is consistent with definitions in the Federal regulations issued under the CAA at 40 CFR 86.1803–01, where a heavy-duty vehicle ''that has the primary load carrying device or container attached'' is referred to as a ''[c]omplete heavy-duty vehicle,'' while a heavy-duty vehicle or truck ''which does not have the primary load carrying device or container attached'' is referred to as an ''[i]ncomplete heavy-duty vehicle'' or ''[i]ncomplete truck.'' The trailers that would be covered by this proposal are properly considered ''the primary load carrying device or container'' for the heavy-duty vehicles to which they become attached for use. Therefore, under these definitions, such trailers are implicitly part of a ''complete heavy-duty vehicle,'' and thus part of a ''motor vehicle.''[65] [66] [67]

The argument that trailers do not themselves emit pollutants and so are not subject to emission standards is also unfounded. First, the argument lacks a factual predicate. Trailers indisputably contribute to the motor vehicle's CO_2 emissions by increasing engine load, and these emissions can be reduced through various means such as trailer aerodynamic and tire rolling resistance improvements. See Section IV below. The argument also lacks a legal predicate. Section 202(a)(1) authorizes standards applicable to emissions of air pollutants ''from'' either the motor vehicle or the engine. There is no requirement that pollutants be emitted from a specified part of the motor vehicle or engine. And indeed, the argument proves too much, since tractors and vocational vehicle chassis likewise contribute to emissions (including contributing by the same mechanisms that trailers do) but do not themselves directly emit pollutants. The fact that Section 202(a)(1) applies explicitly to both motor vehicles and engines likewise indicates that EPA has unquestionable authority to interpret pollutant emission caused by the vehicle component to be ''from'' the motor vehicle and so within its regulatory authority under Section 202(a)(1).[68]

(2) NHTSA Authority

The Energy Policy and Conservation Act (EPCA) of 1975 mandates a regulatory program for motor vehicle fuel economy to meet the various facets of the need to conserve energy. In December 2007, Congress enacted the Energy Independence and Security Act (EISA), amending EPCA to require, among other things, the creation of a medium- and heavy-duty fuel efficiency program for the first time.

Statutory authority for the fuel consumption standards in this proposed rule is found in EISA section 103, 49 U.S.C. 32902(k). This section authorizes a fuel efficiency improvement program, designed to achieve the maximum feasible improvement to be created for commercial medium- and heavy-duty on-highway vehicles and work trucks, to include appropriate test methods, measurement metrics, standards, and compliance and enforcement protocols that are appropriate, cost-effective and technologically feasible.

NHTSA has responsibility for fuel economy and consumption standards, and assures compliance with EISA through rulemaking, including standard-setting; technical reviews, audits and studies; investigations; and enforcement of implementing regulations including penalty actions. This proposed rule would continue to fulfill the requirements of Section 103 of EISA, which instructs NHTSA to create a fuel efficiency improvement program for ''commercial medium- and heavy-duty on-highway vehicles and work trucks'' by rulemaking, which is to include standards, test methods, measurement metrics, and enforcement protocols. *See* 49 U.S.C. 32902(k)(2).

Congress directed that the standards, test methods, measurement metrics, and compliance and enforcement protocols be ''appropriate, cost-effective, and technologically feasible'' for the vehicles to be regulated, while achieving the ''maximum feasible improvement'' in fuel efficiency. NHTSA has broad discretion to balance the statutory factors in Section 103 in developing fuel consumption standards to achieve the maximum feasible improvement.

As discussed in the Phase 1 final rule notice, NHTSA has determined that the five year statutory limit on average fuel economy standards that applies to passengers and light trucks is not applicable to the HD vehicle and engine standards. As a result, the Phase 1 HD engine and vehicle standards remain in effect indefinitely at their 2018 or 2019 MY levels until amended by a future rulemaking action. As was contemplated in that notice, NHTSA is currently engaging in this Phase 2 rulemaking action. Therefore, the Phase 1 standards would not remain in effect at their 2018 or 2019 MY levels indefinitely; they would remain in effect until the MY Phase 2 standards apply. In accordance with Section 103 of EISA, NHTSA will ensure that not less than four full MYs of regulatory lead-time and three full MYs of regulatory stability are provided for in the Phase 2 standards.

(a) Authority To Regulate Trailers

As contemplated in the Phase 1 proposed and final rules, the agencies are proposing standards for trailers in this rulemaking. Because Phase 1 did not include standards for trailers, NHTSA did not discuss its authority for regulating them in the proposed or final rules; that authority is described here.

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[64] Indeed, an argument that a trailer is not a motor vehicle because, considered (artificially) as a separate piece of equipment it is not self-propelled, applies equally to the cab-chassis—the tractor. No entity has suggested that tractors are not motor vehicles; nor is such an argument plausible.

[65] We note further, however, that certain hauled items, for example a boat, would not be considered to be a trailer under the proposal. See proposed section 1037.801, proposing to define ''trailer' as being ''designed for cargo and for being drawn by a tractor.''

[66] This concept is likewise reflected in the definition of ''tractor'' in the parallel Department of Transportation regulations: ''a truck designed primarily for drawing other motor vehicles and not so constructed as to carry a load other than a part of the weight of the vehicle and the load so drawn.'' See 49 CFR 571.3.

[67] EPA's proposed definition of ''vehicle'' in 40 CFR 1037.801 makes clear that an incomplete trailer becomes a vehicle (and thus subject to the prohibition against introduction into commerce without a certificate) when it has a frame with axles attached. Complete trailers are also vehicles.

[68] This argument applies equally to emissions of criteria pollutants, whose rate of emission is likewise affected by vehicle characteristics. It is for this reason that EPA's implementing rules for criteria pollutants from heavy duty vehicles and engines specify a test weight for certification testing, since that weight influences the amount of pollution emission.

EISA directs NHTSA to ''determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement. . . .'' EISA defines a commercial medium- and heavy-duty on-highway vehicle to mean ''an on-highway vehicle with a GVWR of 10,000 lbs or more.'' A ''work truck'' is defined as a vehicle between 8,500 and 10,000 lbs GVWR that is not an MDPV. These definitions do not explicitly exclude trailers, in contrast to MDPVs. Because Congress did not act to exclude trailers when defining GVWRs, despite demonstrating the ability to exclude MDPVs, it is reasonable to interpret the provision to include them.

Both commercial medium- and heavy-duty on-highway vehicles and work trucks, though, must be vehicles in order to be regulated under this program. Although EISA does not define the term ''vehicle,'' NHTSA's authority to regulate motor vehicles under its organic statute, the Motor Vehicle Safety Act (''Safety Act''), does. The Safety Act defines a motor vehicle as ''a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways. . . .'' NHTSA clearly has authority to regulate trailers under this Act as vehicles that are drawn and has exercised that authority numerous times. Given the absence of any apparent contrary intent on the part of Congress in EISA, NHTSA believes it is reasonable to interpret the term ''vehicle'' as used in the EISA definitions to have a similar meaning that includes trailers.

Furthermore, the general definition of a vehicle is something used to transport goods or persons from one location to another. A tractor-trailer is designed for the purpose of transporting goods. Therefore it is reasonable to consider all of its parts—the engine, the cab-chassis, and the trailer—as parts of a whole. As such they are all parts of a vehicle, and are captured within the definition of vehicle. As EPA describes above, the tractor and trailer are both incomplete without the other. Neither can fulfill the function of the vehicle without the other. For this reason, and the other reasons stated above, NHTSA interprets its authority to regulate commercial medium- and heavy-duty on-highway vehicles, including tractor-trailers, as encompassing both tractors and trailers.

(b) Authority To Regulate Recreational Vehicles

NHTSA did not regulate recreational vehicles as part of the Phase 1 medium- and heavy-duty fuel consumption standards, although EPA did regulate them as vocational vehicles for GHG emissions.[69] In the Phase 1 proposed rule, NHTSA interpreted ''commercial medium- and heavy duty'' to mean that recreational vehicles, such as motor homes, were not to be included within the program because recreational vehicles are not commercial. Oshkosh Corporation submitted a comment on the agency's interpretation stating that it did not match the statutory definition of ''commercial medium- and heavy-duty on-highway vehicle,'' which defines the phrase by GVWR and on-highway use. In the Phase 1 final rule NHTSA agreed with Oshkosh Corporation that the agency had effectively read words into the statutory definition. However, because recreational vehicles were not proposed in the Phase 1 proposed rule, they were not within the scope of the rulemaking and were excluded from NHTSA's standards.[70] NHTSA expressed that it would address recreational vehicles in its next rulemaking.

NHTSA is proposing that recreational vehicles be included in the Phase 2 fuel consumption standards. As discussed above, EISA prescribes that NHTSA shall set average fuel economy standards for work trucks and commercial medium-duty or heavy-duty on-highway vehicles. ''Work truck'' means a vehicle that is rated between 8,500 and 10,000 lbs GVWR and is not an MDPV. ''Commercial medium- and heavy-duty on-road highway vehicle'' means an on-highway vehicle with a gross vehicle weight rating of 10,000 lbs or more.[71] Based on the definitions in EISA, recreational vehicles would be regulated as class 2b-8 vocational vehicles. Excluding recreational vehicles from the NHTSA standards in Phase 2 could create illogical results, including treating similar vehicles differently. Moreover, including recreational vehicles under NHTSA regulations furthers the agencies' goal of one national program, as EPA regulations already cover recreational vehicles.

NHTSA is proposing that recreational vehicles be included in the Phase 2 fuel consumption standards and that early compliance be allowed for manufacturers who want to certify during the Phase 1 period.[72]

F. Other Issues

In addition to the standards being proposed, this notice discusses several other issues related to those standards. It also proposes some regulatory provisions related to the Phase 1 program, as well as amendments related to other EPA and NHTSA regulations. These other issues are summarized briefly here and discussed in greater detail in later sections.

(1) Issues Related to Phase 2

(a) Natural Gas Engines and Vehicles

This combined rulemaking by EPA and NHTSA is designed to regulate two separate characteristics of heavy duty vehicles: GHGs and fuel consumption. In the case of diesel or gasoline powered vehicles, there is a one-to-one relationship between these two characteristics. For alternatively fueled vehicles, which use no petroleum, the situation is different. For example, a natural gas vehicle that achieves approximately the same fuel efficiency as a diesel powered vehicle would emit 20 percent less CO_2; and a natural gas vehicle with the same fuel efficiency as a gasoline vehicle would emit 30 percent less CO_2. Yet natural gas vehicles consume no petroleum. In Phase 1, the agencies balanced these facts by applying the gasoline and diesel CO_2 standards to natural gas engines based on the engine type of the natural gas engine. Fuel consumption for these vehicles is then calculated according to their tailpipe CO_2 emissions. In essence, this applies a one-to-one relationship between fuel efficiency and tailpipe CO_2 emissions for all vehicles, including natural gas vehicles. The agencies determined that this approach would likely create a small balanced incentive for natural gas use. In other words, it created a small incentive for the use of natural gas engines that appropriately balanced concerns about the climate impact methane emissions against other factors such as the energy security benefits of using domestic natural gas. See 76 FR 57123. We propose to maintain this approach for Phase 2. Note that EPA is also considering natural gas in a broader context of life cycle emissions, as described in Section XI.

(b) Alternative Refrigerants

In addition to use of leak-tight components in air conditioning system

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[69] EPA did not give special consideration to recreational vehicles because the CAA applies to heavy-duty motor vehicle generally.

[70] Motor homes are still subject to EPA's Phase 1 CO_2 standards for vocational vehicles.

[71] 49 U.S.C. 32901(a)(7).

[72] NHTSA did not allow early compliance for one RV manufacturer in MY 2014 that is currently complying EPA's GHG standards.

Ceres

Testimony of Ceres Regarding EPA and NHTSA's Proposed Phase 2 Greenhouse Gas Emission Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles, Engines, and Trailers

August 18, 2015

My name is Kirsten James, and I am the Senior Manager of California Policy and Partnerships at Ceres; our organization's mission is to mobilize investors and business leaders to build a thriving, sustainable global economy. Ceres coordinates three networks of investors and business leaders: (1) The first is the Investor Network on Climate Risk (INCR) which consists of more than 110 institutional investors, with assets exceeding $13 trillion, (2) the second, Businesses for Innovative Climate and Energy Policy (BICEP), is an advocacy coalition of leading businesses committed to working with policy makers to enact meaningful energy and climate legislation, (3) and finally, Ceres's company network, which includes nearly 70 member companies, over half of which are listed on the S&P500 Index.

Ceres commends EPA and NHTSA for taking action to address fuel efficiency and GHG emissions associated with the medium- and heavy-duty vehicle sector, and for its thorough and inclusive rulemaking process. We urge EPA and NHTSA to strengthen the proposed Phase 2 standard under consideration today.by adopting a standard requiring a 40% reduction in fuel consumption compared to 2010 by 2025; Alternative 4 comes closest to that standard.

Freight trucks currently account for over half a billion tons of GHG emissions per year and are the fastest growing single source of GHG emissions in the United States. Strict standards will catalyze investment in high efficiency truck technologies, thereby serving to retain the U.S. leadership position in this sector, save businesses money, promote energy security and reduce climate risk.

Such standards would be important drivers of economic growth, benefiting business, the trucking industry, and American consumers. Despite higher upfront costs, advanced fuel-efficient trucks will more than pay for themselves over a typical ownership period due to fuel cost savings. A joint analysis by Ceres and the Environmental Defense Fund found these standards would reduce freight costs by 3% in 2030 and 7% in 2040, an estimated $34 billion annual saving potential.[1] Furthermore, these benefits would accrue to the greater economy and American consumers; as operating costs come down due to more fuel-efficient trucks, business owners and consumers will reinvest that money in goods and services throughout the economy. Under stricter standards, the average U.S. household stands to save $250 per year in lower priced goods.[2]

I'd also like to highlight the Global Investor Statement submitted with my testimony, which was coordinated by Ceres. The statement was signed by 285 investors, both owners and asset managers, representing assets of over $20 trillion, and included a call for strict vehicle standards as a means of both minimizing climate risk and helping provide a long-term policy framework that will shift the investment risk-reward balance in favor of less carbon-intensive investment.

Strict standards are also key to retaining the US leadership position in efficient truck manufacturing, and expanding job opportunities in that sector. We are currently the world leader in the development, production and use of energy efficient and hybrid trucks. Without strong standards in place, companies and investors will lack the requisite certainty to invest in the development and production of new technologies that will allow us to retain our primary position and increase job growth.

Strong standards are also critical to national energy security. We are increasingly dependent on trucking, and need to minimize our vulnerability to fuel price volatility. Standards requiring the use of existing and emerging technologies would significantly reduce our dependence on oil. According to 2014 study by organizations including the Union of Concerned Scientists and the American Council for an Energy-Efficient Economy, a stronger standard requiring a 40% reduction in fuel consumption by 2025—would decrease daily oil consumption by 1.4 million barrels per day by 2030.[3]

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[1] M. J. Bradley and Associates LLC, "EPA/NHTSA Phase 2 Fuel Efficiency & GHG Standards for Freight Trucks: Projected Effect on Freight Costs." May 2015. Web. http://www.ceres.org/trucksavings

[2] Cooper, Mark Dr. and Gillis, Jack. "The Consumer Benefits of Increasing the Fuel Economy of Medium and Heavy Duty Trucks." *The Consumer Federation of America*. February 2014. Web. http://www.consumerfed.org/pdfs/Paying-the-Freight.pdf

[3] American Council for an Energy-Efficient Economy (ACEEE), Environmental Defense Fund (EDF), Natural Resources Defense Council (NRDC), Sierra Club, and Union of Concerned Scientists (UCS). 2014. Big fuel savings available in new trucks. Web. http://aceee.org/files/pdf/fact-sheet/truck-savings-0614.pdf, accessed June 29, 2015.

Ceres agrees with the California Air Resources Board (CARB), which recommends the adoption of the Alternative 4 standards at a minimum, stating this option is both technology forcing and technologically feasible. Accelerating the timeline to require compliance by MY2024 is a cost-effective way to rapidly reduce emissions. A recent CARB report indicates vehicle technology payback periods under Alternative 4 remain virtually unchanged compared to Alternative 3, with the exception of pickups and vans, which stand to gain just a single year.[4]

Finally, companies in a variety of sectors are increasingly interested in tracking Scope 3 emissions, including GHG emissions associated with transportation and freight movement, as part of their publicly disclosed GHG assessment. Thus, a growing number of companies support policies such as strict truck standards that would help them achieve their own GHG emission reduction goals as well as save money. A recent Wall Street Journal op-ed co-authored by Indra K. Nooyi, Chairman and CEO of PepsiCo, takes the position that better standards are better for the environment *and* businesses, explaining that strong standards will cut costs and allow companies to reinvest in their products and compete in their industry.[5] Likewise, a recent article written by Jostein Solheim, the CEO of Ben & Jerry's, in the Guardian describes similar benefits for companies that rely on trucking to get their products to market. Notably, Mr. Solheim calls for a 40% reduction in heavy truck fuel consumption by 2025.[6]

In sum, we urge EPA and NHTSA to adopt standards requiring a 40% reduction in fuel use by 2025. Such technology forcing standards would drive innovation, catalyze investment in high efficiency truck and supplier manufacturing, as well as promote energy security and reduce climate risk. It is time to move forward aggressively with policies that will optimize private investment in a low carbon economy, cut freight costs, and reduce GHG emissions from the trucking sector.

Thank you for the opportunity to speak today, and your leadership on this important issue.

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[4] California Environmental Protection Agency Air Resources Board, Update on the Proposed Federal Phase 2 GHG and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles. July 23. 2015. Sacramento, California. Web. http://insideepa.com//sites/insideepa.com/files/documents/jul2015/epa2015_1591.pdf

[5] Nooyi, Indra K., and Fred Krupp. "Delivering a Greener Fleet of Trucks." *WSJ.* N.p., 19 June. 2015. Web.

[6] Jostein Solheim. "I Scream, You Scream, We All Scream—For Higher Fuel Emissions Standards." *The Guardian.* N.p., 3 July. 2015. Web.

TTMA
TRUCK TRAILER Manufacturers Association
TTMAnet.org Since 1941

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September 30, 2015

Air and Radiation Docket and Information Center
Environmental Protection Agency
Mail code: 28221T
1200 Pennsylvania Ave. NW.
Washington, DC 20460

Docket Management Facility
M-30
U.S. Department of Transportation
West Building, Ground Floor, Rm. W12-140
1200 New Jersey Avenue SE.,
Washington, DC 20590

Re: Docket ID No.s: EPA-HQ-OAR-2014-0827 & NHTSA-2014-0132

Dear Sirs,

The Truck Trailer Manufacturers Association (TTMA) is an international trade association representing approximately 90% of the truck-pulled trailers manufactured in the United States. TTMA has a history of working closely with regulators to help them understand the unique nature of the heavy-duty trailer industry and to act as a conduit between the member companies and regulators. TTMA has been working hard to help its members fully understand the proposal and draw forth a consensus comment. We present the following comment to the Proposed Rule "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles— Phase 2" (EPA-HQ-OAR-2014-0827 & NHTSA-2014-0132).

1 - Introduction

We must first start out by observing that the proposed rule, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles— Phase 2" ("proposed rule" or "proposal" hereafter), is vast in scope and covers a wide range of vehicles and devices. We are directing our comments only at proposals that relate to heavy duty trailers, without comment for or against any other parts of the proposal.

We also had asked for a longer time to pursue a more detailed evaluation of the proposal. TTMA is an organization of trailer manufacturing companies and we rely on voluntary participation of our member companies. As the agencies admit, a large proportion of these member companies are small manufacturers and as such, lack the time and resources to detail to such a long and complicated proposal. We had asked for a 90 – 180 day extension to allow those small manufacturers to adequately be brought up to speed and provide specifics to our commentary, but were granted only a 14 day extension. We will continue to pursue a dialog with the agencies past the October 1st, 2015 deadline and encourage the agencies to reach out to us as they have been doing so that we can work together to craft the best possible solutions.

2- Summary/Overview

TTMA notes that the proposal lacks legal authority, has significant safety impacts, and is overly broad and complex in light of the more functional existing voluntary systems. We will be discussing this in several sections as follows:

In our “Authority Objections” section (3), we will discuss the legal rationale the agencies are putting forward for regulating trailers, why that rationale is flawed, and that the agencies should focus their efforts on end users, which they actually do have authority to regulate.

In our “Safety Impact” section (4) we quantify some of the negative safety impacts that this proposal would entail. We strongly urge the agencies to exercise caution in this regard; both TTMA and regulating agencies have been working and continue to work diligently trying to maximize safety and this proposal sets that back.

We strongly urge the agencies to reconsider the existing voluntary program in our “SmartWay & Alternative 1” section (5). Alternative 1 works best to save fuel & GHG emissions without the numerous drawbacks found in the proposal.

We detail two different types of classification that the agencies must use in any future proposal in our “Further Areas Requiring Exclusion/Exemption” and our “Non-Aero Box Trailers” sections (6 & 7). In this way, the agencies can minimize the negative effects of the proposal.

In our “Averaging” section (8), we discuss the problems with the proposal’s averaging provisions and how what the agencies regard as beneficial to industry would actually be harmful to the trailer industry. We discourage the agencies from using this scheme in regard to trailers.

The existing proposal is overly complex and in our “Ways to Simplify/Streamline” section (9), we discuss a few ideas to modify it.

In our “Model Year” section (10), we detail the problems we have with the proposals use of model years and suggest a few fixes for future regulation.

Finally, we have a few “Miscellaneous Points” to add before we offer up our “Conclusion” in those sections (11 & 12).

3 - Authority Objections

EPA and NHTSA do not have statutory authority to adopt GHG emission and fuel efficiency standards applicable to trailers.

EPA lacks statutory authority.

Trailers themselves fail to meet the definition of a “motor vehicle” which states:

> (2) The term “motor vehicle” means any self-propelled vehicle designed for transporting persons or property on a street or highway.[1]

Trailers are not self-propelled, do not burn fuel or exhaust “Greenhouse Gasses.” A vehicle is defined as something used for conveyance having a frame, a suspension, and a braking system. A motorized vehicle is a vehicle (such as a car, truck, or motorcycle) that is powered by a motor. A trailer is a *vehicle* that is not motorized and therefore does not fall under the jurisdiction of the Clean Air Act.

EPA acknowledges this in its claim to authority and then attempts to dismiss it by claiming that the tractor, when combined with the trailer, together creates the motor vehicle that they are allowed to regulate under the CAA. “Connected together, a tractor and trailer constitute ‘‘a self-propelled vehicle designed for transporting . . . property on a street or highway,’’ and thus meets the definition of ‘‘motor vehicle’’ under Section 216(2) of the CAA.”[2]

Trucks and trailers are legally recognized by the U.S. federal and state governments as two different vehicles, each possessing its own DOT vehicle identification number (VIN), state license plate, registration, regulations, and ownership. The EPA cannot legally declare one vehicle part of the other or the two vehicles to be the same or treated as the same vehicle to enable a new regulation. If they do, then it is not the trailer manufacturer who is creating a new motor vehicle. The CAA directs the EPA Administrator to regulate “new motor vehicles.”[3] The trailer is not a motor vehicle under CAA statute until it is “connected” making it possibly subject to EPA authority not at the time the trailer was constructed, but at the time an operator connects it to a tractor and completes the “Self-propelled motor vehicle” that EPA is claiming meets the definition provided under 216(2) of the CAA. At connection, the

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[1] Clean Air Act, Section 216(2)

[2] Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium and Heavy-Duty Engines and Vehicles – ;Phase 2; Proposed Rule, 80 FR 40170 (July 13, 2015 / Proposed Rule)

[3] 42 USC 7521(a)(1)

combination could then be said to meet the definition for "new motor vehicle" in 216(3) since the combination has not yet had its title transferred to the ultimate purchaser, defined in 216(5) as "the first person who in good faith purchases such new motor vehicle."

Any given trailer is not intended to be permanently connected to any truck by the trailer OEM for the useful life of the trailer. This is the distinction that makes the trailer different from any other part or component of the truck. The truck has a device that engages the trailer's king pin and traps it within the truck's fifth wheel. It is a third party that engages and disengages this truck device, not the trailer, and not the trailer OEM. Specifically, trailer manufacturers do not sell new "tractor-trailers." As such, the tractor and trailer cannot be considered a single motor vehicle (indeed, a single trailer is likely to be hauled by multiple tractors during its lifetime, and, conversely, a single tractor is likely to haul multiple trailers).

Therefore, if the Agency wants to claim, for practical reasons, that the trailer and tractor are a regulated motor vehicle, it can only regulate the party that joined the trailer to the tractor. EPA has been claiming that they cannot regulate end users of trailers, and so must aim their regulations at trailer manufactures, but this exposes EPA's lack of authority to regulate, for these trailer manufacturers do not create the vehicles that EPA claims authority to regulate. Under the laws given in the CAA and the usual industry practice of creating new combinations of tractors and trailers to be used briefly and then separating the tractor from the trailer to create a new combination, all without transferring the titles of the combination or even of any of the individual components of the combination, it is those end users who are routinely manufacturing motor vehicles and are thus possibly subject to regulation under the laws of the CAA. It is these very end users who could and possibly should be directed to select certain trailer-based GHG-Reduction/Fuel-Economy devices based on how they ultimately use the vehicle they alone assemble.

Since a trailer is built for customer specifications and not an intended truck, trailer OEMs cannot be regulated by the EPA GHG-2 regulations. At the time of trailer manufacture, there is no defined or intended truck and the trailer is still a non-motor vehicle. Upon completion and the trailer title is passed from the trailer OEM to the trailer dealer, or end user, there is still no motorized truck that can be associated with the trailer. The trailer can be pulled by a gas, diesel, natural gas, or electric truck in the future with unknown, varying aerodynamic characteristics. When title of the trailer passes, the trailer OEM has no legal ownership of the trailer vehicle and the trailer is not a part of any truck or other motorized vehicle. The trailer at this point is a separate product yet to be put into commerce. The EPA's definition of a trailer being a part of a motorized vehicle has not been met and the OEM no longer has a legal basis to alter the vehicle.

The language and structure of the Clean Air Act requirements and prohibitions for new motor vehicles and engines also contradict EPA's interpretation. Those provisions contemplate a single manufacturer of each new motor vehicle or each new motor vehicle engine. For example, Section 206(a)(1) requires EPA to require testing of "any new motor vehicle . . . submitted by a manufacturer" to determine whether the vehicle may be certified as conforming to emissions regulations. Section 206(b) authorizes EPA to conduct emissions testing to determine whether new motor vehicles "manufactured by a manufacturer do in fact conform" after being certified. Section 207 requires "the manufacturer of each new motor vehicle" to provide an emissions warranty to the ultimate purchaser to certify that the vehicle conforms to the emissions regulations and is free of defects for its useful life. And Section 203(a) prohibits "a manufacturer of new motor vehicles or new motor vehicle engines" from selling or importing such vehicles or engines unless covered by a certificate of conformity. The language of these provisions plainly contemplates a single manufacturer that is responsible for each motor vehicle, not multiple manufacturers of "two detachable parts" that together constitute the single motor vehicle, and are mixed and matched in different pairs throughout their lifetime. Moreover, these provisions on their face do not work as applied to "two detachable parts" of a single motor vehicle that are mixed and matched. In the case of separate manufacturers of the tractor and various trailers that might be hauled by that tractor, the requirements to test, certify, and warrant "the motor vehicle" cannot on their face apply as written, since there is no single manufacturer of "the motor vehicle." And responsibility for violations, such as by selling an uncertified new motor vehicle, is unspecified.

EPA also contends that the tractor minus the engine constitutes a "motor vehicle," even though such a chassis cannot move without the engine.[4] We are skeptical of this assertion. We are aware of no instance in which EPA has sought to regulate a "motor vehicle" that does not contain an engine, for the obvious reason that such a "vehicle" is not self-propelled and thus does not fall within EPA's jurisdiction. In short, Congress authorized EPA to regulate both engines and complete motor vehicles (containing engines), but did not authorize EPA to regulate a trailer, which is not self-propelled, even if that trailer might be regarded as essential to the purpose of a tractor to transport property.

Therefore, as the legal basis of the proposal from the EPA perspective is flawed, all parts of the proposal suggesting expansion of regulation of EPA to trailers should be struck. NHTSA regulation should remove requirements that, by extension, require trailer manufacturers to be regulated by EPA by directing compliance with regulations in 40CFR.

NHTSA lacks statutory authority.

NHTSA's claim to authority relies on the Energy Independence and Security Act (EISA), which does not itself define the term "vehicle" to include trailers. To do this, NHTSA relies on the language under its organic statute, the Motor Vehicle Safety Act.[5] It is important to note that the Safety Act's definition is put forward "to reduce traffic accidents and deaths and injuries resulting from traffic accidents."[6] As we will describe below, many parts of the proposal are at odds with this mission and we urge NHTSA to carefully consider their mandate as they propose trading safety for assumed fuel savings. Here, the point is simply that NHTSA is grasping for statutory authority for the proposed rule by citing an enabling statute that has nothing to do with greenhouse gas emissions.

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[4] 80 Fed. Reg. 40,170 n.64.

[5] 80FR4071: *" Although EISA does not define the term ''vehicle,'' NHTSA's authority to regulate motor vehicles under its organic statute, the Motor Vehicle Safety Act (''Safety Act''), does."*

[6] 40USC30101 Purpose and policy

Additionally, NHTSA cites the EISA direction to create standards for commercial medium- and heavy-duty on-highway vehicles and work trucks in 49 USC 32902(k). That section includes a 24 month window for rulemaking to take place: "(2) RULEMAKING.—Not later than 24 months after completion of the study required under paragraph (1), the Secretary, in consultation with the Secretary of Energy and the Administrator of the Environmental Protection Agency, by regulation, shall determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement, …" The study referred to in paragraph (1) was to be completed within one year of the publication of a National Academy of Sciences study that was published in 2010[7]. That brings the maximum window for NHTSA to bring regulations under this law to 2013. The proposal being put forward, coming after the window set forth under law, lacks congressional authorization.

Further, NHTSA contends that the Energy Independence and Security Act ("EISA") gives it statutory authority to regulate trailers. Specifically, NHTSA points to a provision in the EISA that directs NHTSA to "determine in a rulemaking proceeding how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement . . . ." [8] The EISA defines "commercial medium- and heavy-duty on-highway vehicle" to mean "an on-highway vehicle with a gross vehicle weight rating [GVWR] of 10,000 pounds or more." [9] NHTSA contends that, "[b]ecause Congress did not act to exclude trailers when defining GVWRs . . . it is reasonable to interpret the provision to include them."[10]

However, this definition shows just the opposite – that EISA's definition of "commercial medium- and heavy-duty on-highway vehicle" excludes trailers. GVWR is distinct from the gross combined weight rating ("GCWR"), which includes both the weight of a loaded trailer and the weight of the tractor. EPA and NHTSA recognized this important distinction in promulgating GHG Phase One emission standards and fuel efficiency standards for medium- and heavy-duty engines and vehicles in 2011, stating: "GVWR describes the maximum load that can be carried by a vehicle, including the weight of the vehicle itself. Heavy-duty vehicles also have a gross combined weight rating (GCWR), which describes the maximum load that the vehicle can haul, including the weight of a loaded trailer *and the vehicle itself*." (emphasis added)[11]. In other words, the trailer is not included in the definition of "commercial medium-and-heavy-duty on highway vehicle" as previously interpreted by NHTSA, since that definition refers only to a tractor's GVWR and does not refer to a combination tractor and trailer GCWR. It is therefore reasonable (and it is consistent with the agencies' previous interpretation) to *exclude* trailers when interpreting 40 U.S.C. § 32902(k)(2).

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[7] http://www.nap.edu/catalog/12845/technologies-and-approaches-to-reducing-the-fuel-consumption-of-medium-and-heavy-duty-vehicles

[8] 49 U.S.C. § 32902(k)(2).

[9] Id. at § 32901(a)(7).

[10] See 80 Fed. Reg. at 40,171.

[11] See 76 Fed. Reg. 57,106, 57,114 (Sept. 15, 2011)

We understand that the agencies may take issue with our claims as to the way the law interacts with the truck trailer industry and the agencies' proposal, so we will address further comments at both EPA and NHTSA parts of the proposal. This is intended to instruct both agencies as to ways that the proposal could be improved with regard to the truck trailer industry without condoning the agencies' proposed expansion without legal authority.

4 - Safety Impact

TTMA is highly concerned with creating and maintaining a safe environment on and off the nation's roadways when it comes to the use of truck trailers. The current voluntary model of Federal GHG & fuel conservation relies on payback to incentivize end users to adopt technologies like aerodynamic features. Such a payback-based feature causes users to avoid the technology in end-use situations where either speeds or loads preclude payback; e.g. if a user needs to leave a pallet off their trailer because the aero devices put them over the weight limit, they will choose not to use them. The proposed rule will, of necessity, force aero devices on end users who otherwise would be avoiding them. For low speed users, this is simply a waste of resources[12], but for users operating at or near weigh-out conditions, the weight of the aero devices forces more trips as freight has to be hauled on a second load. Those extra trips pose a safety risk which must be accounted for.

Estimate of Safety Impact of Deadweight Load of Aerodynamic Devices

Using a 250 lb. weight of aerodynamic devices per trailer, and a cargo load of 50,000 lb. when tractor-trailer is in Weigh-out mode means that the 250 lb. for extra devices will have to be hauled on an additional trip.

$$\frac{250\ lb\ add'l}{50{,}000\ lb\ cargo\ per\ Weigh\text{–}out\ Trip} = 0.5\%\ increase\ in\ Weigh\text{–}out\ Trips$$

Approximately 30% of tractor-trailers are operating at or near weigh-out conditions.[13]

$$0.5\%\ increase\ in\ Weigh\text{–}out\ Trips\ \times 30\%\ VMT\ in\ Weigh\text{–}out\ Conditions$$
$$= 0.15\%\ increase\ in\ Vehicle\ Miles\ Traveled\ (VMT)$$

Annual VMT for tractor-trailers is 122,705 M VMT/year.[14]

$$0.15\%\ Increase\ in\ VMT\ \times 122{,}705\ \frac{M\ VMT}{year} = increase\ of\ 184\ M\ VMT/Year$$

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[12] Draft RIA, p2-155 "It can also be seen that very little benefit is seen for tractor trailers driving under highly transient conditions."

[13] "…weigh-in-motion data for 3-S2s indicate that over 70 percent operate at 70,000 pounds gross vehicle weight or less." (Comprehensive Truck Size and Weight Limits Study, November 2013, Modal Shift Analysis, p8.) http://www.ops.fhwa.dot.gov/freight/sw/map21tswstudy/deskscan/modal_shift_dksn.pdf

[14] Base Case for VMT total: 122,705,589,552. Ibid. Table 1, p12.

Collision rate for Tractor-trailers is 134/100 M VMT.[15]

$$Increase\ of\ 184\ \frac{M\ VMT}{Yr} \times \frac{134\ Collisions}{100\ M\ VMT} = Increase\ of\ 246\ collisions/year$$

Approximately 3% of Tractor-trailer Collisions involve fatalities.[16]

$$Increase\ of\ 246\frac{Collisions}{year} \times 3\%\ \frac{Fatality\ Involvement}{Collision} \approx 7\ extra\ fatal\ accidents\ per\ year$$

In general, the safety impact of additional weight on trailers is 1 extra collision per year for every pound of added trailer weight, and one additional fatality-involved crash per year for every 35 pounds additional trailer weight.

Note that since the proposal relies heavily on EPA methodology that favors "technology-forcing" regulation, where regulations are formulated to require devices that do not currently exist, the proposal goes beyond NHTSA's mandate to reduce deaths, injuries and economic losses resulting from motor vehicle crashes. Some of these devices don't yet exist in a form that would satisfy the proposal, and those that do have potential safety risks that have not been fully explored.

5 - SmartWay & Alternative 1

For the purposes of trailer manufacture and end use, the EPA's SmartWay program coupled with voluntary adoption bring the optimal solution to reducing greenhouse gas emissions and fuel consumption in the heavy duty freight sector.

Unlike the private car market, heavy duty trailers are used almost exclusively in a very competitive commercial market where fuel costs are second only to labor costs. As such, there is a huge financial incentive for end users to reduce the amount of fuel consumed and incidentally reduce greenhouse gas emissions released during operations. Innovators have been coming up with devices, methods and strategies to accomplish this for decades. These innovations often had varying degrees of actual effect compared to the claimed effect as each innovator would tout their product only in its best light. To complicate matters, not every innovation would be appropriate for every end user's operation. This double level of confusion created a barrier to new products coming into use.

SmartWay, when it came on the scene, removed one side of the confusion. By setting a standard to test products against, it allowed end users to remove one layer of variables to be evaluated before selecting a new approach to control fuel consumption. End users could now consider how well their operations

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[15] "The rate for tractor-semitrailers was 42/100 million VKT (134/100 million vmt)" (Comprehensive Truck Size and Weight Limits Study, November 2013, Highway Safety and Truck Crash Comparative Analysis, p16.) http://www.ops.fhwa.dot.gov/freight/sw/map21tswstudy/deskscan/safety_dksn.pdf

[16] "For example, in Idaho, about 3% of crash involvements for each involved a fatality, about 30-33% included an injury, and the remainder involved only property damage (PDO)." Ibid. p17.

would respond to SmartWay verified technologies when making their decisions. In doing so, the adoption of workable fuel savings technologies in areas where they will actually perform was accelerated.

SmartWay is not perfect. For example, it lacks ability to account for possible savings from tire inflation control strategies, and it's still limited in the types of trailers it considers, only recently expanding into refrigerated trailers. However, a voluntary program manages to get the maximum feasible improvement in fuel economy and greenhouse gas emission reduction without the unintended side effects of inappropriately pushing strategies into areas where they do not have an actual gain.

We urge all parties concerned with creating an actual reduction in fuel consumption and greenhouse gas emissions to adopt Alternative 1 with respect to trailers. If the agencies feel the need to regulate, they should direct their regulations at end users who are selecting particular trailers to use with particular tractors for a given cargo and route. While California's blanket requirement for trailers to be SmartWay certified was poorly thought out as to which end users might actually see benefit and which wouldn't and had a host of unintended effects as a result, it was at least aimed at the correct market to effect change.

We also note that in the current environment outside of California, end users that could benefit from SmartWay verified aero technologies are already using it. The proposal's cost benefit analysis seems to overlook this important factor. As such, it both undervalues the work that has been done, by failing to note that aero-device adoption is disproportionately adopted in long haul operations and overvalues the proposal by assuming that new devices fitted to trailers that currently don't have them would be used at fleet-average speeds, when that group of trailers are actually running at below average speeds.

As we will describe below, any steps to pursue the agencies' goals of improving fuel economy and reducing greenhouse gas emissions must carefully consider areas to exclude and/or exempt from regulation to avoid unintended effects.

6 - Further Areas Requiring Exclusion/Exemption

The proposal asks for input on the merits of exclusion versus exemption of various trailer types.[17] Our objections to the agencies' authority notwithstanding, we feel that all regulations should be crafted in such a way as to minimize unnecessary negative impact on manufacturers. Tracking and reporting burdens are very real costs, and should only be used by the agencies when there is a definite social gain to be had. There is no gain to be had by requiring reporting and tracking for classes of trailers that are not the subject of this proposal, so we encourage the agencies to maximize the use of exclusions wherever practicable.

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[17] 80 FR 40259: "We seek comments on whether, in lieu of the exclusion of trailers from the program, the agencies should instead exempt these trailers from the standards, but still require reporting to the agencies in order to verify that a manufacturer qualifies for an exemption."

TTMA recognizes that the agencies have made great strides in gaining an understanding of the trailer industry and have laid forth certain types of trailers which should be excluded from the proposal.[18] There are certain problems with the classification of some trailers and other types that also ought to be excluded.

Heavy Haul Exclusion

The proposal intended to exclude trailers designed for heavy-haul applications, but apparently used a simplistic combination of length and axle count to define a heavy-haul trailer. While such a metric is a useful test, it omits several other design characteristics that define certain heavy-haul trailers that otherwise would not pass the proposal's "Trailers shorter than 35 feet in length with three axles, and all trailers with four or more axles (including any lift axles)."

Heavy-haul style trailers are designed to carry equipment used for construction, agricultural, mining, logging, power generation and other industries, specialized loads generally not transported on a regular basis, high center of gravity loads, and over-sized (length, width, height, and/or weight) loads. Most of these trailers operate in either very small fleets (two to three trailers) or are owner-operated where requirements for specific tire and equipment types would cause a larger financial burden than the perceived benefit of reduced fuel use.

The following recommendations for exclusion are based on specific physical characteristics that are designed into each trailer type in order for it to perform its intended function. These trailers are not intended for nor are they used for over-the-highway long haul operations or at highway speeds for extended periods of time. These trailers will operate both on and off road, at various speeds, and in various terrains. There are not specific design characteristics that indicate that this trailer should operate at low speeds or on a specific type of terrain, but, these are physical characteristics that can distinguish heavy-haul style trailers from other trailer types.

"Jeep; Dolly, Load Divider"

As defined in 49 CFR 571.121 S4, a load divider dolly means a trailer composed of a trailer chassis and one or more axles, with no solid bed, body, or container attached, and which is designed exclusively to support a portion of the load on a trailer or truck excluded from all the requirements of this standard.

"Heavy Haul"

Any trailer that has a gross vehicle weight rating (GVWR) of more than 120,000 pounds or any trailer equipped with an axle that has a gross axle weight rating (GAWR) of 29,000 pounds or more.

"Expandable"

As defined in 49 CFR 571.121 S3.(a), any trailer that has a width of more than 102.36 inches with extendable equipment in the fully retracted position and is equipped with two short track axles in a line across the width of the trailer.

"Extendable"

Any trailer that has air lines designed to allow extension of the vehicle frame or load deck.

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[18] 80 FR 40259: "(5) Exclusions and Less-Stringent Standards"

"Modular"

Any trailer that has air lines designed to allow separation and removal of deck sections or insertion of deck sections to create longer or shorter load carrying areas.

"Sliding"

Any trailer that has an undercarriage system designed to move forward or back to allow the load deck to tilt, slide, or adjust into a position that facilitates the loading or unloading of equipment but must return to original position for transport.

"Multi-Axle"

Any trailer that has two or more permanently attached axles (including lift axles) and designed to accept additional removable axles, flip axles, and/or load transferring boosters; both mechanical, hydraulic, or air (or other gas).

Dump Trailer Exclusion:

There are a variety of trailer designs that nominally appear to be simple box trailers, but due to the design being used for in-field operations and short haul/low speed operations almost exclusively, should be excluded from the proposal.

"Dump trailer"

An open-topped trailer having a load-bearing container body structure with a hydraulic cylinder that allows the container to be tilted to discharge its contents through an open tailgate or equipped with special doors/gates to allow discharge of contents by gravity that is used in short-haul transport of construction, paving, demolition and other bulk materials such as sand, gravel, asphalt, sludge, scrap metal, farm products etcetera from off-road mine/pit loading sites to off-road construction unloading sites.

"Refuse transfer trailer"

A usually open-topped trailer having a load-bearing container body structure that can be tilted on an external hydraulic tipping platform or equipped with a self-unloading floor to discharge its contents through an open tailgate that is used in short-haul transport of refuse material (garbage) from off-road transfer station loading sites to off-road landfill unloading sites.

ATIS Exemption:

Certain tires/loads have working pressures is excess of what tractors can provide. These trailers should be exempt from the ATIS requirement.

Lift Gate Equipped Trailers:

Rail Lift & Lift Gate equipped trailers operate at low speeds and perform local deliveries. As such, they ought to be classified as "non-aero" based solely on the inclusion of a lift, however a better approach non-aero trailer classification will be discussed below.

7 - Non-Aero Box Trailers

TTMA recognizes that the agencies have tried to account for the variety of trailer designs and the various sorts of service they are put in by creating a "non-aero box" category of trailer that is defined by the deployment of certain equipment or design features similar to our call for a "work performing equipment" exclusion in our October 16, 2014 letter.[19] Unfortunately, the way that the proposal crafts this, it fails to capture the full extent of trailers that are operated at low speeds and for short trips.

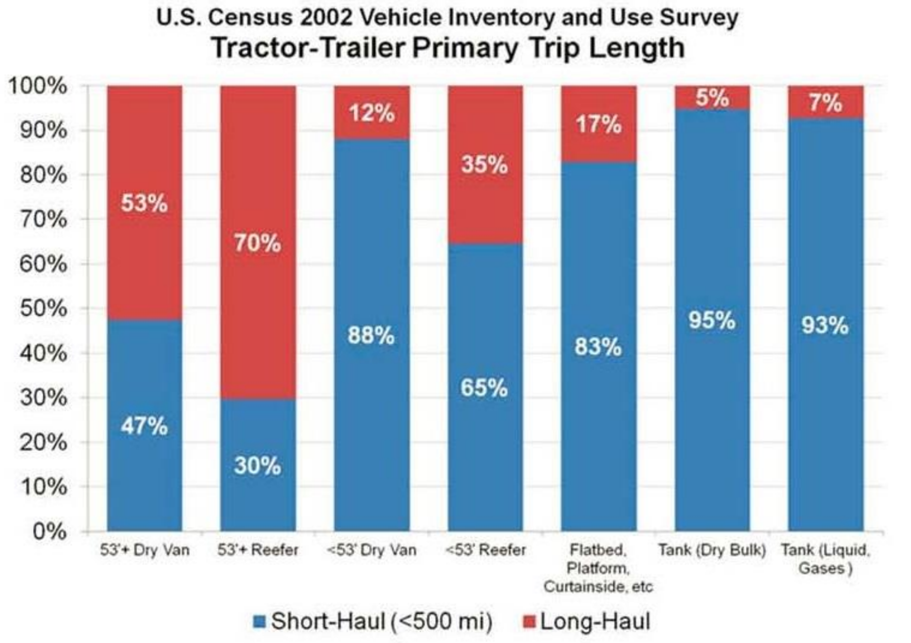

Figure 1-5 2002 Vehicle Inventory and Use Survey Considering Primary Trip Length for Tractor-Trailers

Consulting Figure 1-5 from the draft RIA[20] a significant fraction of the trailers are used on short trips and are therefore predominantly operated according to what the Agencies term "transiently."

As written, the proposal neglects the fuel costs and greenhouse gas emissions associated outside of operations on the trailer. The rule needs to account for the GHG and energy consumption of various devices during the entire lifetime of the component; construction, delivery, use and disposal, rather than just highway use as they do now. Although not required by statute, it would be foolish to require the use of devices whose GHG savings in use are small compared to the GHG emissions used during production, delivery, disposal, and necessary uses outside of running down the highway such as maintenance, retreading, etc.

For aero-devices, estimating the carbon footprint of manufacture, distribution, service and disposal is difficult. One approach is to use a simplified cost of goods calculation based on the carbon footprint of the general automobile industry. This gives a rate of 460 kgCO$_2$/\$1,000[21] Therefore, for a van trailer operated in a transient mode but still required to have \$900 of aero-devices fitted, there will be a CO$_2$ penalty of \$900*(460/\$1000) = 414 kg CO$_2$ over the useful life of the aero-device. Additionally, this

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[19] EPA-HQ-OAR-2014-0827-0146

[20] EPA-HQ-OAR-2014-0827-0243

[21] *How Bad Are Bananas? The Carbon Footprint of Everything*: puts the carbon emission of automobile manufacture at 720 kgCO$_2$/£1,000. Converting to dollars gets the quoted figure.

device will need to be hauled itself, its 250lb or 1/8th ton, would lend an additional 11g per mile (baseline emissions of 85 per ton mile times .125 ton, this would be higher on short trailers with their higher baseline). This in addition to the .15% decrease in performance from the effect of displaced cargo when operating at or near weigh-out conditions as described under "Safety Impact."

For these transiently operated trailers, what benefit is available would come from LRR Tires and ATIS. As described above, applying aero treatments to these trailers will result in an increase of GHG emissions/fuel consumption relative to an untreated trailer with LRR tires and ATIS rather than the desired reduction. The appropriate solution here is to recognize that trailers operated in transient service are more appropriately categorized as "non-aero box trailers". The agencies can and should recognize some fraction of the annual tractor-trailer combinations of each category as non-aero. End users eager to reap the rewards of aero-treatment payback, if it is realistic for their uses, can be counted on to select the correct type for their particular trip use.

While we recognize the steps the proposal made to define a non-aero box trailer by certain devices fitted to it, by focusing solely on these items rather than on usage, you could create a situation where the market drives increased adoption of features to move trailers intended to be used transiently into the non-aero box category despite those devices not otherwise being needed to complete the job. An unneeded rear lift gate or side-mounted pull-out platform would have all the negative consequences of an unneeded skirt in terms of weight impact creating both a safety hazard and increased emissions described above. By allowing a fraction of tractor-trailer combinations with applicable trailers (Long vs Short/Dry vs Refrigerated) to be designated as "non-aero," you eliminate these perversities that would arise between the proposed regulation and market forces and instead allow regulators and industry to focus on maximizing improvement. By removing the fraction of trailers that are used transiently, the standards that are set for the remaining trailers could possibly be raised from the proposed values and on a faster timetable. But this would *only* be possible with reasonable levels of non-aero box van classification.

8 - Averaging

While we understand that the agencies view Averaging, Banking and Trading programs as beneficial to the regulated industry, it's important to realize that the trailer industry is not the automobile industry. The six year annual production average for trailers is 187,666 while for cars, it is 13,906,666. It would take the trailer industry 74 years to build what the automobile industry builds in a single year.

Averaging will cause unnecessary disruption in the trailer industry. Currently, most trailers are built to customer specification and most customers have found a preferred manufacturer to build to that specification. With averaging, a given manufacturer may find that the mix of customers in a given year does not allow them to meet their target, which would require that manufacturer to turn away customers and force customers to seek new vendors for established trailers. Manufacturers who specialize in making trailers that are typically used transiently, such as trailers used for intra-city distribution, would be particularly hard hit; the trailer they specialize in would have little to no real-world gains in efficiency while it would have many real-world penalties. Customers would be quick to recognize this and when the specialist manufacturers had to stop selling optimal trailers to meet the averages in the proposal, the customers would have to seek out a new trailer supplier. Large manufacturers aren't looking forward to this either, as a flood of new customers looking for these trailers would skew their numbers and create problems for the larger customers they focus on.

Rather than do this, we would prefer that averaging be done away with entirely: each trailer subject to regulation should be required to meet a given standard. This will require that certain users will have to change their specifications, but will cause minimal disruption to the industry. To do this with minimal disruption to the greater freight industry, careful thought will be needed to be given to trailers that are excluded as mentioned above. The best option would be to allow market forces to work on the situation with the voluntary SmartWay program.

More importantly, however, we request that the agencies demonstrate the commercial feasibility of the proposed rules before they can take effect –i.e., that EPA and NHTSA provide reliable evidence that the technologies imposed by the proposed regulations can be successfully marketed to motor carriers, given that these technologies already exist as options but are not being widely purchased by many motor carriers because their mix of drop-and-hook operations and multiple short, low-speed deliveries does not generate measurable fuel savings benefits. The proposed rules do not require *motor carriers* to purchase specific equipment or to attain specific fuel efficiency goals. Instead, the proposed rules will *require trailer manufacturers to sell* this equipment to an increasing majority of their customers whether these customers want it or not. More accurately, the proposed rules will require the larger manufacturers to sell this equipment, while exempting smaller manufacturers from that requirement at the outset, an exemption that will certainly divert sales to the smaller trailer manufacturers in early years and thereby fail to achieve the agencies' desired goals while arbitrarily and unreasonably imposing the sales obligation on the larger manufacturers. As noted above, however, the reality is that all trailer manufacturers are small manufacturers when compared to the manufacturers of the millions of other motor vehicles sold in the United States annually, which, because of those huge volumes, have the ability to sell expensive and highly fuel efficient vehicles at little or no profit in order to offset sales of more popular less fuel efficient vehicles. Trailer manufacturers, by contrast, do not have the sales volumes needed to absorb trailer sales that produce little or no profit, which will certainly be the effect of requiring them to install equipment that their customers have so far refused to purchase and which those customers will simply refuse to pay for if the new rules take effect. The EPA and NHTSA have produced no reliable, measurable evidence that those motor carriers can be forced to pay for the required technologies, and instead the agencies are proposing to put (some) trailer manufacturers in the completely unreasonable position of insisting that their customers pay for equipment that is not wanted or accept delivery of unwanted equipment at the trailer manufacturer's expense. In the latter instance, the cost of the proposed regulations, which are purportedly justified achieve a national benefit, will be arbitrarily and unreasonably (and in many cases impossibly) imposed solely on (some) trailer manufacturers and not passed on to the motor carriers and then on to their customers, the shippers and the public at large. Therefore, for the proposed rules to satisfy the legal requirements that they be reasonably drawn and achievable in fact, their commercial feasibility must be proven and not merely assumed, and the proposed rules must not establish unreasonable and arbitrary distinctions and sales requirements that disproportionately burden a minority of market participants. Alternatively, the legal requirements to purchase and install the desired equipment should be imposed on the motor carriers directly so that the free market for trailer sales will not be arbitrarily segmented and defeated.

9 - Ways to simplify/streamline

When and if legal authority is given to regulate trailers, there are certain ways that the program could be streamlined. One example would be to require trailer tires to be low rolling resistance and/or trailers to have ATIS as part of NHTSA only, so that compliance can be within the manufacturer's certification label to remove unneeded compliance burden. That way, the regulated classes of trailers goes down and the EPA can focus its priorities where they will do the most good, while manufacturers of non-aero- and non-box-trailers will have a minimum of compliance burden while maximizing the available CO_2 reductions/fuel savings.

Moreover, there are far more effective methods to reduce fuel consumption and improve the freight sectors carbon footprint. Recent proposals to lengthen combination trailers to 33' would have a tremendous impact. This can be seen in the agencies own data and proposed CO_2 standards for trailers, where longer trailers have substantially lower CO_2 emissions per ton-mile[22]. Similarly, an increase in permissible weights would be met with improvements in fuel economy and carbon footprint. Also, a slight reduction in speed limits for HD vehicles would be most effective[23]. Any and all of these would have to be done carefully so as to give due consideration to all aspects including safety concerns, but they would work better than the proposal as written.

Regardless of exemption levels and classification schemes, requiring reporting on every individual trailer produced and each device fitted as the proposal envisions is overly capricious, unreasonably burdensome and is not supportive of the goal of reducing greenhouse gas emissions or saving fuel. Individual trailer manufacturers can certify that they have complied with the regulations and that should be sufficient. If the agencies elect to regulate end users as we suggested in our authority objections sections, we could see adding a panel/label that clearly spells out the characteristics of the trailer in terms that work with that regulation.

10 - Model Year

The proposal's definition of Model Year (see p 40663) differs from NHTSA's[24] and penalizes manufacturers who are making trailers with forward reaching model years for sales purposes. EPA staffers have verbally assured us that the model year as required under this rule does not need to be the same model year used for sales purposes. We will be in position of potentially selling trailers marketed and marked on the VIN plate as Model Year 2019, while marking on the EPA plate ''THIS VEHICLE COMPLIES WITH U.S. EPA REGULATIONS FOR 2018 HEAVY-DUTY VEHICLES.'' Any proposed definition of Model Year should explicitly state this. For example, §1037.801 could be expanded to include a new paragraph:

> * * *
>
> (3) The model year as used in this part need not correspond with the model year used for VIN and marketing purposes.
>
> * * *

while the same paragraph should be added to §535.4's definition of MODEL YEAR.

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[22] E.g. 80FR40612 Table 1 of §1037.107 – Phase 2 CO_2 Standards for Trailers.

[23] For Long Dry Vans, the proposal goes from a baseline of 87.6 to 77 g/ton-mile of CO_2 or a 12% reduction. Fuel required roughly scales with the cube of speed, so a reduction of 4% to speed limits, or reducing 65 to 62 would do that.

[24] 49CFR565.12(m) – "*Model year* means the year used to designate a discrete vehicle model, irrespective of the calendar year in which the vehicle was actually produced, provided that the production period does not exceed 24 months."

Additionally, modify the labeling requirements in 1037.135(8) to read:

> (8) State: ''THIS VEHICLE COMPLIES WITH U.S. EPA REGULATIONS FOR [MODEL YEAR] HEAVY-DUTY VEHICLES.'' Optionally, the word ''MANUFACTURED'' may be added after the model year.

This will make it clear that if a trailer manufacturer adopts a calendar year model year for this rule, it can continue its practice of using an advance model year for VIN and marketing purposes and to avoid confusion, the Emission Control Label on a vehicle with a 2019 Model Year on the VIN plate manufactured in 2018 could read "THIS VEHICLE COMPLIES WITH U.S. EPA REGULATIONS FOR 2018 MANUFACTURED HEAVY-DUTY VEHICLES". If authority comes through NHTSA, a similar label requirement could be used in §535.

11 - Miscellaneous Points:

Automatic Tire Inflation Systems:

The definition of ATIS describes a system that does not exist. "Automatic tire inflation system means a system installed on a vehicle to keep each tire inflated to within 10 percent of the target value with no operator input." State of the art systems only add air to underinflated tires. While overinflated tires do not have a detriment in terms of rolling resistance, they do have problems with accelerated tread wear. [25] As stated earlier, this proposal overlooks the full carbon footprint of the things it's proposing to regulate. For tires, CO_2 emitted outside of use is 16% of the amount emitted during use.[26] An ATIS system is slated to give a 1.5% reduction in emissions, but if that results in a substantial reduction in tread life, the relative fraction of emissions will balloon to eclipse the savings.

Requirements of Tire & Component Manufacturers:

On page 40278 and in footnote 246, the rule mentions that EPA is considering adopting regulatory text addressing obligations for tire manufacturers. Specifically, the EPA asks that, in the event they discover tires on certified trailers that do not conform to the regulations, that they require the tire manufacturer to recall and replace the nonconforming tires. TTMA supports this concept and suggests that when and if regulatory authority is granted, if possible, it be extended in two specific ways. First, that the recall and replace provisions not be limited to tire manufacturers, but to all suppliers of regulated trailer components including Automatic Tire Inflation Systems and Aerodynamic Components. As EPA alludes to in footnote 246, the industry would be uniquely challenged by recall and replace provisions if a tire manufacturer is found to be out of compliance, but the same situation would apply if an aerodynamic skirt were also found to be out of compliance. Second, if the agency insists on collecting data for every trailer made, that the agency tracks the relevant performance figures from component manufacturers (C_{RR} for tires, Delta C_DA for aero-devices) and allows the manufacturers to select the actual component they fitted when filing with the Agency so that it will auto populate with the correct figure. This would have two major advantages.

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[25] *TIRE PRESSURE MONITORING AND INLFATION MAINTENACE* Developed by the Technology & Maintenance Council's (TMC) S.2 Tire & Wheel Study Group; Study Group Information Report: 2010-2. "…10 percent overinflation will reduce tread wear by five percent. … Overinflated tires are more vulnerable to tread surface cutting, impact breaks, punctures, and shock damage which also shortens tire life."

[26] http://www.bridgestone.com/responsibilities/environment/mission/emissions.html Total Lifecycle CO2 emissions for a tire are 86.4% during use.

First it would prevent transcription errors as manufacturers filed with the agency. Second, it would provide the Agency with a database of trailers that may have been fitted with a given tire or aero-device in the event that they determine that a recall is required. Provision would still be needed for trailer manufacturers to enter their own data in the event they are using components of their own manufacture or their own testing of particular device combinations as the Agency is encouraging[27].

Weight:

As described in our Safety Impact section, increased tare weight contributes to increased VMT. While the safety concerns associated with this are our first concern, we ought to consider the fuel consumption and GHG emission effects of these extra trips. This will serve to reduce benefit from applied devices. Similarly, light-weighting trailers will allow more cargo to be carried and thus result in a reduction in VMT and a corresponding reduction in Fuel consumption and GHG emissions. Based on our reading of the EPA documents, the factors applied to weight reduction strategies do not include this effect and most certainly should.

Warranty Problems:

The proposal requires that all devices added to trailers be warranted for a period of five years, one year for tires. Such a warranty would be required “to warrant that these components and systems are designed to remain functional for the warranty period.”[28] This has a few significant problems. For tires, some users will wear through their tires in less than a year’s period. With the overinflation problems expected with the widespread adoption of ATIS, we would expect that number to grow. Tire wear must not be covered under any warranty. Speaking of ATIS, the useful life for these systems is on the order of 5 years alone and we are not aware of any system that has a baseline warranty of more than 3 years. The proposed warranty period for ATIS needs to be reduced. Further, the most common problem with aero-devices is with collisions with infrastructure and other road hazards. Any warranty requirement must also exempt collisions and other non-routine use.

Unintended consequence: brake/wheel end warming:

Over the history of design of a wheel end for usage on trailers, a continued goal has been to provide for the safest, longest lasting, and cost sensitive components possible. The industry continues to reconfigure the brake drum toward these ends. Consequently the weight of a brake drum has been reduced approximately 18% over the past 30+ years (resulting in reduced fuel consumption and therefore reduce CO2 creation). The proposal may reverse this design due to the need to dissipate heat. The heat is created due to braking action, which up until now was cooled via air flow. The concern with the proposal is that, with added side skirts and wheel deflectors for aero purposes, the air flow across the drum area is minimized resulting in an allowance of temperature increase. One way to manage the temperature would be to add mass to the brake drum, resulting in additional weight, thus conflicting with the intended potential advantages of fuel conservation. If temperature is allowed to build it will affect bearings, lubricant, seals, brake lining, heat treatment of drum……in extreme conditions the tire bead could break seal from the rim or the tire could actually ignite and burn the unit to the ground.

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[27] P40280: “In addition, the agencies believe that discounting the delta CDA values of individually-tested devices used as a combination would provide a modest incentive for trailer or device manufacturers to test and get EPA preapproval of the combination as an aerodynamic system for compliance.”

[28] 80FR40282

The Problem with Technology Forcing and Long-Duration Regulations:

This proposed regulation postulates an aggressive schedule of technological development for a long period into the future. While we appreciate the experience the agencies have brought forward in making these predictions, and that the regulation is crafted with the intent of bringing a certain degree of stability to regulation by laying out a roadmap until MY 2027, facts often fly contrary to the best predictions. Moreover, other voices are calling on the agencies to pursue a more aggressive schedule, one that would require an even faster technological development and deployment schedule. Therefore, we request that the regulation have built into it a mid-course review. For areas where there have been unexpected delays, say due to intellectual property rules creating a monopoly for a critical item such as a trailer boat-tail, then this could be addressed. If the rule posited the boat tails would be developed for trailers equipped with roll-up doors despite that no such devices exist today, only to find out that the technical challenges of creating a viable device precluded one, the rule could be revisited. Similarly, if a new device came along that offered improvements beyond what the Agencies envisioned, then the rule's goals could be pushed forward to include that.

DOE Super Truck Program

In the DOE Super Truck Program, a truck and trailer were paired together and optimized together as a pair for aerodynamic performance. At the end of this optimization, neither the trailer nor the tractor could be said to be interchangeable with other trucks or trailers. There are truck aerodynamic design specifications or characteristics that can counteract and negate the trailer aerodynamic device fuel savings. The trailer OEM should not be regulated to add aero devices to trailers because the truck, trucks, or variety of trucks, to be used to tow the trailer is not known and such an understanding of the effects of truck aero design and how it affects the aerodynamic characteristics of the trailer is mostly not well understood nor have been shown to be constant or changing over time.

Costing

Anti-Trust issues prevent us from gathering cost of goods data. Our members have commented that the costs of certain components in the RIA seem quite low. [29] We will encourage members to submit specific examples directly to the agencies as confidential business information.

12 - Conclusion

The legal basis for including trailers in this rulemaking is flawed and as such it should remove trailers from consideration. If the agencies are set on working to reduce greenhouse gas emissions and fuel consumption as a result of trailer use, they would be better served by regulating that use directly. Drivers and fleets are the ones in control of trailer use, from specification thru disposal; they create new tractor-trailer combinations every day and are the ones who purchase fuel and emit greenhouse gas as a result.

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[29] As pointed out in the text, member companies cannot share specifics through the Truck Trailer Manufacturers Association. We will be encouraging individual members to cite this footnote and supply supporting materials as confidential business information.

Outside of regulating direct use, the agencies should continue voluntary implementation of technological advances. The trucking transportation industry has been and still is very interested in all aspects of fuel-saving technology, and has, through programs such as SmartWay, made great strides in fuel conservation. The driving force behind such implementations has been the financial bottom line of the motor carriers. Some of the innovations employed include increases to interior volume while maintaining exterior size, reduction in weight, decking systems for multi-layer cargo transportation; along with some of the technologies the EPA regulation is basing its reductions on, such as aerodynamic devices, low rolling resistance tires, and automatic tire inflation systems. These advances have been employed as the industry has seen and realized value supported by evidence. The current proposal for a regulation will indeed claim a difference which would likely have been accomplished through the voluntary adoption of systems proven as functional. An unintended side-effect will be the increased creation of CO2 due to the additional fuel expended on those "regulated units" that do not operate in a manner which causes the added options to provide for a realized and effective performance.

When push comes to shove, the motor carrier industry is very resourceful and may take action which actually detracts from the overall purpose of reducing CO_2 creation. One such scenario has been experienced in the CARB trailer regulations in the state of California; many shipments have found their way to container/chassis combinations as an over-the-road mode of transportation which will not be required under the current proposal to be equipped with any of the aerodynamic features that trailer manufacturers will have to install on trailers. Cargo containers are also, by common design, inherently less aerodynamic given their ribbed sides and square edges. The combined weight effect of this diversion is a 5,000 lb. increase per container-chassis shipment to the empty weight of the unit of transference. Thus the proposed regulations will create an arbitrary and unreasonable outcome by diverting substantial cargo on a nationwide basis to far less efficient container chassis modes of transportation, and this will significantly undermine the desired goals of the proposal. Container and chassis manufacturers will be unreasonably favored in the marketplace by exclusion from the regulations, while their unregulated products will continue to produce less efficient aerodynamic outcomes than trailers currently in production today.

If rules must be crafted, they should be done so reasonably, and not arbitrarily, so as to avoid these sorts of deleterious effects. We have pointed out certain areas that the agencies have overlooked for both exclusion from the rule and for changing the ways that box trailers are counted to account for the ways that they are used. We also encourage regulators to refrain from unnecessarily harming the trailer manufacturing industry by being sensitive to its small-business, produce-to-order nature and to craft any such regulation with the realization that there is no "average" trailer manufacturer. Putting a manufacturer out of business by forcing it to make what it cannot sell or exclusively absorb costs that it cannot pass on will save no fuel and reduces no emissions. There are methods in use today that accomplish regulation of the industry without such an arbitrarily heavy hand as the agencies are proposing here. We have detailed a few such ways that the agencies should consider that would reduce the unreasonable burden while still accomplishing the agencies goals.

Once again, we appreciate the agencies' outreach to us and pledge to continue dialog to help the agencies craft the best regulations possible. We will continue to gather data and may submit further information as it becomes available, and welcome inquiries from the agencies.

Sincerely,

John Freiler

John Freiler

Engineering Manager

Truck Trailer Manufacturers Association

Comments of Wabash National Corporation on Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, 80 Fed. Reg. 40,137 (proposed July 13, 2015) – Docket ID Nos. EPA–HQ–OAR–2014–0827, NHTSA–2014–0132

October 1, 2015

I. Introduction

Wabash National Corporation ("Wabash") welcomes the opportunity to submit these comments on the U.S. Environmental Protection Agency's ("EPA's") and the National Highway Traffic Safety Administration's ("NHTSA's") Phase 2 Proposed Rule.[1]

As the leading trailer manufacturer in the world, Wabash has a strong interest in the Proposal, including its potential impact on the ongoing innovations in aerodynamic trailer technologies. We share the agencies' goals of improving fuel economy and reducing greenhouse gas ("GHG") through aerodynamic improvements. Consistent with those goals, Wabash supports several critical aspects of the Proposal and applauds the agencies for their thoughtful analysis of difficult issues of first impression. Nonetheless, we have significant concerns regarding certain aspects of the Proposal that may impose rigid and burdensome requirements within the trailer market. Our specific comments are provided below for the agencies' review and consideration.

II. Wabash National Is a Leader in Trailer Innovations

Wabash is North America's leading producer of semi-trailers, having shipped more than 57,000 units in 2014. With today's just-in-time environment, semi-trailers are vital to keeping the U.S. economy moving, as they deliver nearly 70% of all freight tonnage. Wabash products are widely recognized and highly regarded, often holding the number-one position in market share across their respective categories. Wabash brands include: Wabash National®, Beall®, Benson®, Brenner® Tank, Bulk Tank International, DuraPlate®, Extract Technology®, Garsite, Progress Tank, Transcraft®, TST®, Walker Barrier Systems, Walker Engineered Products, and Walker Transport.

Wabash is the largest trailer manufacturer and employer in the U.S. With its corporate headquarters and several manufacturing facilities in Lafayette, Indiana, Wabash also has manufacturing facilities in several other locations, including:

- Frankfort, Indiana;
- Cadiz, Kentucky;
- Harrison, Arkansas;
- Fond du Lac, Wisconsin;
- Portland, Oregon;
- New Lisbon, Wisconsin;
- Kansas City, Missouri; and
- Kansas City, Kansas.

In addition to the manufacturing plants, Wabash operates two expert service networks to support a wide range of customers and trailer equipment from dry and refrigerated vans to

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[1] Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, 80 Fed. Reg. 40,137 (proposed July 13, 2015) ("Phase 2 Proposed Rule" or "Proposal").

platform and tank trailers. Those retail networks, the Wabash National Trailer Centers and Brenner Tank Services, have locations in the following communities:

- Cadiz, Kentucky;
- Columbus, Ohio;
- Dallas, Texas;
- Denver, Colorado;
- Miami, Florida;
- Phoenix, Arizona;
- San Antonio, Texas;
- Scranton, Pennsylvania;
- Smithton, Pennsylvania;
- Ashland, Kentucky;
- Baton Rouge, Louisiana;
- Chicago, Illinois;
- Houston, Texas;
- Mauston, Texas; and
- West Memphis, Arkansas.

In 2014, Wabash shipped 57,350 new trailers. For 14 of the past 21 years, Wabash has been first in total trailer production. Wabash employs 6,000 associates (full-time and contract) at its manufacturing facilities, company-owned retail locations, corporate headquarters, and other facilities.

As an innovation leader with more than 200 patents worldwide, Wabash continuously explores solutions to improve fuel efficiency on trailers and lower operating costs for our customers. To provide our customers the best products in the industry, Wabash employs a dedicated team of nationally recognized experts that design and support aerodynamic trailer products. As part of the product development process, the Wabash aero team conducts extensive testing including wind tunnel testing, computer simulation modeling, lab durability tests, track tests, and road tests. Wabash has obtained EPA's verification of several aerodynamic products under the voluntary SmartWay Technology Program, an important recognition that Wabash's products improve efficiency and reduce emissions.[2]

In exploring the next generation of trailer fuel efficiency technology, the Wabash team looks for aerodynamic products that provide: (1) real world, quantifiable fuel efficiency improvements; (2) cost-effective payback periods; and (3) freight efficiency improvements, all while maintaining safety and ensuring no interference in operations. Wabash recently launched the Ventix DRS™ and AeroFin™, which combined provide more than a 9% improvement in fuel

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[2] *See* EPA, *SmartWay Verified Trailer Aerodynamic Devices*, http://epa.gov/smartway/forpartners/technology.htm (last updated Aug. 14, 2015) (Ex. 1).

efficiency. Future products that Wabash is exploring include variable shape trailers and variable ride height suspension.[3]

Wabash engages in extensive outreach with the technical, scientific, and regulatory communities to ensure that trailer innovations continue in a manner that delivers value to our customers. Our investment in outreach includes participating in several scientific and technical reviews, regulatory proceedings, and discussions with our customers. Wabash views these comments as a continuation of our ongoing dialogue and looks forward to further engagement with the agencies.

III. Wabash Supports the Goals of the Phase 2 Proposed Rule

Wabash supports the objectives of the Phase 2 Proposed Rule and agrees that sensibly reducing GHG emissions through fuel efficiency solutions can result in important economic and environmental benefits. Not only are sensible fuel efficiency solutions good for our air quality, but they also help conserve our fuel resources, deliver fuel cost savings for fleets, and decrease the cost of freight transportation by creating greater overall freight efficiency.

Wabash supports improvements in fuel efficiency as part of an overarching goal of improving overall freight efficiency. Wabash believes in two core principles with respect to the proposed regulations: (1) maximum compliance flexibility and (2) simplicity in compliance. The agencies should offer opportunities for compliance flexibility, including allowing for exemptions when the proposed measures are not economically feasible, and thus will not contribute to freight efficiency. Such exemptions are valid, and do not suggest that the industry is trying to avoid compliance, but instead represent common-sense and cost-effective regulation. Given that the composition and operation of the trailer industry is quite different from the engine and vehicle manufacturing industries, simplicity of regulation is essential. History has shown that the trailer industry has proactively and voluntarily embraced innovations when the fuel economy benefits are demonstrated, even without regulatory pressures.

IV. Wabash Generally Supports the Scope of the Proposed Rule, but Certain Adjustments Are Necessary and Appropriate

In the Proposal, the agencies recognize that the trailer industry encompasses a wide variety of trailer applications and designs, ranging from those designed for dedicated uses in logging and mining operations to the more common highway trailers—box trailers (dry vans and refrigerated vans of all sizes) and "non-box" trailers including platform or flatbed, tank, container chassis, bulk, dump, grain, and other specialized types of trailers.[4] The agencies propose to regulate only those trailers designed to be drawn by Class 7 and 8 tractors when coupled to the tractor's fifth wheel, not those designed to be drawn by vehicles other than tractors, or those that are coupled to vehicles with pintle hooks or hitches instead of a fifth

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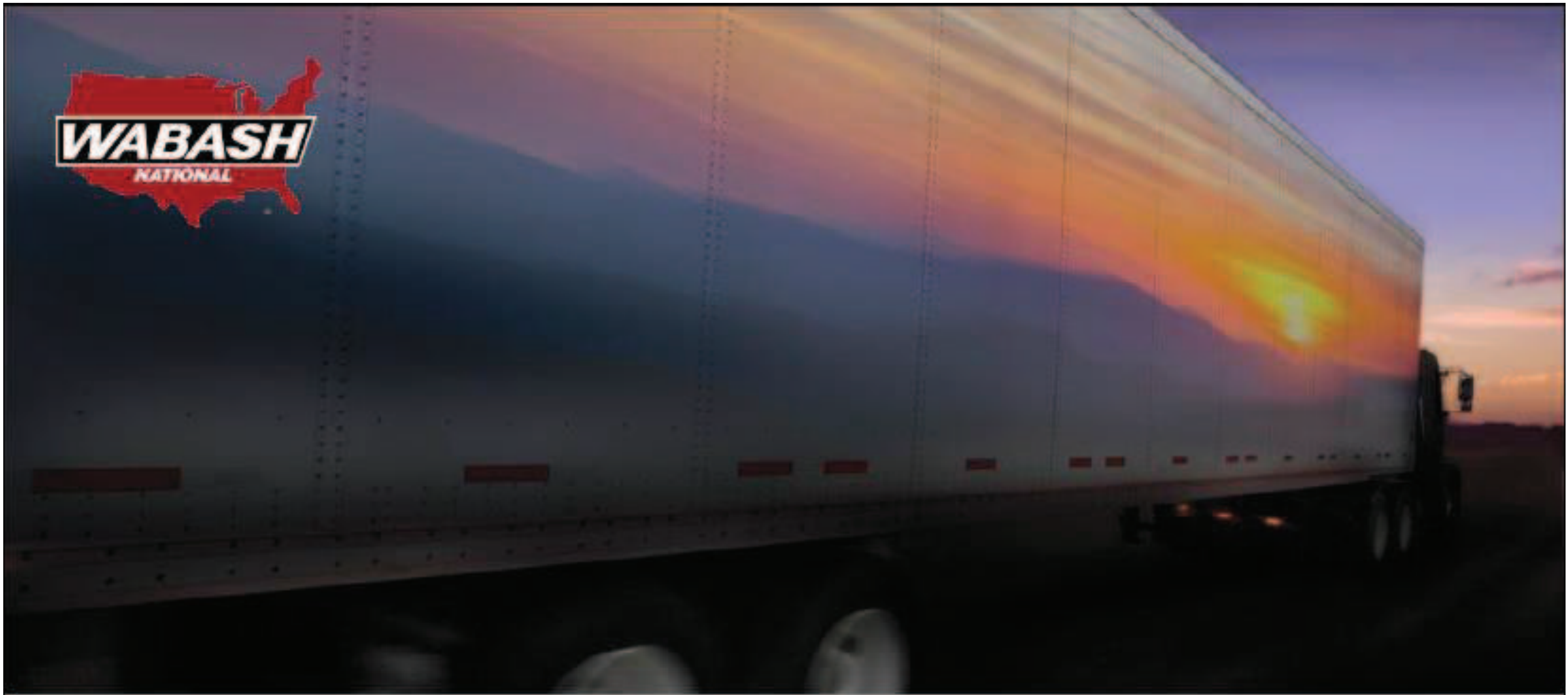
[3] *See* G. Sumcad, Director of Engineering, Wabash National Corporation, *Fuel Efficiency for Trailers: California Air Resources Board Symposium on Phase 2 Greenhouse Gas Emissions Standards for On-Road Heavy Duty Vehicles* (Apr. 22, 2015), http://www.arb.ca.gov/msprog/onroad/caphase2ghg/presentations/2_12_gus_s_wabash.pdf (Ex. 2).

[4] 80 Fed. Reg. at 40,253.



FUEL EFFICIENCY FOR TRAILERS

California Air Resource Board Symposium
Phase 2 Greenhouse Gas Emissions Standards for On-Road Heavy Duty Vehicles

22 April 2015

Gus Sumcad
Director Engineering

CURRENT FUEL EFFICIENCY TECHNOLOGY EXAMPLES

Trailer Mounted Gap Reducers
Saves 1-2%

Trailer Boat Tails
Saves 1-6%

Trailer Side Skirts
Saves 4-8%

Low Rolling Resistance Tires
Saves 2-4%
(Duals and Wide Base)

Tire Inflation
Saves 1-2%

Trailer Under Tray Systems
Saves 1-3%

Source: *Performance Innovation Transport*, Cascade Sierra Solutions, Device Manufacturers Data

TRAILER AERODYNAMICS – FUTURE OPPORTUNITIES

- Trailer shape → requires changes in length, weight, and height regulations (State and Federal)
- Matching tractor and trailer → requires greater collaboration between truck and trailer manufacturers
- Variable Ride Height Suspensions → new technology in development
- Lighter Weight Components → costs Vs weight savings benefits

SOURCE: Navistar SuperTruck DOE Merit Review, May 2014

Technology and design will continue to evolve – fuel savings $ are the driver

Environmental Defense Fund

October 1, 2015

SUBMITTED ONLINE

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Submitted online at: www.regulations.gov

Attention: Docket ID Nos. **EPA–HQ–OAR–2014–0827**
NHTSA–2014–0132

Re: Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Proposed Rule

Environmental Defense Fund (EDF) appreciates the opportunity to submit comments on EPA and the NHTSA's ("the Agencies") proposed rule to adopt greenhouse gas (GHG) emissions standards and fuel efficiency standards for new medium- and heavy-duty engines and vehicles. EDF is a non-profit, non-partisan, non-governmental environmental organization that combines law, policy, science, and economics to find solutions to today's most pressing environmental problems. We respectfully submit these comments on behalf of our more than one million members who support cleaner air and climate security. All of the documents cited to and relied on in these comments are hereby incorporated as part of the administrative record. EDF is also submitting separate joint comments on the Social Cost of Carbon and the Social Cost of Methane to this docket and they are hereby incorporated.

In a June 2013 speech about the pressing need to address climate change, President Obama acknowledged the importance of building on the first-ever standards for heavy-duty trucks and committed to strengthening fuel economy and greenhouse gas emission standards for post-2018 vehicles, stating: "in the coming months we'll partner with truck makers to do it again for the next generation of vehicle."[1] The President's Climate Action Plan calls for standards that continue to reduce fuel consumption through cost-effective technologies that will increase the

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[1] The White House, *Remarks by the President on Climate Change*, Georgetown University (June 25, 2013), *available at* http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change.

efficiency of shipping goods across the United States.[2] And the President reiterated his commitment in a U.S.-China Joint Presidential Statement on Climate Change: "The United States commits to finalize its next-stage, world-class fuel efficiency standards for heavy-duty vehicles in 2016 and implement them in 2019."[3]

EDF likewise recognizes the importance of a rigorous second phase of standards to reduce greenhouse gas emissions and improve fuel efficiency for medium- and heavy-duty vehicles ("Phase 2 Standards"). Accordingly, we respectfully urge EPA to strengthen the proposed Phase 2 Standards to reflect the full suite of existing and emerging cost-effective technologies. The nation's fleet of trucks and buses consumes more than 135 million gallons of fuel every day and emits more than 450 million metric tons of climate pollution annually.[4] And freight movement is one of the fastest growing sources of greenhouse gas emissions and fuel consumption in the United States – despite historic first-ever fuel economy and greenhouse gas standards finalized by the Obama Administration in 2011.[5] Reducing fuel consumption and GHG emissions from these vehicles is one of the most consequential actions we can take to lessen our dependence on oil, improve our energy security and help mitigate climate change. But only robust and timely Phase 2 standards will drive the innovative technologies needed to secure these benefits. We urge the Agencies not to delay in finalizing strong standards to protect our communities and families.

In summary, our comments:

- Discuss the harms associated with climate change;
- Identify rigorous aspects of the proposal that we support;
- Recommend improvements to the economic impacts analysis;
- Make specific recommendations for areas of the proposal that should be strengthened, including the engine standard and requirements for natural gas vehicles;
- Request the agencies provide transparent emissions and fuel economy information to consumers through window labels and online tools;
- Urge the agencies to establish protective particulate emissions standards for APUs and strengthen NOx standards for heavy-duty vehicles

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[2] The White House, *The President's Climate Action Plan,* (June 2013), *available at* http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

[3] White House press release, *US-China Joint Presidential Statement on Climate Change*, (September 25, 2015), *available at* https://www.whitehouse.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change.

[4] Energy Information Agency (EIA), *Annual Energy Outlook* (2015), Tables A-7 and A-19.

[5] EIA, *Annual Energy Outlook* (2015), Table 19.

method, identifies the major steps necessary in refinement of the device, and offers plausible reasons for believing that each of those steps can be completed in the time available."[95]

Likewise, in 2001, EPA established diesel PM and NOx emissions standards for heavy-duty trucks and buses that required substantial reductions and relied on studies suggesting that technologies currently being tested could collectively overcome then-existing obstacles.[96] The D.C. Circuit upheld these standards, affirming EPA's technological predictions and noting that "the rule c[ould] stand so long as there was one solution as to which EPA's prediction was not arbitrary."[97]

EPA describes its Phase 2 proposal as technology forcing, in line with this long and successful history.[98] As we set forth more fully below, however, certain key aspects of the agency's proposal—including the engine standards—are based almost entirely on today's technologies and conservative assumptions about the development of those technologies. EPA must strengthen these provisions to be consistent with the technology-forcing history of section 202 and the agency's own stated intention in the Phase 2 proposal.

B. EPA has clear authority to regulate trailers

EPA and NHTSA have proposed standards for trailers that are used in combination with two different classes of tractors.[99] EPA's authority to adopt these proposed standards rests on firm legal footing, reflects a reasonable interpretation of the relevant Clean Air Act provisions, and is consistent with the agency's past regulatory practice.

Section 202(a)(1) of the Act authorizes EPA to regulate "the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines . . ."[100] 'Motor vehicle,' as it is used in Section 202(a)(1), is defined under Section 216 as "any self-propelled vehicle *designed for transporting persons or property* on a street or highway."[101]

EPA has interpreted this statutory definition to enable the agency to adopt standards addressing emissions from the Class 7 and 8 combination tractor-trailers, which "consist of a cab and engine

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[95] *Id.* at 331-32.

[96] Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, 66 Fed. Reg. 5002 (2001).

[97] *Nat'l Petrochemicals & Refiners Ass'n v. EPA*, 287 F.3d 1130 (D.C. Cir. 2002) at 1140.

[98] *E.g.*, 80 Fed. Reg. 40154 ("The proposed Phase 2 standards would represent a more technology forcing approach than the Phase 1 approach, predicated on use of both off the-shelf technologies and emerging technologies that are not yet in widespread use. The agencies are proposing standards for MY 2027 that would likely require manufacturers to make extensive use of these technologies.")

[99] 80 Fed. Reg. 40146.

[100] *Id.*

[101] 42 U.S.C. § 7550 (emphasis added).

(tractor or combination tractor) and a detachable trailer."[102] The statutory definition of 'motor vehicle' in section 216 expressly defines that term in light of the vehicle's intended use: "transporting persons or property on a road or highway." EPA has reasonably interpreted 'motor vehicle' to encompass all of the components of Class 7 and 8 tractor-trailers (including the trailer), which are needed to accomplish that objective.

In particular, Class 7 and 8 tractor-trailers are designed and used to transport large quantities of goods. To perform this task, the vehicle must have three components: an engine, a tractor, and a trailer. These three components are inextricably linked; no one part can successfully transport goods without the other two. And the trailers addressed in the proposal are designed and engineered to operate in tandem with tractors.[103]

As their design features would suggest, these tractors and trailers are operated together almost exclusively.[104] The height of the tractor is designed to correspond to the height of the trailer, achieving optimal aerodynamic performance and minimal air-resistance only when the two are coordinated.[105] Moreover, as the primary load-carrying device, trailers account for a substantial percentage of the engine load and therefore contribute significantly to the vehicle's emissions. Accordingly, the use of improved aerodynamic and tire technologies on the trailer will reduce the vehicle's emissions.[106] [107] EPA's interpretation of 'motor vehicle' as consisting of the engine, tractor, and trailer in the heavy-duty context is therefore a reasonable interpretation of the statute.[108]

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[102] 80 Fed. Reg. 40151.

[103] The proposed standards are applicable to "trailers specifically designed to be drawn by Class 7 and 8 tractors when coupled to the tractor's fifth wheel. The agencies are not proposing standards for trailers designed to be drawn by vehicles other than tractors, and those that are coupled to vehicles with pintle hooks or hitches instead of a fifth wheel." 80 Fed. Reg. 40253.

[104] Trucking companies do not provide insurance protection for truckers when operating a truck-tractor without an attached trailer; it is considered a non-business activity. Truckers must separately purchase 'bobtail insurance' to be covered between dropping off one trailer load and picking up the next one. *See, e.g.* Insure My Rig, http://www.insuremyrig.com/what-is-bobtail-insurance.html (last visited Sept. 29, 2015); *Understanding the Difference Between Bobtail and Non-Trucking Liability Insurance*,

[105] 76 Fed. Reg. 57138-39 (Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 1).

[106] EPA notes in the proposed rule that the trailers that are pulled by Class 7 and 8 tractors account for two-thirds of the heavy-duty sector's total CO_2 emissions and fuel consumption. 80 Fed. Reg. 40253.

[107] As a result of studies undertaken as part of initiatives such as the Department of Energy's SuperTruck program and EPA's SmartWay program, design and operational practices have already been developed to cost-effectively reduce those emissions.

[108] The fact that the trailer does not itself 'emit,' does not exclude it from EPA's regulatory authority. Section 202(a)(1) authorizes EPA to adopt standards "applicable to the emission of any air pollutant" from new motor vehicles and motor vehicle engines. This statutory grant of authority clearly encompasses standards like those EPA has previously adopted for vehicle attributes that effect emissions, including low-rolling-resistance tires, low-drag brakes, and more aerodynamic vehicle shapes. 75 Fed. Reg. 25374 (2010 Light Duty Vehicle Greenhouse Gas Emission Standards). EPA has likewise interpreted this authority to allow the agency to adopt compliance approaches that reflect upstream emissions. *See id. See also* Response to Comments ("[Section 202(a)] does not directly address what the "standards applicable to" the emissions must be, or how those standards are to be measured. It does not specify how or what mechanisms EPA may reasonably use in applying a standard to vehicle

EPA's interpretation is likewise consistent with other provisions of the CAA and EPA implementing regulations addressing heavy-duty vehicles. Section 202(b), which authorizes EPA to adopt criteria pollutant standards for heavy-duty vehicles, defines a 'heavy duty vehicle' as, among other things, having "a gross vehicle weight (as determined under regulations promulgated by the Administrator) in excess of six thousand pounds."[109] EPA regulations confirm that a vehicle's 'gross vehicle weight' can be measured by "the maximum weight of a loaded vehicle and trailer," or by "the maximum design loaded weight of a single vehicle."[110] These provisions are both tied to the way in which the vehicles are operated and contemplate the load carried by the trailer. As EPA notes in the proposal, its determination of its authority as to trailers is also consistent with a prior interpretation of the heavy-duty vehicle as being incomplete unless a trailer is attached. [111] EPA must strengthen these provisions to be consistent with **its delegated responsibility to establish technology-forcing standards under section 202** and the Agency's own stated intention in the Phase 2 proposal.

V. Assessment of Benefits

A. Social cost of carbon and social cost of methane

Please see separate comments submitted jointly to the docket by EDF, Institute for Policy Integrity, Union of Concerned Scientists and the Natural Resources Defense Council.

B. Rebound

1. New studies should be used to inform final rebound values

The agencies have proposed to maintain the same rebound values finalized in the Phase 1 program – 5% for tractor trailers, 15% for vocational and 10% for pickups and vans – stating they had "insufficient evidence to justify revising the rebound effect values that were used in the Phase 1 analysis."[112] New analyses by Winebrake et. al., however, indicate that these Phase 1 values may be too high.

A 2015 paper by Winebrake *et. al.* looks at fuel price elasticity estimates for single-unit truck activity (vocational trucks), as measured in VMT, and concludes they "cannot reject a null

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emissions. This leaves EPA with discretion to develop both elements of the standards and the means of measuring compliance with them.").

[109] 42 U.S.C. § 7521.

[110] 40 CFR 86.1803-01.

[111] 40 CFR 86.1803–01 defines a 'complete heavy-duty vehicle' as a heavy-duty vehicle "that has the primary load carrying device or container attached," while a heavy-duty truck without a load-carrying device is considered an 'incomplete vehicle.' Because trailers are 'load carrying devices,' they are implicitly part of the vehicle.

[112] Preamble at 40453.

Legal Memorandum Discussing Issues Pertaining to Trailers, Glider Vehicles, and Glider Kits under the Clean Air Act

The following is a discussion of EPA's understanding of issues regarding trailers, glider vehicles, and glider kits under the Clean Air Act ("CAA" or "the Act"). This document is specific to the EPA and its legal authorities. For a discussion of the National Highway Traffic Safety Administration's (NHTSA) legal authority regarding trailers, please see Section I. E. (2)(a) of the NPRM (80 FR 40137). For NHTSA's proposal regarding gliders and glider kits, please see Section XIV. B. of the NPRM. *Id*.

The EPA proposed to establish emission standards applicable to trailers hauled by tractors. 80 FR 40170. Certain commenters, notably the Truck Trailer Manufacturers Association (TTMA), maintained that EPA lacks authority to adopt requirements for trailer manufacturers, and that emission standards for trailers could only be implemented, if at all, by requirements applicable to the entity assembling a tractor-trailer combination. The argument is that trailers by themselves are not "motor vehicles" as defined in section 216 (2) of the Act, that trailer manufacturers therefore do not manufacture motor vehicles, and that standards for trailers can be imposed, if at all, only on "the party that joined the trailer to the tractor". Comments of TTMA, p. 4.

EPA also proposed a number of changes and clarifications for rules respecting glider kits and glider vehicles. 80 FR 40527-530. A glider kit is a tractor chassis with axles, rear end, interior cab, and brakes. It is intended for self-propelled highway use, and becomes a glider vehicle when an engine and transmission are added. Engines are often salvaged from earlier model year vehicles and installed in the glider kit. The final manufacturer of the glider vehicle, i.e. the entity that reinstalls an engine, is typically a different manufacturer than the original manufacturer of the glider kit. A glider kit manufacturer typically knows what the final configuration of the vehicle will be, since all wiring of modern heavy duty vehicles is predicated on a particular engine/transmission configuration. A number of commenters, including Daimler, argued that glider kits are not motor vehicles and so EPA lacks the authority to impose any rules respecting their sale or configuration.

Under the Act, "motor vehicle" is defined as "any self-propelled vehicle designed for transporting persons or property on a street or highway." CAA section 216 (2). At proposal, EPA maintained that tractor-trailers are motor vehicles and that EPA therefore has the authority to promulgate emission standards for each of the chief components – both the tractor and the trailer. 80 FR 40170. The same proposition holds for glider kits. The argument that a trailer, or a glider kit, standing alone, is not self-propelled, and therefore is not a motor vehicle, appears to miss the key issues of authority under the Clean Air Act to promulgate emission standards for motor vehicles produced in discrete segments, and the further issue of the entities – namely "manufacturers" – to which standards and certification requirements apply. This memorandum addresses those issues (while soliciting further comment), and also discusses and solicits comments on certain alternative authorities and approaches for requiring manufacturers of trailers and glider kits to meet standards are conduct needed testing of emission control systems.

a. Standards for Complete Vehicles – Tractor-Trailers and Glider Vehicles

Section 202 (a)(1) authorizes EPA to set standards "applicable to the emission of any air pollutant from any … new motor vehicles". There is no question that EPA is authorized to establish emission standards under this provision for complete new motor vehicles, and thus can promulgate emission standards for air pollutants emitted by tractor-trailers and by glider vehicles.

Issues raised in the comments with respect to authority to promulgate emission standards for glider vehicles questioned whether glider vehicles are "new" as well as the emission standards applicable to engines reinstalled into glider vehicles. At proposal, EPA indicated that engines used in glider vehicles are to be certified to standards for the model year in which these vehicles are assembled. 80 FR 40528. This proposal appears to be well within the agency's legal authority. The Act contains no specific guidance regarding whether the model year of the engine or of the assembly of the vehicle is controlling, either in provisions on rebuilt engines or otherwise. Given the Act's purpose of controlling emissions of air pollutants from motor vehicle engines, with special concern for emissions from heavy-duty engines, it appears reasonable to require engines placed in newly-assembled vehicles to meet the same standards as all other engines in new motor vehicles. Indeed, one prominent assembler of glider kits and glider vehicles advertises that "Fitzgerald Glider Kits offers customers the option to purchase a *brand new 2016 tractor*, in any configuration offered by the manufacturer… Fitzgerald Glider Kits has mastered the process of taking the 'Glider Kit' and installing the components to work seamlessly *with the new truck*." [1] It seems both reasonable and equitable for the engines in "new trucks" to meet the emission standards for all other engines installed in new trucks.

Daimler maintained in its comments that although a glider vehicle is a motor vehicle, it may not be a "new" motor vehicle because "glider vehicles, when constructed retain the identity of the donor vehicle, such that the title has already been exchanged, making the vehicles not 'new' under the CAA." Daimler Comments p. 121. The Act defines "new motor vehicle" as "a motor vehicle the equitable or legal title to which has never been transferred to an ultimate purchaser" (section 216(3)). As just quoted, glider vehicles are typically marketed and sold as "brand new" trucks. The purchaser of a "new truck" necessarily takes initial title to that truck. It is possible Daimler is referring to a practice whereby the glider vehicle retains the vehicle identification number (VIN) of the vehicle from which the engine is taken. See 80 FR 40529. As EPA observed at proposal, the Act does not compel exaltation of form over substance, such that a truck marketed and sold as new with title to that new vehicle conveyed to the purchaser must be considered to be a remnant of the vehicle from which the engine was taken. Id.[2] Nor does the Act make Vehicle Identification Numbers determinative of new motor vehicle status.

b. Standards for Incomplete Vehicles

Section 202 (a)(1) not only authorizes EPA to set standards "applicable to the emission of any air pollutant from any … new motor vehicles", but states further that these standards are applicable "whether such vehicles … are designed as complete systems or incorporate devices to prevent or control

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[1] Advertisement for Fitzgerald Glider kits in Overrdrive magazine (December 2015)(emphasis added).

[2] Even in the very rare instance where the same entity builds the glider kit, installs an old engine from its own vehicle into a glider vehicle for its own use and somehow does so without new title passing, EPA would have authority over the practice under the engine rebuilding authority of section 202 (a)(3)(D), which authority includes removal of an engine from the donor vehicle. See 40 CFR section 86.004-40 and 62 FR 54701 (Oct. 21, 1997).

such pollution." The Act in fact not only contemplates, but in some instances, directly commands that EPA establish standards for incomplete vehicles and vehicle components. See CAA section 202 (a)(6) (standards for onboard vapor recovery systems on "new light-duty vehicles", and requiring installation of such systems); section 202 (a)(5)(A) (standards to control emissions from refueling motor vehicles, and requiring consideration of, and possible design standards for, fueling system components); 202 (k) (standards to control evaporative emissions from gasoline-fueled motor vehicles).

Emission standards EPA sets pursuant to this authority thus can be, and often are focused on emissions from the new motor vehicle, and from portions, systems, parts, or components of the vehicle. Standards thus apply not just to exhaust emissions, but to emissions from non-exhaust portions of a vehicle, or from specific vehicle components or parts. See the various evaporative emission standards for light duty vehicles in 40 CFR Part 86 subpart B (e.g. 86. 146-96 and 86.150-98 (refueling spitback and refueling test procedures); sections 1060.101-103 and 73 FR 59114-115 ((various evaporative emission standards for small spark ignition equipment); : section 86.1813-17(a)(2)(iii) (canister bleed evaporative emission test procedure, where testing is solely of fuel tank and evaporative canister); see also 79 FR 23507 (April 28, 2014) (incomplete heavy duty gasoline vehicles could be subject to, and required to certify compliance with, evaporative emission standards). These standards are implemented by testing the particular vehicle component, not by whole vehicle testing, notwithstanding that the component may not yet be self-propelled or (in the case of non-road equipment), propelled by an engine [3]

EPA thus can set standards for all or just part of the motor vehicle, notwithstanding that an incomplete motor vehicle may not yet be self-propelled. This is not to say that the Act authorizes emission standards for any part of a motor vehicle, however small. EPA thus proposed that a trailer is a vehicle "when it has a frame with axles attached", and a glider kit becomes a vehicle when "it includes a passenger compartment attached to a frame with axles" Proposed sections 1037.801 (definition of "vehicle" section (1)(ii) and (iii) (80 FR 40665)).

Incomplete vehicle standards must, of course, be reasonably designed to control emissions caused by that particular vehicle segment. The standards for trailers would do so and account for the tractor-trailer combination by using a reference tractor in the trailer test procedure (and, conversely, a reference trailer in the tractor test procedure). All of these standards appear to be reasonably considered to be standards applicable to emissions from a new motor vehicle.

The following section of this memorandum discusses the issue of the entities to which emission standards can appropriately apply in incomplete vehicle situations. At the outset, however, we note that EPA has already discussed and applied the general principle for determining the appropriate entities for testing and certifying: namely, on the entities with most control over the particular vehicle segment due to producing it. . [4] EPA has proposed to implement the trailer and glider kit emission standards in accord with this principle.

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[3] "Non-road vehicles" are defined differently than "motor vehicles" under the Act, but the difference does not appear relevant here. Non-road vehicles, like motor vehicles, must be propelled by an engine. See CAA section 216 (11) ("'nonroad vehicle' means a vehicle that is powered by a nonroad engine"). Pursuant to this authority, EPA has promulgated many emission standards applicable to components of engineless non-road equipment, for which the equipment manufacturer must certify.

[4] See discussion of standards applicable to small SI equipment fuel systems, implemented by standards for the manufacturers of that equipment at 73 FR 59115 ("In most cases, nonroad standards apply to the manufacturer of

c. To Whom do Emission Standards Apply

Emission standards are implemented through regulation of the manufacturer of the new motor vehicle. See, e.g. section 206 (a)(1) (certification testing of motor vehicle submitted by "a manufacturer"); 203 (a)(1) (manufacturer of new motor vehicle prohibited from introducing uncertified motor vehicles into commerce); 207 (a)(1) (manufacturer of motor vehicle to provide warranty to ultimate purchaser of compliance with applicable emission standards); 207 (c) (recall authority); 208 (a) (recordkeeping and testing can be required of every manufacturer of new motor vehicle). [5]

The Act further distinguishes between manufacturers of motor vehicles and manufacturers of motor vehicle parts. See, e.g. section 206 (a)(2) (voluntary emission control system verification testing); 203 (a)(3)(B) (prohibition on parts manufacturers and other persons relating to defeat devices); 207 (a)(2) (part manufacturer may provide warranty certification regarding use of parts); 208 (a) (recordkeeping and testing requirements for manufacturers of vehicle and engine "parts or components").

Thus, the question here is whether a trailer manufacturer or glider kit manufacturer can be a manufacturer of a new motor vehicle, or must necessarily be classified as a manufacturer of a motor vehicle part or component. We show in the following section that EPA may reasonably classify trailer manufacturers and glider kit manufacturers as motor vehicle manufacturers, although we also believe that EPA would have adequate authority for the standards even if these entities were classified simply as manufacturers of motor vehicle parts.

d. Trailer Manufacturers May Be Classified as Motor Vehicle Manufacturers

Section 216 (1) defines a "manufacturer" as:

> any person engaged in the manufacturing or assembling of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, or importing such vehicles or engines for resale, or who acts for and is under the control of any such person in connection with the distribution of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, but shall not include any dealer with respect to new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines received by him in commerce

It appears plain that this definition was not intended to restrict the definition of "manufacturer" to a single person per vehicle. The use of the conjunctive, specifying that a manufacturer is "any person engaged in the manufacturing or assembling of new motor vehicles . . . or who acts for and is under the

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the engine or the manufacturer of the nonroad equipment. Here, the products subject to the standards (fuel lines and fuel tanks) are typically manufactured by a different manufacturer. In most cases the engine manufacturers do not produce complete fuel systems and therefore are not in a position to do all the testing and certification work necessary to cover the whole range of products that will be used. We are therefore providing an arrangement in which manufacturers of fuel-system components are in most cases subject to the standards and are subject to certification and other compliance requirements associated with the applicable standards.")

[5] See also *Engine Manufacturers Ass'n v. South Coast Air Quality Management District*, 541 U.S.246, 254-55 (2004) (distinction between standards, and implementation of standards by means of requirements for manufacturers).

control of any such person…" indicates that Congress anticipated that motor vehicles could have more than one manufacturer, since in at least some cases those will plainly be different people.

Moreover, even had the statute simply referred to "any person engaged in the manufacturing of motor vehicles" the natural inference would be that more that it could apply to multiple people engaged in manufacturing. See *United States v. Gonzales,* 520 U.S. 1, 5, (1997) ("Read naturally the word `any' has an expansive meaning, that is, `one or some indiscriminately of whatever kind'); *New York v. EPA*, 443 F.3d 880, 884-87 (DC Cir. 2006).

The provision also applies both to entities which manufacture and entities which assemble, and does so in such a way as to encompass multiple parties: manufacturers "or" (rather than 'and') assemblers are included. Nor is there any obvious reason that only one person can be engaged in vehicle manufacture or vehicle assembling.

Reading the Act to provide for multiple motor vehicle manufacturers reasonably reflects industry realities, and achieves important goals of the CAA. Since title II requirements are generally imposed on "manufacturers" it is important that the appropriate parties be included within the definition of manufacturer --"any person engaged in the manufacturing or assembling of new motor vehicles". Indeed, as set out in chapter 1 of the draft RIA, most heavy duty vehicles are manufactured or assembled by multiple entities; see also Comments of Daimler (October 1, 2015) p. 103.[6] One entity produces a chassis; a different entity manufactures the engine; specialized components (e.g. garbage compactors, cement mixers) are produced by still different entities. For tractor-trailers, one person manufactures the tractor, another the trailer, a third the engine, and another typically assembles the trailer to the tractor. Installation of various vehicle components occurs at different and varied points and by different entities, depending on ultimate desired configurations. See, e.g. Comments of Navistar (October 1, 2015), pp. 12-13. The heavy duty sector thus differs markedly from the light duty sector (and from manufacturing of light duty pickups and vans), where a single company designs the vehicle and engine (and many of the parts), and does all assembling of components into the finished motor vehicle.

It is reasonable to view the trailer manufacturer as "engaged in" (section 216 (1)) the manufacturing or assembling of the tractor-trailer. The trailer manufacturer designs, builds, and assembles a complete and finished portion of the tractor-trailer. All components of the trailer – the tires, axles, flat bed, outsider cover, aerodynamics – are within its control and are part of its assembling process. The trailer manufacturer sets the design specifications that affect the GHG emissions attributable to pulling the trailer. It commences all work on the trailer, and when that work is complete, nothing more is to be done. The trailer is a finished product. With respect to the trailer, the trailer manufacturer is analogous to the manufacturer of the light duty vehicle, specifying, controlling, and assembling all aspects of the product from inception to completion. GHG emissions attributable to the trailer are a substantial

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[6] "The EPA should understand that vehicle manufacturing is a multi-stage process (regardless of the technologies on the vehicles) and that each stage of manufacturer has the incentive to properly complete manufacturing …[T]he EPA should continue the longstanding industry practice of allowing primary manufacturers to pass incomplete vehicles with incomplete vehicle documents to secondary manufacturers who complete the installation."

portion of the total GHG emissions from the tractor-trailer.[7] Moreover, the trailer manufacturer is not fully analogous to the manufacturer of a vehicle part or component, like a tire manufacturer, or the manufacturer of a side skirt.[8] The trailer is a significant, integral part of the finished motor vehicle, and is essential for the tractor-trailer to carry out its commercial purpose. See 80 FR 40170. Although it is true that another person may ultimately hitch the trailer to a tractor (which might be viewed as completing assembly of the tractor-trailer), as noted above, EPA does not believe that the fact that one person might qualify as a manufacturer, due to "assembling" the motor vehicle, precludes another person from qualifying as a manufacturer, due to "manufacturing" the motor vehicle.

Given these circumstances, it is also reasonable to interpret section 216 (1) as including the trailer manufacturer as one of the persons engaged in the manufacture or assembly of the motor vehicle – the tractor-trailer. As just explained, the trailer manufacturer designs, builds, and assembles a substantial, complete and finished portion of the motor vehicle. That portion contributes substantially to the GHG emissions from the tractor-trailer. Given the magnitude of the activity and the contribution to GHG emissions, it appears reasonable (if not evident) to view a trailer manufacturer as a manufacturer of the vehicle, rather than as solely a manufacturer of parts**.** As noted above, current rules distinguish between manufacture of parts and manufacture of vehicles. Section 1037.801 states that a piece of equipment intended for self-propelled highway use becomes a "vehicle" "when it includes a passenger compartment attached to a frame with axles". EPA further proposed in this rulemaking a further definition that a trailer becomes a "vehicle" when it has a frame with axles attached. This continues to appear reasonable. Given that section 216(1) does not restrict motor vehicle manufacturers to a single entity, it appears to be consistent with the facts and the Act to consider trailer manufacturers as persons engaged in the manufacture of a motor vehicle.

This interpretation fits well within the related structure of the Act. As noted above, the section 202 standard-setting authority applies not just to exhaust emissions, but to parts or portions of the vehicle as well. This broad standard setting authority is consistent with the view that more than one person can meet the definition of manufacturer and thereby be subject to those emission standards.

This interpretation of section 216(1) is also reasonable in light of the various provisions noted above relating to implementation of the emissions standards – certification under section 206, prohibitions on entry into commerce under section 203, warranty and recall under section 207, and recall under section 208. All of these provisions are naturally applied to the entity responsible for manufacturing the trailer, which manufacturer is likewise responsible for its GHG emissions.

TTMA maintains that if a tractor-trailer is a motor vehicle, then only the entity connecting the trailer to the tractor could be subject to regulation.[9] This is not a necessary interpretation of section 216 (1), as explained above. TTMA does not discuss that provision, but notes that other provisions refer to "a" manufacturer (or, in one instance, "the" manufacturer), and maintains that this shows that only a single

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[7] The relative contribution of trailer controls depends on the types of tractors and trailers, as well as the tier of standards applicable; however, it can be approximately one-third of the total reduction achievable for the tractor-trailer.

[8] For purposes of this memorandum, we take no position as to the possibility of such component manufacturers also being vehicle manufacturers.

[9] Consequently, the essential issue here is not whether EPA can issue and implement emission standards for trailers, but at what point in the implementation process those standards apply.

entity can be a manufacturer. See TTMA Comment pp. 4-5, citing to sections 206 (a)(1), 206 (b), 207, and 203 (a). This reading does not appear to be compelled. First, the term "manufacturer" in all of all of these provisions necessarily reflects the underlying definition in section 216(1), and therefore is not limited to a single entity, as discussed above. Second, the interpretation makes no practical sense. An end assembler of a tractor-trailer is not in a position to certify and warrant performance of the trailer, given that the end-assembler has no control over how trailers are designed, constructed, or even which trailers are attached to the tractor. It makes little sense for the entity least able to control the outcome to be responsible for that outcome. The EPA doubts that Congress compelled such an ungainly implementation mechanism, especially given that it is well known that vehicle manufacture responsibility in the heavy duty vehicle sector is divided, and given further that title II includes requirements for EPA to promulgate standards for portions of vehicles.[10]

However, EPA is also soliciting comment on other possible bases for establishing requirements for trailer manufacturers. .

e. Controls on Tractor-Trailers

There appears to be no legitimate question but that a tractor-trailer is a motor vehicle and hence subject to standards controlling the pollutants it emits. TTMA, however, notes that under Department of Transportation regulations, trailers and tractors have separate Vehicle identification Numbers (VIN) and therefore should be regarded as separate vehicles under the Clean Air Act. This does not seem persuasive. The Clean Air Act contains no provisions which would make VIN classifications by other entities determinative of whether a vehicle is a motor vehicle under the CAA. TTMA's position is also inconsistent with the Act's statutory scheme that contemplates emission standards for incomplete vehicles, and allows for multiple manufacturers of a motor vehicle.

f. Controls on Manufacturers of Glider Kits

As noted above, glider kits include the entire tractor chassis, cab, tires, body, and brakes. Glider kit manufacturers thus control critical elements of the ultimate vehicle's greenhouse gas emissions, in particular, all aerodynamic features and all emissions related to tire type. Glider kit manufacturers would therefore be the entity generating critical GEM inputs – at the least, those for aerodynamics and tires. Glider kit manufacturers also invariably know the final configuration of the glider vehicle, i.e. the type of engine and transmission which the final assembler will add to the glider kit. This is because the glider kit contains all necessary wiring, and it is necessary, in turn, for the glider kit manufacturer to know the end configuration in order to wire the kit properly. Thus, a manufacturer of a glider kit can reasonably be viewed as a manufacturer of a motor vehicle under the same logic as above: there can be multiple manufacturers of a motor vehicle; the glider kit manufacturer designs, builds, and assembles a

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[10] We would likely prohibit the introduction into commerce of a noncompliant trailer intended for use with a tractor. EPA would thus take the view that the prohibition in section 203 (a) (1) can apply before final assembly of discrete components of the motor vehicle. This appears to be reasonable given that the Act contemplates standards for incomplete vehicle segments, and allows for multiple motor vehicle manufacturers. See also discussion below that the prohibition in section 203 (a) applies to acts which cause a Title II violation as well as to enumerated prohibited acts

substantial, complete and finished portion of the motor vehicle; and that portion contributes substantially to the GHG emissions from the ultimate glider vehicle.

Under current EPA rules, glider kits are considered to be incomplete vehicles which may be introduced into commerce to a secondary manufacturer for final assembly. 1037.620 (b)(1)(i) and 1037.801 (definition of “vehicle” and “incomplete vehicle”). EPA proposed to expand somewhat on these provisions, but in essence, under the proposed rule, glider kit manufacturers would continue to be able to ship uncertified kits to secondary manufacturers, and the secondary manufacturer must assemble the vehicle into certifiable condition. Proposed section 1037.622. Glider kit and glider vehicle manufacturers could also operate under delegated assembly provisions whereby the glider kit manufacturer would be the certificate holder. See proposed section 1037.621. These provisions appear to be well within EPA’s authority for the reasons just given**.**

g. Alternative Provisions for Trailer and Glider Kit Manufacturers as Manufacturers of Motor Vehicle Parts

The EPA also is considering the following provisions that would apply to manufacturers of trailers and glider kits in the event that the primary implementation provisions are held not to apply, so that the standards only apply to the “manufacturer” of the combined tractor-trailer, i.e. the entity that attaches the trailer to the tractor, or to the entity which installs the engine into the glider vehicle. These alternative provision would take effect automatically should those primary implementation provisions be held inapplicable. .

Section 203 (a)(1) of the Act prohibits certain acts, and also prohibits “the causing” of those acts. If the trailer standard were to apply only to the entity attaching the trailer to the tractor, then furnishing a trailer not meeting the trailer standard would cause a violation of that standard, and the trailer manufacturer would be liable under section 203 (a)(1) for causing the prohibited act to occur. In addition, section 203 (a)(3)(B) prohibits use of ‘defeat devices’ – which include “any part or component intended for use with, or as part of, any motor vehicle … where a principal effect of the part or component is to … defeat … any … element of design installed … in a motor vehicle” otherwise in compliance with emission standards. Manufacturing or installing a trailer not meeting the trailer emission standard could thus be a defeat device causing a violation of the emission standard.

Similarly, a glider kit manufacturer furnishing a glider kit in a configuration that would not meet the tractor standard when the specified engine, transmission, and axle are installed would likewise cause a violation of the tractor emission standard. For example, providing a tractor with a coefficient of drag or tire rolling resistance level inconsistent with tractor certified condition would be a violation of the Act because it would cause the glider final assembler to introduce into commerce a new tractor that is not covered by a *valid* certificate of conformity.

To prevent these prohibited acts, the EPA is considering an alternative rule which requires trailer and glider kit manufacturers to do one of two things: either a) affix a label on the trailer or glider kit stating that the trailer or glider kit is not to be used in combination with tractors certified to the applicable phase 2 GHG standard; or b1) for trailers, conduct testing to demonstrate that the trailer meets the applicable phase 2 GHG standard, the results of such testing to be provided by the trailer manufacturer to each entity attaching trailers to tractors, or b2) for glider kits, conduct testing (including aerodynamic and tire testing) to show that the glider kit is consistent with the glider vehicle’s final certified condition.

There is also additional authority for EPA to adopt testing requirements for manufacturers of motor vehicle parts. Section 208 (a) of the Act authorizes EPA to require "every manufacturer of new motor vehicle or engine parts or components" to "perform tests where such testing is not otherwise reasonably available". This testing can be required to "provide information the Administrator may reasonably require to determine whether the manufacturer … has acted or is acting in compliance with this part", which includes showing whether or not the parts manufacturer is engaged in conduct which can cause a prohibited act. Testing would be required to show that the trailer will conform to the vehicle emission standards. In addition, testing for trailer manufacturers would be necessary here to show that the trailer manufacturer is not causing a violation of the combined tractor-trailer GHG emission standard either by manufacturing a trailer which fails to comply with the trailer emission standards, or by furnishing a trailer to the entity assembling tractor-trailers inconsistent with tractor-trailer certified condition . Testing for glider kit manufacturers is necessary to prevent a glider kit manufacturer furnishing a glider kit inconsistent with tractor certified condition, as noted above.

h. Alternative Provisions for Engine Remanufacturers

The EPA also is considering, and solicit comment on, the following provisions that would apply to remanufacturers of engines used in glider vehicles in the event that the primary implementation provisions are held not to apply, so that the standards only apply to the "manufacturer" which assembles the glider vehicle. These alternative provisions would take effect automatically should those primary implementation provisions be held inapplicable.

Section 202 (a)(3)(D) of the Act authorizes EPA to "prescribe requirements to control rebuilding practices, including standards applicable to emissions from any rebuilt heavy-duty engines (whether or not the engine is past its statutory useful life), which in the Administrator's judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare taking costs into account." EPA is considering an alternative rule pursuant to this authority that would require any rebuilt/remanufactured motor vehicle engines to meet current model year engine standards if they are intended to be installed in new motor vehicle chassis. See 80 FR 40529 and n. 2 above. In this context, we recognize that the new chassis enables the use of aftertreatment devices that might not be feasible for older chassis due to space constraints on an existing chassis.

i. Glider Vehicles Using Newer Engines

In addition to raising questions about EPA's legal authority to regulate glider kits and glider vehicles, commenters also raised concerns about the lack of distinction between gliders that reuse relatively new engines and those that use very old engines. In response to such comments, EPA is considering revising the proposed regulations to treat these two groups separately.

Since the proposal, EPA has become aware that it is common for vehicles in certain severe duty applications (such as cement mixers and dump trucks) to incur substantial chassis damage before the engine reaches the end of its regulatory useful life. (For Class 8 vehicles, regulatory useful life is 435,000 miles or 10 years, whichever comes first.) Thus, glider vehicles in these applications are often produced using engines meeting the 2010 NOx and PM standards. Because the potential for adverse environmental effects from such vehicles is significantly reduced (compared to the more common use of pre-2004 model year engines, with their much higher criteria pollutant emissions), EPA is considering allowing greater flexibility for them. For example, EPA could cap sales at some higher value than the proposed 300 glider vehicles per assembler per year for glider vehicles using engines still within their regulatory useful life. EPA could also eliminate the cap altogether for them.

For Class 8 engines to be within their useful life, they must both be less than 10 years old and have fewer than 435,000 miles of use. We are aware that in some very low use applications, vehicles may have less than 100,000 miles after 10 years. At the other extreme, some vehicles may reach 435,000 miles within a few years. EPA is also considering whether we should offer additional flexibility for these vehicles. For example, EPA could treat engines that are more than 10 years old but have fewer than 100,000 miles of service accumulation the same as other engines that are within their useful life in terms of both miles and years. EPA could similarly treat engines that are less than 3 years old as being within their useful life, without regard to the number of miles they have accumulated.

Finally, EPA could also make a distinction between pre-2010 engines and later engines that were certified to meet the 2010 NOx and PM standards (i.e., to allow a higher cap or eliminate the cap for engines meeting the 2010 standards). This would generally be less flexible (than the useful life-based flexibility discussed above) in earlier years of the glider requirements because it would not address pre-2010 engines that are still within their useful life. However, in the longer term it could be more flexible because it would cover all 2010 and later engines, without regard to their useful life. EPA solicits comments from the public on these various options.

Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2

Response to Comments for Joint Rulemaking

United States
Environmental Protection
Agency

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Introduction

On June 19, 2015, the Administrator of the U.S. Environmental Protection Agency (EPA) and the Secretary of the Department of Transportation (DOT) jointly signed a Notice of Proposed Rulemaking (NPRM) to propose a national program that would establish the next phase of greenhouse gas (GHG) emissions and fuel efficiency standards for medium- and heavy-duty vehicles. This “Phase 2 program” would significantly reduce carbon emissions and improve the fuel efficiency of heavy-duty vehicles, helping to address the challenges of global climate change and energy security. On July 13, 2015, the NPRM was published in the Federal Register, and following an extension, the public comment period closed on October 1, 2015. During this time EPA and the National Highway Traffic Safety Administration (NHTSA) held two public hearings, one in Chicago, IL on August 6, 2015 and one in Long Beach, CA on August 18, 2015. EPA and NHTSA later issued a Notice of Data Availability (NODA) on March 2, 2016 to provide an opportunity to comment on new information being made available by EPA and by NHTSA related to the proposed Phase 2 program. The comment period for the NODA closed on April 1, 2016. This joint Response to Comments (RTC) document addresses written comments and testimony received during both public comment periods. In the spirit of our commitment to meaningful collaboration with stakeholders and the public to identify and understand the opportunities and challenges involved with this next level of fuel-saving technology, we address late comments (i.e., comments received after the comment periods were closed) to the extent that they were received in time to include in this document.

We received over 230,000 comments written comments on the proposed Phase 2 rules. The comments and responses are organized by topic (see Table of Contents) to help the reader find comments and responses of interest. The general layout of each RTC subsection is organized such that excerpts of comments based on a particular topic are first provided, and then our responses to either individual excerpts or groups of comments represented by the excerpts follows. Whether responding to a single comment or a group, the agencies’ responses are separated from the comments with the following section header:

Response

The excerpts include either portions of a commenter’s submission on a particular topic, or the entirety of the commenter’s submission if the breadth of the comments were narrow enough. In general, we have associated comments with a specific commenter in responding to comments. However, due to the large number of comments that addressed similar issues, as well as the volume of the comments received, we do not claim to have identified for each response every comment or commenter addressed by the response. A complete list of organizations and individuals that provided comments is contained in this document below. This RTC addresses citizen comments that raised unique substantive issues. Tens of thousands of citizens also commented through mass e-mail campaigns; these comments are not included individually, but rather examples are provided.

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CAA section 207(c)(1) requires "the manufacturer" to remedy certain in-use problems. The remedy process is generally called recall, and the regulations for this process are in 40 CFR part 1068, subpart F. EPA requested comment on whether to apply these requirements to tire manufacturers in the case of in-use problems with trailer tires. EPA is not adopting this suggestion in the Phase 2 rules, and so we are not requiring that component manufacturers conduct recalls independent of the certificate holder. The Rubber Manufacturers Association indicates correctly that tires are not incomplete vehicles and hence that the recall authority does not apply. However, EPA remains of the view that in the event that trailers do not conform to the standards in-use due to nonconforming tires, tire manufacturers would have a role to play in remedying the problem. In this (hypothetical) situation, a tire manufacturer would not only have produced the part in question, but would have significantly more resources and knowledge regarding how to address (and redress) the problem. Accordingly, EPA would likely require that a component manufacturer responsible for the nonconformity assist in the recall to an extent and in a manner consistent with the provisions of CAA 208 (a). This section specifies that component and part manufacturers "shall establish and maintain records, perform tests where such testing is not otherwise reasonably available under this part and part C of this subchapter (including fees for testing), make reports and provide information the Administrator may reasonably require to determine whether the manufacturer or other person has acted or is acting in compliance with this part and part C of this subchapter and regulations thereunder, or to otherwise carry out the provision of this part and part C of this subchapter...". Any such action would be considered on a case-by-case basis, adapted to the particular circumstances at the time.

Response: EPA Authority for Gliders and Trailers

In this final rule, EPA is establishing first-time CO_2 emission standards for trailers hauled by tractors. 80 FR 40170. Certain commenters, notably the Truck Trailer Manufacturers Association (TTMA), maintained that EPA lacks authority to adopt requirements for trailer manufacturers, and that emission standards for trailers could be implemented, if at all, by requirements applicable to the entity assembling a tractor-trailer combination. The argument is that trailers by themselves are not "motor vehicles" as defined in section 216 (2) of the Act, that trailer manufacturers therefore do not manufacture motor vehicles, and that standards for trailers can be imposed, if at all, only on "the party that joined the trailer to the tractor." Comments of TTMA, p. 4; Comments of TTMA (March 31, 2016) p. 2.

EPA also proposed a number of changes and clarifications for rules respecting glider kits and glider vehicles. 80 FR 40527-40530. As shown in **Error! Reference source not found.**, a glider kit is a tractor chassis with frame, front axle, interior and exterior cab, and brakes. It is intended for self-propelled highway use, and becomes a glider vehicle when an engine, transmission, and rear axle are added. Engines are often salvaged from earlier model year vehicles, remanufactured, and installed in the glider kit. The final manufacturer of the glider vehicle, i.e. the entity that installs an engine, is typically a different manufacturer than the original manufacturer of the glider kit. The final rule contains emission standards for engines used in glider vehicles and for greenhouse gas emissions from glider vehicles, but does not contain separate standards for glider kits.[2]

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[2] As discussed below, however, manufacturers of glider kits can, and typically are, responsible for obtaining a certificate of conformity before shipping a glider kit. This is because they are manufacturers of motor vehicles, in this case, an incomplete vehicle. Note that Daimler, in its comments, essentially indicates (in the context of comments related to delegated assembly provisions) that EPA may adopt "test-based" provisions for manufacturers of incomplete vehicles ("even if the EPA could regulate prior to the first use of an engine or

Figure 1 - Typical Glider Kit Configuration

Many commenters to both the proposed rule and the NODA supported EPA's interpretation. However, a number of commenters, including Daimler, argued that glider kits are not motor vehicles and so EPA lacks the authority to impose any rules respecting their sale or configuration. Comments of Daimler, pp.

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vehicle, Congress authorized only test-based standards …testing of vehicles or engines is the means by which the EPA determines the compliance that is necessary for a vehicle or engine's introduction into commerce") The provisions applicable to glider kits are just this type of testing provision, examples being testing of tires and aerodynamic components to generate inputs used in the certification process. (The commenter's arguments that other aspects of the delegated assembly provisions are impermissible are addressed earlier in this same Response).

122-23; Comments of Daimler Trucks (April 1, 2016) pp. 2-3. We respond to these comments below, with additional discussion in RTC Section 14.2.

Under the Act, “motor vehicle” is defined as “any self-propelled vehicle designed for transporting persons or property on a street or highway.” CAA section 216 (2). At proposal, EPA maintained that tractor-trailers are motor vehicles and that EPA therefore has the authority to promulgate emission standards for complete and incomplete vehicles – both the tractor and the trailer. 80 FR 40170. The same proposition holds for glider kits and glider vehicles. Id. at 80 FR 40528. The argument that a trailer, or a glider kit, standing alone, is not self-propelled, and therefore is not a motor vehicle, misses the key issues of authority under the Clean Air Act to promulgate emission standards for motor vehicles produced in discrete segments, and the further issue of the entities – namely “manufacturers” – to which standards and certification requirements apply. Simply put, EPA is authorized to set emission standards for complete and incomplete motor vehicles, manufacturers of complete and incomplete motor vehicles can be required to certify to those emission standards, and there can be multiple manufacturers of a motor vehicle, each of which can be required to certify.

Standards for Complete Vehicles – Tractor-Trailers and Glider Vehicles

Section 202 (a)(1) authorizes EPA to set standards “applicable to the emission of any air pollutant from any … new motor vehicles.” There is no question that EPA is authorized to establish emission standards under this provision for complete new motor vehicles, and thus can promulgate emission standards for air pollutants emitted by tractor-trailers and by glider vehicles.

Daimler maintained in its comments that although a glider vehicle is a motor vehicle, it is not a “new” motor vehicle because “glider vehicles, when constructed retain the identity of the donor vehicle, such that the title has already been exchanged, making the vehicles not ‘new’ under the CAA.” Daimler Comments p. 121; see also the similar argument in Daimler Truck Comments (April 1, 2016), p. 4. Daimler maintains that because title to the powertrain from the donor vehicle has already been transferred, the glider vehicle to which the powertrain is added cannot be “new.” Comments of April 1, 2016 p. 4. Daimler also notes that NHTSA considers a truck to be "newly manufactured" and subject to Federal Motor Vehicle Safety Standards when a new cab is used in its assembly, "unless the engine, transmission, and drive axle(s) (as a minimum) of the assembled vehicle are not new, and at least two of these components were taken from the same vehicle." 49 CFR 571.7(e). Daimler urges EPA to adopt a parallel provision here.

First, this argument appears to be untimely. In Phase 1, EPA already indicated that glider vehicles are new motor vehicles, at least implicitly, by adopting an interim exemption for them. See 76 FR 57407 (adopting 40 CFR 1037.150(j) indicating that the general prohibition against introducing a vehicle not subject to current model year standards does not apply to MY 2013 or earlier engines). Assuming the argument that glider vehicles are not new can be raised in this rulemaking, EPA notes that the Clean Air Act defines “new motor vehicle” as “a motor vehicle the equitable or legal title to which has never been transferred to an ultimate purchaser” (section 216(3)). Glider vehicles are typically marketed and sold as “brand new” trucks. Indeed, one prominent assembler of glider kits and glider vehicles advertises that “Fitzgerald Glider Kits offers customers the option to purchase a *brand new 2016 tractor*, in any configuration offered by the manufacturer… Fitzgerald Glider Kits has mastered the process of taking the ‘Glider Kit’ and installing the components to work seamlessly *with the new truck*.”[3] The purchaser

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[3] Advertisement for Fitzgerald Glider kits in Overdrive magazine (December 2015)(emphasis added).

of a "new truck" necessarily takes initial title to that truck.[4] Daimler would have it that this 'new truck' terminology is a mere marketing ploy, but it obviously reflects reality. As shown in **Error! Reference source not found.** above, the glider kit constitutes the major parts of the vehicle, lacking only the engine, transmission, and rear axle. The EPA sees nothing in the Act that compels the result that adding a used component to an otherwise new motor vehicle necessarily vitiates classification of the motor vehicle as "new." See 80 FR 40528. Certainly, there is no language in the definition of "new motor vehicle" which directly addresses this issue. Indeed, as noted in Preamble section I.E.1, the definition of "new motor vehicle engine" encompasses engines of any vintage. At the least, this shows that the model year of the engine is not determinative of whether the motor vehicle is "new". Put another way, a "new motor vehicle" can contain an earlier model year engine. See CAA section 216 (3).[5] Many commenters agreed. See, e.g. Comments of MECA ("Glider vehicles are classified as "new motor vehicles" because they use a new chassis, although they can continue to use engines that are 10-15 years old and emit 20-40 times more pollution than vehicles equipped with a new engine"). Thus, EPA is reasonably interpreting the Act to indicate that adding the engine and transmission to the otherwise-complete vehicle does not prevent the glider vehicle from being "new" – as marketed. As to the suggestion to adopt a provision parallel to the NHTSA definition, EPA notes that the NHTSA definition was developed for different purposes using statutory authority which differs from the Clean Air Act in language and intent. There consequently is no basis for requiring EPA to adopt such a definition, and doing so would impede meaningful control of both GHG emissions and criteria pollutant emissions from glider vehicles, the latter being an imperative, immediate public health concern (see RTC 14.2).

Standards for Incomplete Vehicles

Section 202 (a)(1) not only authorizes EPA to set standards "applicable to the emission of any air pollutant from any … new motor vehicles," but states further that these standards are applicable "whether such vehicles … are designed as complete systems or incorporate devices to prevent or control such pollution." The Act in fact thus not only contemplates, but in some instances, directly commands that EPA establish standards for incomplete vehicles and vehicle components. See CAA section 202 (a)(6) (standards for onboard vapor recovery systems on "new light-duty vehicles," and requiring installation of such systems); section 202 (a)(5)(A) (standards to control emissions from refueling motor vehicles, and requiring consideration of, and possible design standards for, fueling system components); 202 (k) (standards to control evaporative emissions from gasoline-fueled motor vehicles). Both TTMA and Daimler argued, in effect, that these provisions are the exceptions that prove the rule and that without this type of enumerated exception, only entire, complete vehicles can be considered to be "motor vehicles." This argument is not persuasive. Congress did not indicate that these incomplete vehicle provisions were exceptions to the definition of motor vehicle. Just the opposite. Without amending the new motor vehicle definition, or otherwise indicating that these provisions were not already encompassed within Title II authority over "new motor vehicles", Congress required EPA to set standards for evaporative emissions from a portion of a motor vehicle. Congress thus indicated in these provisions: 1) that standards should apply to "vehicles" whether or not the "vehicles" were designed as complete systems; 2) that some standards should explicitly apply only to certain components of a

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[4] Fitzgerald states "All Fitzgerald glider kits will be titled in the state of Tennessee and you will receive a title to transfer to your state." https://www.fitzgeraldgliderkits.com/frequently-asked-questions. Last accessed July 9, 2016.

[5] EPA has also previously addressed the issue of used components in new engines and vehicles explicitly in regulations in the context of locomotives and locomotive engines in 40 CFR part 1033. There we defined remanufactured locomotives and locomotive engines to be "new" locomotives and locomotive engines. See 63 FR 18980; see also Summary and Analysis of Comments on Notice of Proposed Rulemaking for Emission Standards for Locomotives and Locomotive Engines (EPA-420-R-97-101 (December 1997)) at pp. 10-14.

vehicle that are plainly not self-propelled. Congress thus necessarily was of the view that incomplete vehicles can be motor vehicles.

Emission standards EPA sets pursuant to this authority thus can be, and often are focused on emissions from the new motor vehicle, and from portions, systems, parts, or components of the vehicle. Standards thus apply not just to exhaust emissions, but to emissions from non-exhaust portions of a vehicle, or from specific vehicle components or parts. See the various evaporative emission standards for light duty vehicles in 40 CFR part 86, subpart B (e.g., 40 CFR 86.146-96 and 86.150-98 (refueling spitback and refueling test procedures); 40 CFR 1060.101-103 and 73 FR 59114-59115 (various evaporative emission standards for small spark ignition equipment); 40 CFR 86.1813-17(a)(2)(iii) (canister bleed evaporative emission test procedure, where testing is solely of fuel tank and evaporative canister); see also 79 FR 23507 (April 28, 2014) (incomplete heavy duty gasoline vehicles could be subject to, and required to certify compliance with, evaporative emission standards)). These standards are implemented by testing the particular vehicle component, not by whole vehicle testing, notwithstanding that the component may not be self-propelled until it is installed in the vehicle or (in the case of non-road equipment), propelled by an engine.[6]

EPA thus can set standards for all or just a portion of the motor vehicle notwithstanding that an incomplete motor vehicle may not yet be self-propelled. This is not to say that the Act authorizes emission standards for any part of a motor vehicle, however insignificant. Under the Act it is reasonable to consider both the significance of the components in comparison to the entire vehicle and the significance of the components for achieving emissions reductions. A vehicle that is complete except for an ignition switch can be subject to standards even though it is not self-propelled. Likewise, as just noted, vehicle components that are significant for controlling evaporative emissions can be subject to standards even though in isolation the components are not self-propelled. However, not every individual component of a complete vehicle can be subjected to standards as an incomplete vehicle. To reflect these considerations, EPA is adopting provisions stating that a trailer is a vehicle "when it has a frame with one or more axles attached," and a glider kit becomes a vehicle when "it includes a passenger compartment attached to a frame with one or more axles." Section 1037.801 definition of "vehicle," paragraphs (1)(ii) and (iii); see also Section XIII.B of the FRM Preamble.

TTMA and Daimler each maintained that this claim of authority is open-ended, and can be extended to the least significant vehicle part. As noted above, EPA acknowledges that lines need to be drawn, but whether looking at the relation between the incomplete vehicle and the complete vehicle, or looking at the relation between the incomplete vehicle and the emissions control requirements, it is evident that trailers and glider kits should properly be treated as vehicles, albeit incomplete ones.[7] They properly fall on the vehicle side of the line. When one finishes assembling a whole aggregation of parts to make a finished section of the vehicle (e.g. the trailer), that is sufficient. You have an entire, complete section made up of assembled parts. Everything needed to be a trailer is complete. This is not an engine block, a wheel, or a headlight. Similarly, glider kits comprise the largely assembled tractor chassis with front axles, frame, interior and exterior cab, and brakes. This is not a few assembled components; rather, it is an assembled truck with a few components missing. See CAA section 216 (9) of the Act, which defines

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[6] "Non-road vehicles" are defined differently than "motor vehicles" under the Act, but the difference does not appear relevant here. Non-road vehicles, like motor vehicles, must be propelled by an engine. See CAA section 216 (11) ("'nonroad vehicle' means a vehicle that is powered by a nonroad engine"). Pursuant to this authority, EPA has promulgated many emission standards applicable to components of engineless non-road equipment, for which the equipment manufacturer must certify.

[7] Cf. *Marine Shale Processors v. EPA*, 81 F. 3d 1371, 1383 (5th Cir. 1996) ("[w]e make no comment on this argument: this is simply not a thimbleful case").

"motor vehicle or engine part manufacturer" as "any person engaged in the manufacturing, assembling or rebuilding of any device, system, part, component or element of design which is installed in or on motor vehicles or motor vehicle engines." Trailers and glider kits are not "installed in or on" a motor vehicle. A trailer is half of the tractor-trailer, not some component installed on the tractor. And one would more naturally refer to the donor drivetrain being installed on the glider kit than vice versa. See Figure 1 above. Furthermore, as discussed below, the trailer and the glider kit are significant for purposes of controlling emissions from the completed vehicle.

Incomplete vehicle standards must, of course, be reasonably designed to control emissions caused by that particular vehicle segment. The standards for trailers would do so and account for the tractor-trailer combination by using a reference tractor in the trailer test procedure (and, conversely, by use of a reference trailer in the tractor test procedure). The Phase 2 rule contains no emission standards for glider kits in isolation, but the standards for engines installed in glider vehicles, and the greenhouse gas standards for the glider vehicles, necessarily reflect the contribution of the glider kit.

Application of Emission Standards to Manufacturers

In some ways, the critical issue is to whom do these emission standards apply.[8] As explained in this section, the emission standards apply to manufacturers of motor vehicles, and manufacturers thus are required to certify compliance to test and to certify compliance to those standards. Moreover, the Act contemplates that a motor vehicle can have multiple manufacturers. With respect to the further question of which manufacturer certifies and tests in multiple manufacturer situations, EPA rules have long contained provisions establishing responsibilities where a vehicle has multiple manufacturers. We are again applying the principles already established in these rules in the Phase 2 provisions. The overarching and common sense principle is that the entity with most control over the particular vehicle segment due to producing it is usually the most appropriate entity to test and certify. [9] EPA is implementing the trailer and glider vehicle emission standards in accord with this principle, so that the entities required to test and certify are the trailer manufacturer and, for glider kits and glider vehicles, either the manufacturer of the glider kit or glider vehicle, depending on which is more appropriate in individual circumstances.

Definition of Manufacturer

Emission standards are implemented through regulation of the manufacturer of the new motor vehicle. See, e.g. section 206 (a)(1) (certification testing of motor vehicle submitted by "a manufacturer"); 203 (a)(1) (manufacturer of new motor vehicle prohibited from introducing uncertified motor vehicles into commerce); 207 (a)(1) (manufacturer of motor vehicle to provide warranty to ultimate purchaser of

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[8] This issue is independent of the discussion above, and thus is not dependent on whether trailers are motor vehicles. Under any theory, EPA may issue emission standards for new motor vehicles and engines. Manufacturers of these vehicles and engines can be required to comply with these standards by testing and certification, and the Act contemplates multiple manufacturers to whom these obligations can attach.

[9] See discussion of standards applicable to small SI equipment fuel systems, implemented by standards for the manufacturers of that equipment at 73 FR 59115 ("In most cases, nonroad standards apply to the manufacturer of the engine or the manufacturer of the nonroad equipment. Here, the products subject to the standards (fuel lines and fuel tanks) are typically manufactured by a different manufacturer. In most cases the engine manufacturers do not produce complete fuel systems and therefore are not in a position to do all the testing and certification work necessary to cover the whole range of products that will be used. We are therefore providing an arrangement in which manufacturers of fuel-system components are in most cases subject to the standards and are subject to certification and other compliance requirements associated with the applicable standards.").

compliance with applicable emission standards); 207 (c) (recall authority); 208 (a) (recordkeeping and testing can be required of every manufacturer of new motor vehicle).

The Act further distinguishes between manufacturers of motor vehicles and manufacturers of motor vehicle parts. See, e.g. section 206 (a)(2) (voluntary emission control system verification testing); 203 (a)(3)(B) (prohibition on parts manufacturers and other persons relating to defeat devices); 207 (a)(2) (parts manufacturer may provide warranty certification regarding use of parts); 208 (a) (recordkeeping and testing requirements for manufacturers of vehicle and engine "parts or components").

Thus, the question here is whether a trailer manufacturer or glider kit manufacturer can be a manufacturer of a new motor vehicle and thereby become subject to the certification and related requirements for manufacturers, or must necessarily be classified as a manufacturer of a motor vehicle part or component. EPA may reasonably classify trailer manufacturers and glider kit manufacturers as motor vehicle manufacturers.

Section 216 (1) defines a "manufacturer" as:

> "any person engaged in the manufacturing or assembling of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, or importing such vehicles or engines for resale, or who acts for and is under the control of any such person in connection with the distribution of new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines, but shall not include any dealer with respect to new motor vehicles, new motor vehicle engines, new nonroad vehicles or new nonroad engines received by him in commerce"

It appears plain that this definition was not intended to restrict the definition of "manufacturer" to a single person per vehicle. The use of the conjunctive, specifying that a manufacturer is "*any* person engaged in the manufacturing or assembling of new motor vehicles . . . *or* who acts for and is under the control of any such person…" (emphasis added) indicates that Congress anticipated that motor vehicles could have more than one manufacturer, since in at least some cases those will plainly be different people. The capacious reference to "any person engaged in the manufacturing of motor vehicles" likewise allows the natural inference that it could apply to multiple entities engaged in manufacturing.[10]

The provision also applies both to entities that manufacture and entities that assemble, and does so in such a way as to encompass multiple parties: manufacturers "or" (rather than 'and') assemblers are included. Nor is there any obvious reason that only one person can be engaged in vehicle manufacture or vehicle assembling.

Reading the Act to provide for multiple motor vehicle manufacturers reasonably reflects industry realities, and achieves important goals of the CAA. Since title II requirements are generally imposed on "manufacturers" it is important that the appropriate parties be included within the definition of manufacturer --"any person engaged in the manufacturing or assembling of new motor vehicles." Indeed, as set out in Chapter 1 of the RIA, most heavy-duty vehicles are manufactured or assembled by multiple entities; see also Comments of Daimler (October 1, 2015) p. 103.[11] One entity produces a

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[10] See *United States v. Gonzales*, 520 U.S. 1, 5, (1997) ("Read naturally the word `any' has an expansive meaning, that is, `one or some indiscriminately of whatever kind'); *New York v. EPA*, 443 F.3d 880, 884-87 (DC Cir. 2006).
[11] "The EPA should understand that vehicle manufacturing is a multi-stage process (regardless of the technologies on the vehicles) and that each stage of manufacturer has the incentive to properly complete manufacturing …[T]he

chassis; a different entity manufactures the engine; specialized components (e.g. garbage compactors, cement mixers) are produced by still different entities. For tractor-trailers, one person manufactures the tractor, another the trailer, a third the engine, and another typically assembles the trailer to the tractor. Installation of various vehicle components occurs at different and varied points and by different entities, depending on ultimate desired configurations. See, e.g. Comments of Navistar (October 1, 2015), pp. 12-13. The heavy-duty sector thus differs markedly from the light-duty sector (and from manufacturing of light duty pickups and vans), where a single company designs the vehicle and engine (and many of the parts), and does all assembling of components into the finished motor vehicle.

Controls on Manufacturers of Trailers

It is reasonable to view the trailer manufacturer as "engaged in" (section 216 (1)) the manufacturing or assembling of the tractor-trailer. The trailer manufacturer designs, builds, and assembles a complete and finished portion of the tractor-trailer. All components of the trailer – the tires, axles, flat bed, outsider cover, aerodynamics – are within its control and are part of its assembling process. The trailer manufacturer sets the design specifications that affect the GHG emissions attributable to pulling the trailer. It commences all work on the trailer, and when that work is complete, nothing more is to be done. The trailer is a finished product. With respect to the trailer, the trailer manufacturer is analogous to the manufacturer of the light duty vehicle, specifying, controlling, and assembling all aspects of the product from inception to completion. GHG emissions attributable to the trailer are a substantial portion of the total GHG emissions from the tractor-trailer.[12] Moreover, the trailer manufacturer is not analogous to the manufacturer of a vehicle part or component, like a tire manufacturer, or to the manufacturer of a side skirt. The trailer is a significant, integral part of the finished motor vehicle, and is essential for the tractor-trailer to carry out its commercial purpose. See 80 FR 40170; see also the comment of EDF at n. 104, explaining that trucking companies do not provide insurance protection for truckers when operating a truck-tractor without an attached trailer; it is considered to be a non-business activity).[13] Although it is true that another person may ultimately hitch the trailer to a tractor (which might be viewed as completing assembly of the tractor-trailer), as noted above, EPA does not believe that the fact that one person might qualify as a manufacturer, due to "assembling" the motor vehicle, precludes another person from qualifying as a manufacturer, due to "manufacturing" the motor vehicle. Given that section 216(1) does not restrict motor vehicle manufacturers to a single entity, it appears to be consistent with the facts and the Act to consider trailer manufacturers as persons engaged in the manufacture of a motor vehicle.

This interpretation of section 216(1) is also reasonable in light of the various provisions noted above relating to implementation of the emissions standards – certification under section 206, prohibitions on entry into commerce under section 203, warranty and recall under section 207, and recall under section 208. All of these provisions are naturally applied to the entity responsible for manufacturing the trailer, which manufacturer is likewise responsible for its GHG emissions.

EPA should continue the longstanding industry practice of allowing primary manufacturers to pass incomplete vehicles with incomplete vehicle documents to secondary manufacturers who complete the installation."

[12] The relative contribution of trailer controls depends on the types of tractors and trailers, as well as the tier of standards applicable; however, it can be approximately one-third of the total reduction achievable for the tractor-trailer.

[13] Truckers must separately purchase 'bobtail insurance' to be covered between dropping off one trailer load and picking up the next one. See, e.g. Insure My Rig, http://www.insuremyrig.com/what-is-bobtail-insurance.html (last visited Sept. 29, 2015); Understanding the Difference Between Bobtail and Non-Trucking Liability Insurance.

TTMA maintains that if a tractor-trailer is a motor vehicle, then only the entity connecting the trailer to the tractor could be subject to regulation.[14] This is not a necessary interpretation of section 216 (1), as explained above. TTMA does not discuss that provision, but notes that other provisions refer to "a" manufacturer (or, in one instance, "the" manufacturer), and maintains that this shows that only a single entity can be a manufacturer. See TTMA Comment pp. 4-5, citing to sections 206 (a)(1), 206 (b), 207, and 203 (a). This reading is not compelled by the statutory text. First, the term "manufacturer" in all of these provisions necessarily reflects the underlying definition in section 216(1), and therefore is not limited to a single entity, as just discussed. Second, the interpretation makes no practical sense. An end assembler of a tractor-trailer is not in a position to certify and warrant performance of the trailer, given that the end-assembler has no control over how trailers are designed, constructed, or even which trailers are attached to the tractor. It makes little sense for the entity least able to control the outcome to be responsible for that outcome. The EPA doubts that Congress compelled such an ungainly implementation mechanism, especially given that it is well known that vehicle manufacture responsibility in the heavy-duty vehicle sector is divided. Moreover, the reference to "a" rather than "the" manufacturer in the provisions of section 206(a)(1) and 203(a)(1) – the provisions on vehicle certification and prohibited acts which are the most critical to Title II's implementation -- is ambiguous as to whether there can be multiple manufacturers. See Webster's New Collegiate Dictionary (1979) (definition of "a" includes "any", the same capacious term used in the section 216 definition of "manufacturer").

TTMA further maintains that the various requirements and prohibitions in Title "on their face do not work as applied to 'two detachable parts' of a single motor vehicle that are mixed and matched. In the case of separate manufacturers of the tractor and various trailers that might be hauled by that tractor, the requirements to test, certify, and warrant 'the motor vehicle' cannot on their face apply as written, since there is no single manufacturer of 'the motor vehicle.' And responsibility for violations, such as by selling an uncertified new motor vehicle, is unspecified."

EPA disagrees. As just explained, the definition of "manufacturer" plainly contemplates that more than one entity can be the manufacturer of a motor vehicle (as do the references to "a manufacturer"). The fact that portions of the CAA refer to "a manufacturer" does not amend the explicit definition of "manufacturer" to limit it to a single entity per motor vehicle —it merely indicates the responsibilities that can attach to any entity that manufactures motor vehicles. EPA has long interpreted and applied these provisions in a manner that comports with Congressional intent and industry practice to place the responsibilities for certification with the most appropriate of those entities. This can be done by explicitly assigning certification responsibility, or by having multiple manufacturers determine among themselves which are the most appropriate to certify given their particular division of responsibilities. Thus, in the case of tractor-trailers, the entity that has control over design and emissions performance of the tractor is responsible for testing and certifying that the tractor will comply with applicable standards, while the entity that has control over design and emissions performance of the trailer is responsible for testing and certifying that the trailer will comply with applicable standards. The long-standing provisions on delegated assembly and secondary manufacturing are examples of the second situation where manufacturers determine among themselves testing, documentation, and certification responsibilities. See 40 CFR 1037.620, 1037.621, 1037.622, and Preamble Section I.F.2.e.

EPA is therefore reasonably interpreting the definition of "manufacturer" and the various implementation provisions using that term to reflect the realities of the heavy duty vehicle industry whereby multiple manufacturers are responsible for assembling the motor vehicle.

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[14] Consequently, the essential issue here is not whether EPA can issue and implement emission standards for trailers, but at what point in the implementation process those standards apply.

NHTSA notes that the fuel efficiency standards are necessarily tailpipe-based, and that a lifecycle approach would likely render it impossible to harmonize the fuel efficiency and GHG emission standards, to the great detriment of our goal of achieving a coordinated program. 76 FR 57125/1-2; (similar finding by EPA); see also Sections I.F. (1) (a) and XI of the FRM preamble.
The agencies received mixed comments on this issue. Many commenters supported the proposed approach, generally agreeing with the agencies' arguments. However, some other commenters opposed this approach. Opposing commenters generally fell into three categories:

- Commenters concerned that tailpipe-only standards ignore the GHG benefits of using renewable fuels.
- Commenters concerned that upstream emissions of methane occurring during the production and distribution of natural gas would offset some or all of the GHG emission reductions observed at the tailpipe.
- Commenters concerned that ignoring upstream emissions overstates benefits for certain technologies.

These and other factors are discussed below. These factors were considered in the context of EPA's engine and vehicle emission standards and NHTSA's vehicle fuel consumption standards (including those for light-duty vehicles), which have been in place for decades as tailpipe standards. The agencies find no reasonable basis in the comments or elsewhere to change fundamentally from this longstanding approach.

Although the final standards do not account for life cycle emissions, the agencies have estimated the upstream emission impact of reducing fuel consumption for heavy-duty vehicles. As shown in Sections VII and VIII of the Preamble to the final rule, these upstream emission reductions are significant and worth estimating, even with some uncertainty. In addition, NHTSA has conducted a life-cycle impact assessment as part of its final environmental impact statement, including an assessment of an examination of medium- and heavy-duty vehicle materials and technologies.[1] Because the standards in today's final rule are performance-based and not attribute-based standards, NHTSA's analysis features a literature synthesis of existing credible scientific information relevant to evaluating the potential environmental impacts from some of the fuels, materials, and technologies that may be used to comply with the standards. However, while the agencies considered life-cycle impacts during the rulemaking process, the inability to quantify those impacts limits the agencies' ability to incorporate life-cycle considerations into the standards themselves.

Renewable Fuels

With respect to fuel effects, EPA notes that there is a separate, statutorily-mandated program under the Clean Air Act which encourages use of renewable fuels in transportation fuels, including renewable fuel used in heavy-duty diesel engines. This program considers lifecycle greenhouse gas emissions compared to petroleum fuel. The agencies are not issuing rules that effectively would turn the Phase 2 rules into a fuel program, rather than an emissions reduction and fuel efficiency program, and thus will continue to measure compliance at the tailpipe, for the reasons just stated. See also response to POP Diesel in Section 1.3 above.

Methane Emissions

Issues relating to whether to consider in the emission standards upstream emissions related to natural gas exploration and production are addressed in detail in Section XI of the FRM and in Section 12 of

With regard to the Advanced Lube Credit of 0.5 percent, Meritor is in favor of the concept, however, it is important to clarify a few matters prior to implementation of the rule as written. One concern is that BASF EmGuard FE 2986 SAE 75W-90 is designated as the baseline lubricant for the axle efficiency test but is also the baseline lubricant for the 0.5 percent "advanced lube" FE credit. As a result, if an axle supplier submits an axle map from an efficiency test, the results would include the advanced lube. When implemented in production, the OE would claim the axle efficiency as tested with the advanced lube and receive the 0.5 percent advanced lube credit, in effect double dipping. This cannot remain the case. One solution is to give the 0.5 percent advanced lube credit when using the default GEM axle efficiency, but eliminate the credit when using an axle-efficiency map. [EPA-HQ-OAR-2014-0827-1254-A1 p.9]

Also, there is no flexibility in the rule to get credit for an even more advanced lube except through off-cycle. We suggest allowing an axle test and the associated map using a more advanced lube than 2986 to provide a simple avenue for more advanced lubrication credits. [EPA-HQ-OAR-2014-0827-1254-A1 p.9]

It is important to note that if a 0.5 percent FE credit is to be given for the use of 2986, then our previous recommendations for baseline axle efficiency should be reduced by 0.45 percent accordingly (i.e. 99.56 is reduced to 99.11; 95.5% and 94.1% are reduced to 95.05% and 93.65% ,repectively; and 94.8% is reduced to 94.35%). [EPA-HQ-OAR-2014-0827-1254-A1 p.9]

Account for 2-Speed Axles

Although there is no regulatory framework regarding 2-Speed Axles, they are mentioned in the Regulatory Impact Analysis' Technology Section 2.4.5.2 Gear Ratio (2-37) as a technology "many axle manufacturers are developing" to enhance vehicle performance. If that statement is true then it follows that 2-Speed Axles should be included in the regulation to better account for future market penetration. [EPA-HQ-OAR-2014-0827-1254-A1 p.11]

The first area that needs to be addressed with regards to 2-Speed Axles is fuel efficiency. A 2-Speed Axle can improve tractive force at low speeds and allow greater downspeeding at high speeds thereby potentially netting greater vehicle fuel efficiency however, it requires several more gears and bearings which will actually reduce axle efficiency. Meritor recommends that default axle efficiency of a 2-Speed Axle be reduced by 1 percent to prevent an artificial market incentive to a potentially less efficient axle configuration. Secondarily, there needs to be some instruction on how to model a 2-Speed Axle in GEM. As written, GEM allows a single-axle ratio input but a 2- speed axle has two distinct ratios. Although a 2-speed axle can be used in conjunction with a transmission to double the number of gear ratios; that is not how this technology is being applied in North America. Rather, the 2-speed axle is being used to enable engine downspeeding by providing a very low downspeed axle ratio as well as a high torque "starting" ratio. Therefore, we suggest that GEM allow for an axle ratio input for each drive cycle in which the lower numerical axle ratio would apply to the 55- and 65-mph drive cycles and the higher numerical ratio would be applied to the transient drive cycle. [EPA-HQ-OAR-2014-0827-1254-A1 p.12]

Response:

We appreciate Meritor's constructive comments on axle efficiency with a flat and fixed efficiency of 95.5% used in NPRM. Specifically, we appreciate very much that Meritor provided many highly valuable information on the axle performance and power loss tables to the agencies. As a result, we adopted their recommendations of using the power loss tables as default, and those default tables can be replaced by a manufacturer's measured values, and therefore, all technologies related to the axle, such as advanced lubricant, can be accounted for by this approach. GEM does allow two speed tandems named as 6x4D, which is only applied to 55 and 65mph cycle with 6x2 option, and then switch back to 6x4 once running the transient cycle. However, the axle ratio would be still the same for these two speed axle option, prompting OEM to select most commonly used axle ratio for GEM based on their driving condition. The main reason for this decision is that we believe that two speed axle is primarily used in tractor applications, where cruise speeds are pre-dominated. The cycle weighing on transient cycle is small compared to ones on two cruise speed cycles. As such, the lower axle ratio should be selected. This is not a perfect solution, but can greatly simplify GEM.

Organization: Odyne Systems LLC

Modeling and Testing for the Full Workday

Odyne understands the difficulty in modeling fuel efficiency improvements for hybrid technology within the GEM, as hybrid systems interact with the transmission, drivetrain, and engine, in addition to auxiliary activities beyond driving not currently modeled in the GEM. We appreciate EPA's efforts to improve the accuracy of the GEM to account for real work driving. However, Odyne strongly believes that it is important to model the full day vocational vehicle duty cycle, including driving, idling, and stationary operation of truck-mounted equipment through a Power Take-off (PTO). [EPA-HQ-OAR-2014-0827-1239-A1 p.18-19]

Modeling the entire duty cycle would be consistent with efforts by CARB to understand the total emissions produced by the vehicle throughout the entire day. Since the GEM does not have a specific module for hybrid systems it is difficult to evaluate their impact on driving and stationary aspects of the full workday. Also it does not seem to properly account for all the differences in idle conditions, which are a large part of the full workday. We believe improvements to the accounting of hybrid systems and modeling of the full workday are necessary to properly developing emission standards and verifying emission savings. This needs to be handled separately from the hybrid PTO / e-PTO module in the GEM to account for idle time. Our system is active during the driving and stationary operation of the vehicle and provides unique benefits in both and when they are properly combined result in the real world benefits of a full workday. [EPA-HQ-OAR-2014-0827-1239-A1 p.19]

Response:

The agencies agree with comments from Odyne with regard to recognizing technologies that reduce emission while the vehicle is moving and at idle and because of this have modified 40 CFR 1036.540, 40 CFR 1037.540 and 40 CFR 1037.550 to allow for testing of these systems. 40 CFR 1036.540 and 40 CFR 1037.550 can be used to test hybrids and PHEV that use the stored energy to propel the vehicle. We added many features to recognize the benefits with various idle technologies. This has been done by the two idle cycles (parked idle and drive idle) and the PTO test. For electrified and PHEV PTO systems 40 CFR 1037.540 can be used to recognize the benefits of these systems, through an input to GEM.

Organization: Oshkosh Corporation

Simulating Axles for Vehicle Certification – The agencies request comment on whether or not we should finalize this test procedure and either require its use or allow its use optionally to determine an axle efficiency data table as an input to GEM, which would override the fixed axle efficiency we are proposing at this time. 80 FR 40185. We recommend that the EPA and NHTSA use the European test engines operate at a lower operating RPM levels than what the proposed test cycle emphasizes (with a lower operating RPM range, the result is a gap between real world operations and test settings). MEMA encourages the agencies to identify potential gaps and make them as small as possible. Bringing the gap closer to real-world operating conditions will help the agencies avoid either unintentionally disincentivizing operational improvements that could have real impact on optimizing engine efficiencies or, conversely, potentially drive technologies that do not result in CO2 reductions. [EPA-HQ-OAR-2014-0827-1274-A1 p.5]

MEMA anticipates that some of our member companies will address these issues more specifically in their comments. [EPA-HQ-OAR-2014-0827-1274-A1 p.5]

Organization: Navistar, Inc.

Navistar feels the following are key areas the agencies must address: [NHTSA-2014-0132-0094-A1 p.2]

• Engine standards must be adjusted to account for the cumulative impact of the various requirements, including N2O, and their feasibility is also predicated on the stability of other emission requirements, such as NOx. [NHTSA-2014-0132-0094-A1 p.2]

Organization: Robert Bosch LLC

Bosch also opposes the proposed rule's uneven handling of vocational vehicle engines. Just as there should be technology neutrality in the HD pickup truck and van sector, so, too, should there be neutrality under Phase 2 for vocational vehicle engines. [EPA-HQ-OAR-2014-0827-1466-A2 p.8]

Response:

As reflected later in the context of more detailed comments, the agencies recognize the need to balance the benefits of establishing stringent engine standards against the risks of setting standards that are too stringent. This is true both in the context of the diesel engine standards by themselves and in the context of the SI engine standards relative to the diesel engine standards.

3.2 Regulatory Structure - Separate Engine Standards

Organization: Achates Power, Inc.

We recognize the importance of a separate engine efficiency standards, for a number of reasons: [NHTSA-2014-0132-0049-A1 p.2]

- The EPA has a robust compliance program based on engine testing, making it straightforward to hold engine manufacturers accountable. Without a separate engine standard, in-use compliance becomes more subjective. Having clearly defined compliance responsibilities is important to both the government agencies and market participants. [NHTSA-2014-0132-0049-A1 p.2]
- Engine standards for CO_2 require engine manufacturers to optimize engines for both efficiency and for non-CO_2 emissions, particularly for NO, emissions given the strong counter-dependency between engine-out NO, and fuel consumption. By requiring engine to meet both NO, and CO_2 standards, manufacturers will include technologies that optimize for both rather than alternative

calibrations that would trade lower NO, emissions for higher CO_2 emissions depending on how the engine and vehicle is tested. [NHTSA-2014-0132-0049-A1 p.2]

- Because engine fuel consumption can vary significantly between transient and steady-state operations, only steady-state engine date is required for chassis certification. The separate engine standard for vocational vehicles provides the only measure of engine fuel consumption under transient conditions. [NHTSA-2014-0132-0049-A1 p.2]
- A separate engine standard enables the federal agencies to exempt certain vehicle classes from some or all of the vehicle standards without foregoing efficiency improvements. [NHTSA-2014-0132-0049-A1 p.2]

To be effective in achieving these benefits, however, the separate engine standard must not only be commercially acceptable and reasonable, but also meaningful. The new MDV and HDV standards are designed to 'spur innovation, encouraging the development of and deployment of existing and advanced cost-effective technologies for a new generation of cleaner, more fuel-efficient commercial trucks....' The standard are meant to be set 'not only on currently available technologies but also on utilization of technologies now under development or not yet widely deployed while providing significant lead time to assure adequate time to develop, test, and phase in these [technologies].' [NHTSA-2014-0132-0049-A1 p.2-3] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, p.287.]]

Organization: Advanced Engine System Institute (AESI)

AESI is pleased that the Agency has proposed to retain the basic regulatory structure used in Phase 1, including a separate engine standard and similar testing and certification procedures. Our industry has invested heavily in research and systems to deliver cost-effective greenhouse gas reductions to meet the Phase 1 schedule while meeting the 2010 standards for NOx and PM. Retaining a separate engine standard with the appropriate compliance enforcement will help ensure the long term environmental integrity of the program. [EPA-HQ-OAR-2014-0827-1152-A1 p.1] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, p.289.]]

Organization: American Automotive Policy Council

Model Approach for Vocational Vehicles while AAPC has concerns about the technical details of the proposed Phase 2 GEM model which will be detailed below, we believe that a model-based approach that looks at the powertrain and chassis as a whole can be an effective way to drive CO2 and fuel consumption improvements through the vocational vehicle fleet. While engine standards should be maintained as a “no-backsliding” provision (hold engine standards at 2017 levels), the inclusion of the engine, transmission, and chassis as a system in a more sophisticated GEM model more accurately reflects the ways in which manufacturers deliver on-road CO2 and fuel consumption benefits to their customers. [EPA-HQ-OAR-2014-0827-1238-A1 p.31]

Conceptually, this could be an improvement over the Phase 1 approach in which only tire rolling resistance was reflected in the model for vocational vehicles and key components such as transmissions were not included at all. Assuming our concerns with the technical details of the model can be addressed, an accurate GEM model-based approach will drive efficiency improvements to engines, transmissions, and chassis technologies. [EPA-HQ-OAR-2014-0827-1238-A1 p.31

Organization: Association for the Work Truck Industry (NTEA)

Regulatory Structure

The NTEA supports the Agencies' structural approach to the rules. It is logical to separate out the four vehicle categories as they tend to be both built and utilized in different manners. Of the categories, vocational trucks will be the most diverse vehicle population, as noted by the possible chassis, body and equipment configurations available in the marketplace. This diversity also continues in the manufacture process. [EPA-HQ-OAR-2014-0827-1187-A1 p.2]

Organization: Autocar, LLC

Autocar Supports Separate Engine and Vehicle Standards

Autocar supports the Agencies' proposal to maintain separate engine and vehicle standards in Phase 2 for vocational vehicles. For Low-speed/Frequent-stop Vehicles in particular, the engine offers the greatest potential for reducing GHG emissions and fuel consumption. Such vehicles have no opportunity for fuel consumption improvement though aerodynamics and other highway-speed technologies. Maintaining standards at the engine level facilitates the Agencies' and Autocar's proposed exemptions and exceptions for certain vehicle and manufacturer types without foregoing the engine improvements, ensuring positive environmental impact across a broader range of applications. [EPA-HQ-OAR-2014-0827-1233-A1 p.16]

Organization: California Air Resources Board (CARB)

Comment on Topic Where NPRM Requests Comment

Comment – Separate engine and vehicle standards

The NPRM requests comment on the choice to maintain separate engine and vehicle standards. [EPA-HQ-OAR-2014-0827-1265-A1 p.29]

CARB staff strongly agrees with U.S. EPA and NHTSA's choice to maintain separate engine standards for the following reasons.

-Engine standards directly address the source of GHG emissions and ensure some efficiency improvements at the engine level will be achieved over the useful life of the vehicle. Without an engine standard, some vehicle manufacturers could elect to rely more heavily on vehicle technologies to meet emission standards. These technologies may prove to be less effective at reducing emissions as the vehicles' vocation changes over time. For example, line-haul tractors with aerodynamic technologies would see less of a benefit from the aerodynamic technologies if placed into local-haul service by a second owner. [EPA-HQ-OAR-2014-0827-1265-A1 p.30]

-Separate engine standards based on the direct measurement of GHG emissions from engines can be directly verified for compliance using existing engine test protocols: U.S. EPA's heavy-duty engine ramped-modal Supplemental Emission Test (SET) and heavy-duty engine transient emissions test, i.e., the Federal Test procedure (FTP). [EPA-HQ-OAR-2014-0827-1265-A1 p.30]

-The SET and FTP would continue to be used to certify heavy-duty engines to GHG emission standards, as well as the criteria pollutant emission standards. This provides a direct link between the

GHG emission measurement and NOx emission measurement methods for certification. [EPA-HQ-OAR-2014-0827-1265-A1 p.30]

<u>Comment on Topic Where NPRM Requests Comment</u>

Comment – Full vehicle simulation approach (advantages and disadvantages)

The NPRM requests comment on the proposed approach for full vehicle simulation. CARB staff generally supports the proposed full vehicle simulation approach, and is in favor of GEM including additional subsystems to provide manufacturers greater design flexibility and incentivize the development of vehicles that fully realize the GHG benefits of well-integrated systems. [EPA-HQ-OAR-2014-0827-1265-A1 p.103]

Additionally, the NPRM requests comment on whether the Phase 2 full vehicle simulation proposal, which potentially requires engine manufacturers to disclose proprietary engine performance information to vehicle manufacturers long before production, would enable the “reverse engineering” of engine manufacturers’ intellectual property, and if so, what steps U.S. EPA and NHTSA could take to address this issue. While CARB staff recognizes that this proposed approach will likely require engine manufacturers to disclose more detailed engine design and performance information early in production cycles, certainly earlier than currently occurs, CARB staff believes this will be a positive development that will facilitate better engine, component, and vehicle integration necessary for achieving maximum, cost-effective fuel efficiency improvements and GHG benefits. [EPA-HQ-OAR-2014-0827-1265-A1 p.103]

<u>Comment on Topic Where NPRM Requests Comment</u>

Comment – Chassis dynamometer test procedure

The NPRM requests comment on whether a chassis dynamometer test procedure should be required in lieu of the proposed vehicle simulation approach. CARB staff supports chassis testing for vehicles that are already emissions certified on chassis dynamometers and provisions for similar vehicles that can also be tested using widely available chassis dynamometer testing resources, as proposed in the NPRM. These are the lighter end of the heavy-duty vehicle range. [EPA-HQ-OAR-2014-0827-1265-A1 p.113]

The NPRM’s proposed chassis dynamometer testing requirements will expand the data set of chassis dynamometer emissions measurements, which will help provide data needed to evaluate vehicle integration success. CARB staff believes chassis dynamometer testing is critical for assessing engine, powertrain, and vehicle integration effects on GHG emission levels. For its own testing needs, CARB staff is committed to developing a robust in-house test program by aggressively working to expand its heavy-duty chassis dynamometer testing capacity for the comparison of chassis data with simulation, PEMS, and engine/powertrain test data. [EPA-HQ-OAR-2014-0827-1265-A1 p.113]

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20 See page 40195 of the NPRM for more details of the technology

[21] See page 40195 to 40196 of the NPRM for more details of the technology

Organization: Caterpillar Inc.

PROMOTE INNOVATION— FOCUS ON FULL VEHICLE OPTIMIZATION BY ELIMINATING ENGINE-BASED STANDARDS

As we examine new, fuel-saving technologies for heavy-duty vehicles, Caterpillar believes vehicle manufacturers must be allowed to focus design efforts on the complete vehicle in order to optimize fuel economy, without the incremental constraint of engine-based standards. Based on our extensive experiences with nonroad equipment, both the opportunities and magnitude of vehicle GHG reductions significantly outweigh possible engine-based GHG reductions. A total systems perspective, considering application variability and appropriately tailoring technologies, provides a broader landscape to advance the optimization of fuel efficiency, productivity, and cost – factors which all lead to a win-win result for both the environment and customers. [EPA-HQ-OAR-2014-0827-1189-A1 p.3]

As an efficiency and productivity proof point, this total systems approach has allowed Caterpillar to be recognized as a major innovator of fuel-saving and GHG-reducing technologies in nonroad equipment. For example, our Caterpillar model 336E H hydraulic hybrid excavator has been demonstrated through a grant from the California Energy Commission to reduce fuel consumption by 30 percent on a per-ton basis. Similarly, our Caterpillar D7E track-type tractor was awarded the 2008 EPA Clean Air Excellence Award for reducing fuel consumption by 10 to 30 percent (depending on work load/cycle) and increasing dozing efficiency by 25 percent (cubic yards moved/gallon of fuel) compared to previous models. These are just two examples of where a system focus rather than an engine focus resulted in substantial efficiency gains. [EPA-HQ-OAR-2014-0827-1189-A1 p.3]

From a cost efficiency perspective, vehicle-based GHG reductions are expected to be lower cost than engine-based reductions. Cost is a key customer buying criteria. The engine should not be treated differently from a GHG perspective than any other vehicle component. There are many components and design selections that must be made on a vehicle. If the EPA constrained each component to certain parameters, (i.e. engine, transmissions, driveshaft, axles, differential, rims, tires, cab, HVAC, APU, etc.) the likely result is that vehicle design would be tightly controlled using components that have essentially been prescribed by EPA. Vehicle manufacturers would have to focus vehicle design efforts on ensuring each individual component met EPA standards rather than spending development efforts on optimizing the system as a whole. The cost of GHG reduction would be higher, and the amount of GHG reduction achievable would be hindered. [EPA-HQ-OAR-2014-0827-1189-A1 p.3]

We urge EPA to allow vehicle manufacturers to fully optimize the entire vehicle as this greatly improves GHG opportunities, and decreases the cost of such reductions. [EPA-HQ-OAR-2014-0827-1189-A1 p.3]

Organization: Caterpillar Inc., et al.

Engines are best evaluated based on how they operate in the vehicle, considering the engine size and power output, the vehicle power demand, and the driveline characteristics – that is, by the full vehicle approach. The engine's operating efficiency is fully accounted for in the complete vehicle evaluation, rendering separate engine standards redundant. The Agencies, however, have proposed in the NPRM to establish separate engine standards. It's absolutely essential that the Agencies avoid setting overly stringent engine standards to avoid repeating the market disruptions the industry experienced when introducing diesel particulate (DPF) technology in 2007. To this end, we are opposed to any decrease in the engine standards as proposed. [EPA-HQ-OAR-2014-0827-1215-A1 p.4]

Organization: Cummins, Inc.

The Agencies recognize that separate engine standards have been successfully used to "achieve emissions reductions from complete vehicles that operate on road," while providing a "well-established, representative, and robust set of engine test procedures" for emissions compliance enforcement (80 FR 40147, 40181). Using the same protocols for criteria and GHG emissions ensures linkage between all pollutants, forcing consideration of all constituents when optimizing engine performance and emissions. With differing certification cycles, one could trade-off GHG improvement at the expense of nitrogen oxides (NO_x) increases. Such a situation would undermine regulatory integrity and environmental benefits from criteria emission reductions achieved over the years. Furthermore, engine certification captures both steady-state and transient behavior that is absent in the vehicle program. Advantages of separate engine standards are identified in the Preamble (80 FR 40181-182) and detailed further in Cummins oral arguments[1] and comments to NHTSA[3]. [EPA-HQ-OAR-2014-0827-1298-A1 p.6]

For Phase 2, EPA and NHTSA are proposing to maintain dividing the commercial vehicle industry into three categories (combination tractors, vocational vehicles and HD pickups and vans), while continuing separate engine and vehicle standards for combination tractors and vocational vehicles. The Phase 2 regulatory proposal adds a fourth category for trailers to establish standards for this component of tractor vehicles. Cummins fully supports this regulatory structure, especially the separate engine program. [EPA-HQ-OAR-2014-0827-1298-A1 p.6]

Engine standards also acknowledge the non-integrated nature of the commercial vehicle market and allow for multiple suppliers of engines and powertrain options for a given vehicle original equipment manufacturer (OEM). Customers can continue to buy a common certified engine and use it in a wide range of vehicle applications, ensuring emissions reductions and economic and regulatory efficiencies across the diversity of vehicles that exist in the marketplace. [EPA-HQ-OAR-2014-0827-1298-A1 p.6-7]

Cummins opposes features of the proposed rule that undermine regulatory integrity [EPA-HQ-OAR-2014-0827-1298-A1 p.7]

Regulatory integrity means that the intended improvements in emissions are assigned appropriately and directly to the engine and vehicle, are realized in real-world use and can be physically verified and enforced. [EPA-HQ-OAR-2014-0827-1298-A1 p.7]

The biggest threat to regulatory integrity is a disconnect between engine NO_x and CO2 regulations. This can arise in several ways, including: (a) different test protocols for each pollutant; (b) significant engine operation outside the criteria-emission[4] Not-To-Exceed (NTE) zone; (c) implicit engine emissions stringency at the vehicle level that is not recognized in engine testing; and (d) lack of robust means to assure compliance in-use and to link NO_x with CO2 at the vehicle level. [EPA-HQ-OAR-2014-0827-1298-A1 p.7]

[Figure 1 can be found on p.8 of docket number EPA-HQ-OAR-2014-0827-1298-A1]

The 55 MPH cycle is outside the NTE zone, suggesting that future vehicles are expected to operate a considerable amount of time outside of this emissions control zone. This means a vehicle could emit higher NO_x emissions which would not be assessed during the in-use enforcement program. Furthermore, since the NTE region is tied to the engine torque curve, there is an incentive for engine manufacturers to skew the torque curve to higher speeds to draw the NO_x NTE zone farther away from the cruising engine speed. This concern could be addressed in a future criteria emissions rulemaking by expanding the NTE zone as defined in 40 CFR 86.1370(b) for engines with transmissions such as Continuously Variable Transmissions (CVT). [EPA-HQ-OAR-2014-0827-1298-A1 p.8-9]

[Figure 2 can be found on p.9 of docket number EPA-HQ-OAR-2014-0827-1298-A1]

Cummins cautions the Agencies against this approach. First, implicit engine stringency in the vehicle program decouples engine CO2 improvements from compliance with standards for oxides of nitrogen (NO_x). This threatens the regulatory integrity of the rule by creating a structure in which in-use NO_x emissions can be increased by operation outside expected NO_x regulatory limits while in-use CO2 emissions are reduced. Second, it allows trading of directly measurable and enforceable improvements at the engine level for less certain and unenforceable improvements at the vehicle level. Third, implied standards lack the regulatory clarity required for focused and sustained innovation in engine technology. For these reasons, required engine CO2 reductions should be explicit in the engine standard, and engine procedures should continue to link CO2 with criteria emissions.[EPA-HQ-OAR-2014-0827-1298-A1 p.10 and 12] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, pp.47-48.]]

(d) The vehicle standard in Phase 2 employs computer simulation to calculate the integrated effect of all component improvements. This is useful for all applications but also problematic for translating apparent benefits for line-haul trucks into real-world effects. To be sure, there are “vehicle”-level technologies that will convey real CO2 benefit, but there are no existing integrated-vehicle test protocols that can be used to validate real-world performance and assure in-use compliance. For this reason, all CO2 reduction that is expected and required from the engine should be assigned explicitly to the engine in the engine standard. It can be physically verified and enforced with protocols that have been honed by EPA and industry over three decades. And by using these established engine certification protocols for both CO2 and criteria emissions, regulators can also assure continued compliance with current and future criteria emission standards as greenhouse gases are reduced. This is an especially important point to protect against increases in NO_x emissions as CO2 is being reduced and to ensure CO2 reductions are protected as future reductions in NO_x emissions are contemplated. [EPA-HQ-OAR-2014-0827-1298-A1 p.12-13]

In addition to enabling direct assurance of performance, assignment of all required engine CO2 reductions explicitly in the engine standard also provides clear direction to engine manufacturers for technology investment and innovation required to meet future GHG goals. [EPA-HQ-OAR-2014-0827-1298-A1 p.13]

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1 See Appendix A for the full text of the testimony. [p.44 of docket number EPA-HQ-OAR-2014-0827-1298-A1]

3 See Appendix B. [p.48 of docket number EPA-HQ-OAR-2014-0827-1298-A1]

4 Criteria emissions are HD exhaust emissions controlled under the Clean Air Act and include oxides of nitrogen (NO_x), particulate matter (PM), hydrocarbons (HC) and carbon monoxide (CO).

Organization: Daimler Trucks North America LLC

Basing vehicle and engine standards on the same technologies - EPA requests comment on whether the engine and vehicle standards should be based on the same projected technologies. 80 FR 40191. DTNA has maintained that the best approach to Phase 2 is for the standards to be based on complete vehicle fuel efficiency wherein technologies that are applied to the engine are integral to complete vehicle package. The separation of standards between the engine and the vehicle creates a number of problems. The most significant problem (which EPA has attempted to at least partially correct with their proposed revisions to the SET test procedure) is the problem of defining an engine test cycle that truly represents the engine operation across a range of powertrain configurations anticipated when Phase 2 takes effect and for powertrains beyond that time. Clearly, no such cycle exists since differing power train designs will result in differing engine operating points. Consequently, the level of improvement from a given technology that is projected onto a fixed engine test cycle will differ from the level of improvement when the technology is projected in simulation across a range of vehicle configurations. This leads to the problem that as powertrains diverge actual engine operation from the fixed test cycle, and as the stringency of the engine certification standards increases, engine manufacturers become driven to apply technologies to improve efficiency on the test cycle but which may derive little benefit in real use. For these reasons and others that DTNA believes that complete vehicle certification where the actual fuel map is included in the simulation is the strongly preferred path. DTNA agrees that engine and vehicle standards should be based on the same technologies but that the magnitude of improvements of each for a given technology need to consider where in the engines operating map the improvements are realized and the differences in how the test cycles operate the engine within the operating map. [EPA-HQ-OAR-2014-0827-1164-A1 p.15]

Mutual exclusivity of engine standard and GEM: EPA states that the use of a fuel map in GEM should eliminate concerns that a separate engine standard and a full vehicle standard are mutually exclusive. 80 FR 40180. While the inclusion of the engine map in GEM helps alleviate some concerns, the existence of the separate engine standard still carries with it this concern. An engine improvement can conflict with a vehicle improvement despite the engine being in GEM. For example, if an engine manufacturer optimizes the engine around the A speed such that vehicles using that engine can be very heavily downsped, the result will likely be lower fuel consumption on the road and in GEM--even if the A-speed optimization harmed B and C speed fuel consumption to a greater extent. It is possible to see technologies that show in-vehicle/real-world improvements that do not show up on the cycle. If this means that the engine OEM with the better real-world performing engine does not meet the standard, but then has to add significant technologies to either meet the engine test-cycle or that don’t actually provide the customer real-world benefit, then either way the cost of this engine has to increase which means in reality a less expensive and less efficient engine becomes more attractive. The agencies should recognize when an engine configuration results in improved on-road fuel efficiency but worse engine dynamometer test results, and the agencies should exempt such engines from strict compliance with the engine test standards--knowing that the ultimate concern is fuel consumption and GHG emissions on real roads not in a test cell. [EPA-HQ-OAR-2014-0827-1164-A1 p.15-16]

Preface - DTNA fundamentally disagrees that separate engine standards are needed in Phase 2 but nonetheless provides comments in response to EPA’s request for comment on engine-side stringency. 80 FR 40156. [EPA-HQ-OAR-2014-0827-1164-A1 P.19]

Other Structures Considered: Chassis Dyno Testing – The agencies request comment on whether a chassis dynamometer test procedure should be required in lieu of the vehicle simulation approach being proposed. 80 FR 40178. EPA requests comment regarding the alternative of chassis dynamometer testing in lieu of the simulation approach that is proposed (80 FR 40178). DTNA is strongly in favor of the proposed simulation approach for multiple reasons many of which led EPA to the conclusion that a simulation approach was most appropriate in Phase 1, and now again in Phase 2. Chassis dynamometer testing as a path for vehicle certification is highly impractical considering the tremendous burden of testing the large number of powertrain and vehicle variants as compared to the simulation approach. [EPA-HQ-OAR-2014-0827-1164-A1 p.67]

More on EPA Alternatives - The agencies have presented a sufficiently wide range of alternatives representing various approaches to further regulating the heavy-duty industry, with the exception of one alternative that was not presented and should be – namely not having a separate engine standard. The agencies should add to their current discussions on the pros and cons of maintaining a separate engine standard, and add an alternative that estimates the benefits and costs of not including a separate engine standard. An additional alternative could be presented on including an anti-backsliding engine standard as opposed to the technology-forcing standard proposed in Alternative 3/the preferred approach. [EPA-HQ-OAR-2014-0827-1164-A1 p.73]

Technology neutral standards: The EPA proposes technology neutral standards. We agree that this is the right approach. Prescribing technology to vehicle manufacturers is not the right role for the EPA. That said, the agencies should recognize that—although they purport to create technology neutral standards—in creating a separate engine standard alongside a vehicle standard, the agencies depart from technology neutrality, forcing technology onto the engine even if the same net emissions impact on-road could be achieved through vehicle-side technologies. We recommend that, upon a showing from a manufacturer that a vehicle-side technology creates extra emission reductions beyond those necessary for vehicle-side compliance, that the manufacturer be able to convert those extra emission reductions into an engine-side credit (and vice versa). Only with such an allowance will the agencies truly achieve the technology neutrality that they claim their regulations have. [EPA-HQ-OAR-2014-0827-1164-A1 p.116]

Organization: Daimler Trucks North America, Navistar Inc., Paccar Inc., and the Volvo Group

Recommendation

EPA and NHTSA should not increase the engine efficiency targets proposed in the NPRM. As a fundamental principle, separate engine standards provide no environmental or energy efficiency benefit because the GHG reduction benefits are calculated only with the engine incorporated into the vehicle. Therefore increasing the stringency of a separate engine standard provides no direct environmental benefit. [EPA-HQ-OAR-2014-0827-1894-A1 p.3

Consequently, the separate engine standards should be set at a level that avoids unintended consequences. EPA and NHTSA should recognize the importance of considering the engine as an integrated part of a complete vehicle. With this approach, the agencies can avoid forcing engine optimization on fixed test cycles that do not, and cannot, replicate how the engine operates in each vehicle. [EPA-HQ-OAR-2014-0827-1894-A1 p.3

The conflicting arguments in the subject paper demonstrate that overly stringent separate engine standards are inappropriate, unnecessary, and counterproductive. As we have argued, it is fundamental that the engine influence on the vehicle (size, weight, cooling demand, and cost) and the vehicle influence on the engine (power demand, gearing, and controls) must be considered. Furthermore, from a purely economic perspective, OEMs should be able to develop and choose the efficiency technologies that best fit with their capabilities and expertise to meet regulatory GHG objectives and customer requirements. This will increase competition and innovative approaches while providing optimized products with greater market acceptance. EPA should support this and acknowledge that the engine specific regulation is meant to ensure a level of improvement to be achieved with minimal potential tradeoffs on other vehicle efficiency features, and to ensure some continued link to criteria emissions testing. [EPA-HQ-OAR-2014-0827-1894-A1 p.4-5]

Conclusion:

Furthermore, there is no efficiency or GHG contribution from a separate engine standard that is not already included in the complete vehicle standard. The logical and appropriate conclusion is that engine improvements should be driven from the complete vehicle standard and any separate engine standard should represent a level that can be achieved without compromise in vehicle efficiency or lowest total cost of vehicle operation, not an aggressive limit that forces manufacturer to focus on the engine over other potential efficiencies. EPA and NHTSA have accomplished this in their phase 2 proposal. These engine targets should not be made more stringent. [EPA-HQ-OAR-2014-0827-1894-A1 p.20]

Organization: Eaton Vehicle Group

[The following comments were submitted as testimony at the Chicago, Illinois public hearing on August 6, 2015. See Docket Number EPA-HQ-OAR-2014-0827-1372, pp. 38-39.]

Eaton believes that the separate engine and vehicle standards found in Phase 1 should be maintained in Phase 2. The separate standards reflect the reality of the commercial vehicle market, drive adoption of efficient technologies, and provide a structure that is proven and accepted in the U.S. market today.

Organization: Engine Research Center

I applaud the agencies in recognizing the importance of a separate engine efficiency standards, for a number of reasons: [EPA-HQ-OAR-2014-0827-1141-A1 p.1]

- The EPA has a robust compliance program based on engine testing, making it straightforward to hold engine manufacturers accountable. Without a separate engine standard, in-use compliance becomes more subjective. Having clearly defined compliance responsibilities is important to both the government agencies and market participants. [EPA-HQ-OAR-2014-0827-1141-A1 p.1]

- Engine standards for C02 require engine manufacturers to optimize engines for both efficiency and for non-C02 emissions, particularly for NOx emissions given the strong counter-dependency between engine-out NOx and fuel consumption. By requiring engine to meet both NOx and C02 standards, manufacturers will include technologies that optimize for both rather than alternative calibrations that would trade lower NOx emissions for higher C02 emissions depending on how the engine and vehicle is tested. [EPA-HQ-OAR-2014-0827-1141-A1 p.2]

- Because engine fuel consumption can vary significantly between transient and steady state operations, only steady-state engine date is required for chassis certification. The separate engine standard for vocational vehicles provides the only measure of engine fuel consumption under transient conditions. [EPA-HQ-OAR-2014-0827-1141-A1 p.2]

- A separate engine standard enables the federal agencies to exempt certain vehicle classes from some or all of the vehicle standards without foregoing efficiency improvements. [EPA-HQ-OAR-2014-0827-1141-A1 p.2]

Organization: Environmental Defense Fund (EDF)

1. Strong engine standards are critical to a meaningful program

We reiterate our strong support for the Agencies’ proposed structure of the rule – separate engine standards are imperative to drive innovative engine technology and provide proven, measureable and durable real-world emissions reductions. However, these benefits can only be realized through robust engine standards. Weak standards, as proposed by the Agencies, do not drive advanced technologies and fall short of unlocking the full capabilities of existing technologies. Additionally, limited engine standards do not take advantage of the robust in-use enforcement provisions of the engine program. These provisions provide high confidence that GHG reductions demonstrated on new engines actually occur in the real world. In order to secure the significant benefits afforded by separate engine standards, the Agencies' must finalize far more meaningful standards that drive technology and allow for robust enforcement. [EPA-HQ-OAR-2014-0827-1886-A1 p.3]

EDF supports a separate engine standard as a key element of a strong rule

EDF fully supports the proposed inclusion of a separate engine performance standard and full vehicle performance standard. An engine performance standard for each vehicle class is an essential element of a well-designed heavy-duty fuel efficiency program for several reasons. First, engine standards provide proven, measureable and durable real-world emissions reductions. Engine standards also help to drive development of advanced engine technologies, which can provide a significant proportion of total vehicle fuel efficiency potential. An engine standard also allows EPA and manufacturers to simultaneously evaluate oxides of nitrogen (NOx) and carbon dioxide (CO2) emissions, ensuring efficiency improvements do not result in higher NOx emissions and vice versa. We encourage the agencies to finalize a robust separate engine standard (see Section VI below). In addition to an engine standard, EDF supports a rigorous full vehicle standard to drive technology advancements across the rest of the vehicle, including the transmission, aerodynamic improvements, idle reduction, and more. [EPA-HQ-OAR-2014-0827-1312-A1 p.15]

Organization: Honeywell Transportation System (HTS)

We strongly support the separate engine standard reflected in the current proposal, as we believe a vehicle-only standard creates problems of sustainability and enforcement. For example, while tractor aerodynamic solutions can provide a tangible benefit for applications that travel long distances at sustained speeds, studies[1] have shown that these require precise adjustment which can be adversely affected in real world situations (aftermarket modifications, improper adjustment) and could negatively impact payload capability due to the increased weight. This increases an operator's maintenance costs, increases compliance complexity for Original Equipment Manufacturers (OEMs), and creates enforcement challenges for the agencies due to additional application-specific testing, diagnostic, and inspection criteria. [EPA-HQ-OAR-2014-0827-1230-A1 p.2]

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[1] Ricardo. Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy Final Report to the European Commission – DG Climate Action Ref: DG ENV. 070307/2009/548572/SER/C3

Organization: Manufacturers of Emission Controls Association (MECA)

MECA strongly supports EPA's decision to retain the Phase 2 regulatory structure based on separate engine and vehicle standards that has been proven effective under the Phase 1 heavy-duty GHG standards. [EPA-HQ-OAR-2014-0827-1210-A3 p.3] [[This comment can also be found in EPA-HQ-OAR-2014-0827-1372, p.96.]] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, p.211.]]

Organization: Motor & Equipment Manufacturers Association (MEMA)

Although we recognize that many vehicle manufacturers are recommending elimination of the separate engine standard and removal of the alternative engine mapping approach, MEMA represents many suppliers that provide technologies that will have a direct impact at achieving the NPRM targets by having separate vehicle and engine requirements. Therefore, we support retaining separate vehicle and engine requirements to provide continuity of the standards' regulatory structures and strike a balance between compliance and market latitude. Additionally, the longer timeframe of the Phase 2 standards provides the industry foresight to develop the technologies needed to continue to meet the standards, particularly during the middle and latter stages of the rule. These approaches are vital to the long-term success of the standards. [EPA-HQ-OAR-2014-0827-1274-A1 p.3] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, p.193.]]

Organization: National Association of Clean Air Agencies (NACAA)

We strongly endorse the continued inclusion of separate but complementary standards for engines and whole vehicles – this is a fundamental aspect of the rule. [EPA-HQ-OAR-2014-0827-1157-A1 p.2] [[These comments can also be found in Docket Number EPA-HQ-OAR-2014-0827-1420, p.51.]]

Separate engine standards are critical for the Phase 2 program because they directly address the source of GHG emissions and ensure that engine manufacturers will incorporate some level of engine efficiency improvements that will reduce GHG emissions over the useful life of the vehicle. Engine test procedures and methods have been refined over decades of implementation and provide high certainty that verifiable emission reductions will occur when engines are in use. Separate engine standards are also important because engine GHG emission levels can be directly verified through the existing engine certification test protocols: the Supplemental Emission Test (SET) and Federal Test Procedure (FTP). The SET and FTP used to certify engines to GHG and criteria pollutant emission standards, such as for oxides of nitrogen (NOx), provide a direct link between GHG and NOx emission measurement methods. Further, separate engine standards prompt development of advanced engine technologies that, in turn, can offer a substantial improvement in a vehicle's fuel efficiency. In the absence of separate engine standards, some vehicle manufacturers may rely more heavily on vehicle improvements, such as aerodynamic technologies, that are less effective at reducing fuel consumption and emissions, particularly as vehicles change vocations, or functions, over time. [EPA-HQ-OAR-2014-0827-1157-A1 p.2]

Organization: National Automobile Dealers Association (NADA)

As with Phase 1, the Phase 2 proposal includes separate standards for tractor and vocational engines. The goal of the diesel engine mandates is to reduce GHG emissions and fuel consumption by some 4 percent over Phase 1. Consequently, 4.2 of the 24 percent improvement sought for large tractors and 4 of the 16 percent improvement for vocational vehicles must come from engine improvements by MY 2027. [EPA-HQ-OAR-2014-0827-1309-A1 p.10]

The Phase 2 proposal's long list of potential improvements for compression (CI) and spark ignition (SI) engines generally fall into the categories of combustion optimization, improved air handling, reduced friction, improved emissions after-treatment, and waste heat recovery.[11] NADA/ATD recognizes that most, if not all, OEMs will rely on engine performance improvements to achieve compliance with the Phase 2 program. But, NADA/ATD is concerned that some of these strategies could involve disproportionately high costs as measured on a unit of benefit realized basis. Consequently, ATD urges EPA and NHTSA to: [EPA-HQ-OAR-2014-0827-1309-A1 p.10]

1. Not to include engine-only mandates in the final rule. Manufacturers should have the ability to choose the most cost-effective compliance strategies from the basket of all available options. [EPA-HQ-OAR-2014-0827-1309-A1 p.10]

2. Alternatively, engine-specific mandates should be designed only to prevent back-sliding from the Phase 1 MY 2018 standards. Moreover, manufacturers involved in both engine and vehicle manufacturing should be free to apply credits generated by "over performing" with "non-engine" strategies against their engine compliance obligations, and should be able to provide credits generated in one vehicle class or category against their compliance obligations for another. Providing OEMs with such flexibility will maximize compliance and economic efficiencies, bringing to market the most affordable compliant vehicles and engines. Since a gallon of fuel is a gallon of fuel and a gram of GHGs is a gram of GHGs, what matters most is the performance outcome, not how compliance is achieved. [EPA-HQ-OAR-2014-0827-1309-A1 p.10]

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11 Advanced technology strategies include: SI engines: cylinder deactivation, direct injection, turbocharging/downsizing, and cooled exhaust gas recirculation. CI: automatic transmissions, hybridization,

Organization: Natural Resources Defense Council (NRDC)

The Proposal Advances Improvements in the Structure of the Standards; The Agencies Should Maintain the Separate Engine Standard [EPA-HQ-OAR-2014-0827-1220-A1 p.6]

NRDC also supports the agencies' proposal to maintain separate engine standards. NRDC believes that the separate standard is necessary to ensure that all feasible and cost-effective advancements are made in the engine to lower carbon pollution and fuel consumption. As we noted previously, there are important opportunities for advancements in tractor engines and vocational gasoline engines. NRDC agrees with the agencies that there are advantages with maintaining separate engine standards including consistent testing with non-GHG emissions requirements that will prevent any trade-offs between carbon dioxide and emissions such as nitrogen oxides. [EPA-HQ-OAR-2014-0827-1220-A1 p.6]

Organization: Power Solutions International (PSI)

We applaud the agencies recognition for the need to have separate efficiency standards applicable to engines. Engine manufacturers are required to meet criteria emission standards and imposing the GHG emission standards on the engine allows manufacturers the opportunity to optimize the engine for fuel efficiency while developing the engine to meet criteria emissions, specifically, NOx, NMHC and CO. [EPA-HQ-OAR-2014-0827-1161-A1 p.1]

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[1] http://www.epa.gov/otaq/documents/eng-cert/on-hwy-2014e.xls. 2015 and 2016MY files posted appear to be incomplete

Organization: Shahed, SM

I applaud the agencies in recognizing the importance of a separate engine efficiency standards, for a number of reasons: [NHTSA-2014-0132-0033-A1 p.1]

- The EPA has a robust compliance program based on engine testing, making it straightforward to hold engine manufacturers accountable. Without a separate engine standard, in-use compliance becomes more subjective. Having clearly defined compliance responsibilities is important to both the government agencies and market participants. [NHTSA-2014-0132-0033-A1 p.1]

- Engine standards for CO2 require engine manufacturers to optimize engines for both efficiency and for non-CO2 emissions, particularly for NOx emissions given the strong counter-dependency between engine-out NOx and fuel consumption. By requiring engine to meet both NOx and CO2 standards, manufacturers will include technologies that optimize for both rather than alternative calibrations that would trade lower NOx emissions for higher CO2 emissions depending on how the engine and vehicle is tested. [NHTSA-2014-0132-0033-A1 p.1-2]

- Because engine fuel consumption can vary significantly between transient and steady-state operations, only steady-state engine date is required for chassis certification. The separate engine standard for vocational vehicles provides the only measure of engine fuel consumption under transient conditions. [NHTSA-2014-0132-0033-A1 p.2]

- A separate engine standard enables the federal agencies to exempt certain vehicle classes from some or all of the vehicle standards without foregoing efficiency improvements. [NHTSA-2014-0132-0033-A1 p.2]

To be effective in achieving these benefits, however, the separate engine standard must not only be commercially acceptable and reasonable, but also meaningful. The new MDV and HDV standards are designed to “spur innovation, encouraging the development of and deployment of existing and advanced cost-effective technologies for a new generation of cleaner, more fuel-efficient commercial trucks….” The standard are meant to be set “not only on currently available technologies but also on utilization of technologies now under development or not yet widely deployed while providing significant lead time to assure adequate time to develop, test, and phase in these [technologies].” [NHTSA-2014-0132-0033-A1 p.2]

Organization: South Coast Air Quality Management District (SCAQMD)

U.S. EPA and NHTSA Proposed Greenhouse Gas Emissions and Fuel Efficiency Standards

In addition, we strongly support having separate emissions standards for engines and full vehicles. Without separate standards, there are no guarantees that even modest enhancements that will provide engine efficiency improvements to reduce greenhouse gas emissions over the useful life of the vehicle are made. As an example, with the recent certification of a 8.9 liter natural gas engine (see Attachment 2 and discussion below), the engine manufacturer implemented a modest enhancement of having closed crankcase ventilation system, which resulted in lower methane emissions. Other technology enhancements that can potentially result in lowering greenhouse gas emissions including improvements in combustion efficiencies, can lead to lowered greenhouse gas emissions directly from the engine. [EPA-HQ-OAR-2014-0827-1181-A1 p.2]

[Attachment 2 can be found on p.15 of this docket]

Organization: Union of Concerned Scientists (UCS)

THE NEED FOR SEPARATE ENGINE STANDARD

We agree with the agencies' proposed structure of the rule, with separate standards for both heavy-duty engines and the vehicles that use these engines, for three reasons: 1) verifiable emissions; 2) compatibility with criteria emissions regulations; and 3) ensured investment in efficiency technologies. [EPA-HQ-OAR-2014-0827-1329-A2 p.5]

While ultimately the emissions of use occur at the vehicle level, the current regulations are measured by simulation with the GEM model, not a true full vehicle test. Therefore, the engine standard provides the closest measure of true real world emissions reductions. Furthermore, unlike many other technologies which may not last the lifetime of the vehicle, such as low-rolling resistance tires or some aerodynamic add-ons, the engine cannot be tampered with nor replaced without meeting a similar level of efficiency. This helps set a guaranteed threshold of fuel savings and global warming emissions reductions throughout the entire vehicle lifetime without relying solely upon the agencies' ability to enforce the regulations. [EPA-HQ-OAR-2014-0827-1329-A2 p.5]

Currently, manufacturers must already perform a separate engine test to certify compliance with existing criteria pollution standards. Therefore, an engine test adds no additional test burden. Furthermore, this helps to ensure that vehicles are achieving reductions in global warming emissions without compromising criteria pollution standards. In addition to the engine standard test procedure, in the agencies' proposed vehicle standard, engines used in GEM must already go through an additional engine map certification—we therefore recommend that the agencies collect this additional data on the criteria emissions during this engine mapping procedure to inform future pollution standards and further ensure that vehicles continue to achieve reductions in both criteria and global warming emissions. [EPA-HQ-OAR-2014-0827-1329-A2 p.5]

The structure of the tractor market also lends itself to a separate engine standard. The largest supplier of tractor engines is independent of the four vehicle manufacturers because of the long-standing desire for vehicle purchasers to fully customize vehicles down to the precise engine, transmission, and axles offered by all suppliers. Currently, the vehicle manufacturers are split between those who are more vertically integrated and those who continue to operate in the way that the market has traditionally behaved. Given this heterogeneous network of suppliers, a separate standard for engines helps ensure that all vehicle manufacturers will be able to rely on technology innovation from individual suppliers by providing the overall certainty that a distributed marketplace cannot. This is exceptionally important in the case of engines, which have significant complexity and heightened research costs compared to many other aspects of the vehicle. This will help ensure that vehicle purchasers will continue to have a wide assortment of compliant, customizable vehicles from all makes. [EPA-HQ-OAR-2014-0827-1329-A2 p.5-6]

Organization: Volvo Group

We fully agree that evaluating vehicle technology as an integrated package is the only effective way to approximate real world results. The Agencies' proposal provides appropriate credits to promote development and deployment of many important efficiency technologies. Since the engine is fully included in the vehicle evaluation, there is no need for, or benefit from, setting separate engine standards. [EPA-HQ-OAR-2014-0827-1290-A1 p.9]

Complete Vehicle Regulation

Volvo Group greatly appreciates that the proposed rule incorporates a complete vehicle approach utilizing a vehicle simulation (GEM) that incorporates the engine, driveline, and other key inputs that impact efficiency. GEM determines the fuel consumption and GHG emissions over an assigned road cycle for each vehicle type. The customer's choice of aero fairings, tire type, engine, powertrain, and other details are entered as inputs to the tool, and the output is compared to the regulated target for that vehicle category for the purpose of credit tracking and averaging. This type of modeling has been done successfully by all major heavy-duty vehicle manufacturers, by Argonne National Lab, and in the regulatory vehicle model (GEM) proposed for the Phase 2 rule. It is a proven technique that correlates well with on-road testing. In fact, modeling is a much more accurate approach than in-use or chassis dyno testing to measure efficiency differences between vehicles because test variables, such as driver differences, traffic, wind, and weather, are eliminated. Even in chassis dyno testing, driver variability is significant, key load factors (rolling resistance and aerodynamics) must be measured and simulated, and testers must compensate for tires interacting with dyno rollers. Simulation offers the most efficient, accurate, robust and repeatable means for assessing vehicle efficiency, and is therefore the ideal tool for certification to efficiency and GHG standards. [EPA-HQ-OAR-2014-0827-1290-A1 p.13-14]

Engines should not be Separately Regulated

In the Phase 1 rule, the engine is separately regulated and not included in the vehicle evaluation. Engine efficiency is measured on the test cycles developed some 30 years ago for criteria emissions evaluation, cycles that no longer reflect how engines operate in today's vehicles. These tests do not consider the size and power output of the engine relative to the vehicle's power demand, the installation impact of the engine system, or the impact of the powertrain on how the engine operates. Instead, each engine's test points are based on its power and torque capability. A larger engine is tested at higher power and torque, regardless of the actual power needed for vehicles in which it will be installed. [EPA-HQ-OAR-2014-0827-1290-A1 p.14]

In recent years, Class 8 tractors (the vehicles that consume most of the commercial fleet fuel) are increasingly using automated manual transmissions or AMTs. These transmissions retain the high efficiency of a manual gearbox but use computer control to precisely and automatically shift gears without the driver operating a clutch or shift lever. Some of these, including the Volvo I-shift and Mack M-drive, sense vehicle load and road grade to optimize shifts points for maximum efficiency. Because shifting is fully automatic, drivers are no longer troubled if a downshift is required on a road grade. This has allowed the industry to increase fuel efficiency by running a lower overall gear ratio, thereby slowing the engine down at typical highway speeds. Engines have been re-optimized to increase low speed torque and to maximize efficiency at these lower speeds. This is one example of vehicle technology changing how engines operate that is reflected in a complete vehicle regulation but not in a separate engine test. The regulatory engine test cycles, even considering the reweighted RMC, would reward optimizing the engine for higher speeds where it rarely even operates in today's trucks. An engine optimized for the regulatory cycles gets higher efficiency in the regulatory test but potentially worse efficiency on the road in service. [EPA-HQ-OAR-2014-0827-1290-A1 p.14]

In addition, as improvements are made to the aerodynamic of tractors and trailers, as tire rolling resistance is reduced, and as accessory loads are reduced, the cruise power demand of vehicles is reduced. This reduced power demand could allow for use of smaller engines or further down-speeding the engine. But bigger engines tend to be more efficient on separate engine tests due to fundamental engine thermodynamics while smaller engines tend to do better on vehicle efficiency because they operate closer to their peak efficiency torque and speed, in addition to the advantages they offer in weight and limiting inefficient driving habits. [EPA-HQ-OAR-2014-0827-1290-A1 p.14]

Perhaps the most significant problem with separately regulating an engine is the failure to consider the installation impacts of the engine and related technology. Bigger engines obviously take up more space and demand more cooling capacity that can only be efficiently provided by forcing ram air through the radiator and charge air cooler. One of the proposed engine efficiency technologies is known as Rankine waste heat recovery. This system is much like a steam engine, using a working fluid that is pumped under pressure through a heat exchanger (or boiler) in the exhaust gas to boil the fluid. The pressurized gas is expanded through a turbine or other mechanical device to produce power that must be delivered back to the vehicle's powertrain either mechanically through a complex gear train or electrically via a generator-motor system. The expanded gas must then be cooled back to liquid state using a condenser prior to re-entering the pumping stage. Beyond the obvious complexity, the whole system adds weight and requires space on the vehicle. Both space requirements and weight distribution can force tractor manufacturers to extend the wheel base, which may increase the trailer gap (particularly for day cabs and short sleepers) resulting in increased aerodynamic drag. Equally concerning is the substantial increase in cooling required by the condenser, resulting in further increase in aerodynamic drag that can negate any benefits of the engine efficiency. Another issue with this type system is the substantial lag time between increased power demand and power availability due to the thermal inertia of the system. In sum, the system can deliver measurable efficiency in an engine test, but may not deliver in the vehicle. The whole industry is evaluating the merits of waste heat recovery, but a lot of research is still needed to determine if this technology is worthy of industrialization. Only then should manufacturers commit to the intensive effort to make this technology reliable, durable, and cost-effective. Even so, it will only work well when it is fully developed and when it is applied with the appropriate engine and vehicle combinations to maximize its efficiency and minimize negative vehicle impacts. [EPA-HQ-OAR-2014-0827-1290-A1 p.14-15]

Engines should only be evaluated based on how they operate in vehicles, not on a fixed cycle in a test cell. Proponents of engine efficiency regulation argue that such testing is more accurate and verifiable than a complete vehicle approach. They fail to consider, however, that, the correlation between these engine tests and the desired in-use fuel efficiency is tenuous at best and may even be inverted. There is little value to highly accurate measurement of a parameter that does not correlate well with the desired goal. When the engine is measured as part of the full vehicle approach, its efficiency is mapped at more than 100 points (compared to only 13 test points in the tractor engine test) that feed into a vehicle model that exercises the engine at the speed and load points dictated by the vehicle's power demand and drivetrain running on an appropriate road cycle, i.e. like it actually runs in the vehicle. [EPA-HQ-OAR-2014-0827-1290-A1 p.15]

Some have argued that it is important to include a separate engine standard so that manufacturers don't neglect enhancement opportunities from the component that actually burns the fuel. The problem is that engineers have been squeezing blood from this stone for decades; this is precisely why the next level of research is aimed at evaluating technologies as exotic as waste heat recovery to eke out a few more percent from a highly mature technology. The fact that OEMs are doing this is strong evidence that OEMs are not neglecting and would not neglect engine technology without the specter of an engine standard. Furthermore, technologies integrated into the engine itself have to operate in the harshest environment found on the vehicle; if such measures are unnecessary, it does not make sense for EPA to insist that manufacturers integrate new technology into this environment. This is especially true in this rulemaking, where other opportunities for efficiency improvement exist elsewhere on the vehicle. In fact, any competitive manufacturer must look at all efficiency technologies and select those that deliver the highest customer value and meet regulatory requirements for the complete vehicle. This is amply demonstrated in the automobile market, where engine improvements are a huge part of the technology deployed to meet regulated efficiency without any requirement specifically regulating engines. [EPA-HQ-OAR-2014-0827-1290-A1 p.15]

Aside from the technical issues related to engine efficiency regulation, we note the typically high cost associated with complex engine system development and deployment. These costs include engineering development, product cost, and manufacturing costs. More concerning however, are on-going costs and operational impacts associated with maintenance and down-time. Such costs and impacts have typically been grossly underestimated by regulators, yet they are the primary reasons customers have been reluctant to purchase such technologies. [EPA-HQ-OAR-2014-0827-1290-A1 p.15-16]

We note that there is no benefit accrued from regulating engine efficiency once the engine has been fully accounted for in the vehicle efficiency evaluation. Unlike the current (Phase 1) rule, wherein the engine is isolated from the vehicle, all benefits accrued under the Phase 2 proposal are based on reductions in fuel used and GHGs emitted from complete vehicles. There is no basis or justification for continued engine regulation. The Agencies have failed to do any assessment of the cost of engine efficiency regulation considering the loss of vehicle design flexibility, on-going testing and reporting requirements, and increased total cost of operation for vehicles. However, since there is no assignable benefit to regulating engines, any cost cannot be justified. [EPA-HQ-OAR-2014-0827-1290-A1 p.16]

Engine Efficiency

Recognizing that the Agencies have chosen to include a separate engine efficiency regulation, we encourage them not to increase stringency beyond the proposed levels. Maintaining engine stringency at these levels pushes the envelope of engine technology without forcing the many negative consequences we have outlined in these comments. Furthermore, we are very concerned that an engine manufacturer could generate significant credits (for example by selling alternatively fueled engines) so that they could avoid selling undesirable, complex, expensive engine technology, while competitors, lacking such credits, would be pushed out of the market. [EPA-HQ-OAR-2014-0827-1290-A1 p.19-20]

Response:

Separate Engine Standards

The agencies receive many comments on the proposed regulatory structure, primarily related to the need for separate engine standards. Those supporting the separate engine standards largely agreed with the agencies' reasons given in the NPRM (80 FR 40181), that they would:

- Enhance the agencies' compliance efforts
- Maintain a connection between GHGs and criteria pollutants (such as NOx)
- Measure transient fuel consumption control
- Enable simpler vehicle requirements for small volume and specialty vehicles

With respect to the compliance advantages, we also see a benefit to having a compliance program that is not entirely dependent upon computer simulations. ACEEE also supported separate engine standards "to set out direct, multiyear targets for engine performance sufficient to promote substantial, sustained investment in engine efficiency." They argued that if "the only signal to improve engine efficiency is filtered through the lens of whole vehicle efficiency, there will remain uncertainly about how much of the improvement will fall to the engine."

Those opposing separate engine standards did not dispute these advantages. Instead they expressed concerns similar to those the agencies discussed in the NPRM. However, commenters opposing separate engine standards appear to actually oppose separate engine standards *that are too stringent* rather than separate engine standards *per se.* Volvo acknowledged that the proposed stringency would not cause the adverse consequences. We addressed this issue in the NPRM (80 FR 40182):

> *Note that commenters opposing separate engine standards should also be careful distinguish between concerns related to the stringency of the proposed engine standards, from concerns inherent to any separate engine standards whatsoever. When meeting with manufacturers prior to this proposal, the agencies heard many concerns about the potential problems with separate engines standards that were actually concerns about separate engine standards that are too stringent. However, we see these as two different issues. The agencies do recognize that setting engine standards at a high stringency could increase the cost to comply with the vehicle standard, if lower-cost vehicle technologies are available. Additionally, the agencies recognize that setting engine standards at a high stringency may promote the use of large-displacement engines, which have inherent heat transfer and efficiency advantages over smaller displacement engines over the engine test cycles, though a smaller engine may be more efficient for a given vehicle application. Thus we encourage commenters supporting the separate engine standards to address the possibility of unintended consequences such as these.*

In addition, the agencies pointed out that:

> *In the past there has been some confusion about the Phase 1 separate engine standards somehow preventing the recognition of engine-vehicle optimization that vehicle manufacturers perform to minimize a vehicle's overall fuel consumption. It was not the existence of separate engine standards that prevented recognition of this optimization. Rather it was that the agencies did not allow manufacturers to enter input into GEM that characterized unique engine performance. For Phase 2 we are proposing to require that manufacturers input such data because we intend GEM to recognize this engine-vehicle optimization. The continuation of separate engine standards in Phase 2 does not undermine in any way the recognition of this optimization in GEM.*

To address these opposing comments, it is helpful to consider them in the context of three relative engine stringency scenarios. For each scenario, the engine stringency is compared to levels vehicle manufacturers would choose if there were no separate engine standards.

1. For the first case, assume the engine standards were low enough that they required less technology than vehicle manufacturers would choose to apply to meet the vehicle standards. In this scenario, the concerns raised in the opposing comments would not apply. However, the benefits of having separate engine standards would occur.

2. For the second case, assume the engine standards were set so they required the same technology that vehicle manufacturers would choose to apply to meet the vehicle standards. Like the first scenario, the concerns raised in the opposing comments would not apply, but the benefits of having separate engine standards would occur.

3. For the third case, assume the engine standards were set stringent enough that they required more technology than vehicle manufacturers would choose to apply to meet the vehicle standards. Only in this scenario, would the concerns raised in the opposing comments would apply. However, since the benefits of having separate engine standards would also occur, the agencies would need to balance these against one another.

In neither the first case nor the second case would the concerns raised in the comments apply at all, so they clearly could not justify sacrificing the benefits of having separate engine standards (benefits which commenters did not dispute) under those scenarios. Thus, only under the third scenario would the opposing comments be relevant. This is the concern raised by the vehicle OEMs. However, the agencies do not believe the standards being set are too stringent. As described elsewhere, the tractor and vocational *vehicle* standards are stringent, technology-forcing standards that will require vehicle manufacturers to make extensive use of available engine and vehicle technologies, including integration of the two. Although the feasibility analyses for those vehicle standards project some technological flexibility for vehicle manufacturers, we believe it to be very unlikely that manufacturers would be able to achieve the final vehicle standards with engines that significantly exceed the engine standards.

It is important to also note that we project the engine standards to be both feasible and very cost-effective. Caterpillar claimed that engine-based controls are expected to be more expensive than vehicle-based controls. We disagree. For example, we project the 2027 heavy heavy-duty tractor standards to cost $1,579 per engine to achieve a 5.1% reduction, which is comparable to the cost-effectiveness of other projected vehicle standards. Thus, if a vehicle manufacturer were to identify some less expensive vehicle technologies, it is not clear that the vehicle manufacturer’s preferred path would be to scale back these cost-effective engine reductions.

Volvo overstates the risks associated with the regulatory engine test cycles, when they argue that the reweighted RMCSET would reward optimizing tractor engines for higher speeds than are common in today’s trucks. This ignores the full range of the impacts of engine speeds, including those associated with the shape of the torque curve. We do not believe manufacturers will intentionally sacrifice in-use fuel efficiency to gain a false benefit on the engine test cycle.

Finally, even if having separate engine standards resulted in marginally higher costs than would have occurred without engine standards, the benefits of having the separate standards would still justify the costs. Therefore, the agencies are finalizing separate engine standards.

Including Engines in GEM

The agencies are finalizing the regulatory structure that includes both separate engine standards and a recognition of engine fuel maps in GEM. Some commenters expressed explicit support for including engine fuel maps in GEM to achieve full vehicle simulation. In addition, other commenters who focused their structural comments on the need for separate engine standards generally did not oppose the inclusion of engine fuel maps in GEM.

Some of the arguments raised in opposition to separate engines standards seemed to assume that having separate engine standards precluded including engine technologies in GEM. However, the final structure accomplishes both.

Chassis Testing

We are finalizing the proposed chassis testing requirements, which will:

- Continue to require chassis-testing for certification of complete HD pickups and vans.
- Add a new requirement for tractor manufacturers to perform demonstration chassis testing on a small sample of production tractors.

CARB supported expanded use of chassis testing. However, Daimler commented that chassis dynamometer is highly impractical. While we understand the potential benefits of expanded chassis testing, we also recognize the practical obstacles to widespread chassis testing. We believe the requirements being finalized strike the proper balance.

Other Regulatory Structure Issues

It is worth noting that the agencies regard the standards for pickups and vans, vocational vehicles, tractors, trailers and engines as independent of each other, functioning sensibly on their own. Thus, for example, the standard for tractors is not dependent on the engine standards (engine standards are separately implemented by engine dynamometer testing, whereas the tractor standards are implemented via GEM);[37] the trailer standard has no relation to the vocational vehicle standard (these are separate averaging sets even after ABT is available for trailers). Also, the NHTSA fuel consumption standards are independent of the EPA greenhouse gas standards and vice versa. Each standard implements, and is justified by, each agency's respective and distinct statutory authority. See preamble Section I.E. and Delta Construction Co. v. EPA, 783 F. 3d 1291, 1297-98 (D.C. Cir. 2015). The agencies therefore regard each of these standards as legally severable.

Although the FRM generally discusses these components separately by category, many if not all the subcategories are also legally severable. Certainly, anything separated by an averaging set would be equally severable. For example, standards for heavy heavy-duty engines and vehicles are independent of the standards for smaller engines and vehicles.

EPA has also issued engine standards for greenhouse gases other than CO_2, namely N_2O and CH_4. These standards are independent of the engine CO_2 standards. Those CO_2 standards function identically whether or not there were the standards for N_2O and CH_4, and vice versa.

Finally, EPA has taken certain final actions which are exclusive to EPA programs. These include actions relating to rebuilt engines used in new chassis (i.e. glider vehicles) and certain additional actions described in Section XIII of the Preamble to the final rule. These actions are independent of the greenhouse gas standards. (The final rule indicates that glider vehicles must meet greenhouse gas standards, but the rules are structured so this requirement functions independently of the requirements providing allowances for usage of engines not meeting criteria pollutant standards for the model year the glider vehicle is assembled.)

3.3 Proposed Engine Standards for CO2 and Fuel Consumption

EPA and NHTSA project that CO_2 emissions and fuel consumption reductions can be feasibly and cost-effectively met through technological improvements to diesel engines. The agencies also discussed several alternatives in the proposal. When considering alternatives, it is necessary to evaluate the impact of a regulation in terms of CO_2 emission reductions, fuel consumption reductions, technical feasibility and technology costs. However, it is also necessary to consider other aspects related to feasibility and cost, such as manufacturers' research and development resources, the impact on purchase price, and the impact on purchasers. Manufacturers are limited in their ability to develop and implement new technologies due to their human resources and budget constraints. This has a direct impact on the amount of lead time that is required to meet any new standards.

The agencies received some general comments on the overall stringency of the proposed Phase 2 diesel engine standards. Several entities encouraged the agencies to adopt more stringent standards, while other commenters cautioned the agencies from adopting final standards that are more stringent than those proposed. The agencies considered all of the general comments associated with the proposed

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[37] GEM requires a measured engine fuel map, which would also be collected using an engine dynamometer; the mapping procedure is independent of the engine standards.

would block the required airflow to the heat exchanger surfaces contained within the TRU, which is necessary to provide adequate refrigeration to the trailer's contents efficiently. Ingersoll Rand believes that added guidance from EPA on the specific technologies for reducing emissions and fuel consumption that are applicable to refrigerated vans, as well suggested approaches to meeting these new GEM requirements in refrigerated vans while only using applicable technologies, will go a long way toward ensuring that trucks with refrigerated trailers operate efficiently as a system. [EPA-HQ-OAR-2014-0827-1196-A1 p.2-3]

Response:

The agencies are adopting standards with the same stringency between dry and refrigerated vans in each length subcategory. We recognize that most current gap reducers would not be appropriate for refrigerated vans with TRUs, yet several technology combinations exist that can compensate for no gap reducer (see our response to CARB in Section 5.3 on page 980). We designed our standards with example technology packages, but we do not restrict our box van performance standards to any given set of technologies. Manufacturers can choose from many combinations of aerodynamic devices, tire rolling resistance levels, weight reduction options, and tire pressure systems to achieve their desired performance. The agencies cannot create a comprehensive list of technologies that may or may not apply for each trailer design. Instead, we rely on the judgment of trailer manufacturers in coordination with their customers to choose the most effective designs that will meet the requirements of the standards as well as the needs of the customers' applications.

Organization: Truck Renting and Leasing Association

We also support: (3) equal focus on the potential fuel economy savings from improvements in the design and aerodynamics of trailers. [EPA-HQ-OAR-2014-0827-1140-A1 p.2]

Response:

The agencies designed the box trailer program to be based on performance standards. As long as a manufacturer can demonstrate improved aerodynamic performance through aerodynamic testing, it does not matter if the improvements were made to the trailer design or achieved with the use of third-party bolt-on devices. The agencies did not have the resources to evaluate trailer design changes in their analysis, but that does not preclude manufacturers from pursuing design changes as part of their compliance plan.

Organization: Truck Trailer Manufacturers Association (TTMA)

TTMA is highly concerned with creating and maintaining a safe environment on and off the nation's roadways when it comes to the use of truck trailers. The current voluntary model of Federal GHG & fuel conservation relies on payback to incentivize end users to adopt technologies like aerodynamic features. Such a payback-based feature causes users to avoid the technology in end-use situations where either speeds or loads preclude payback; e.g. if a user needs to leave a pallet off their trailer because the aero devices put them over the weight limit, they will choose not to use them. The proposed rule will, of necessity, force aero devices on end users who otherwise would be avoiding them. For low speed users, this is simply a waste of resources[12], but for users operating at or near weigh-out conditions, the weight of the aero devices forces more trips as freight has to be hauled on a second load. Those extra trips pose a safety risk which must be accounted for. [EPA-HQ-OAR-2014-0827-1172-A1 p.7]

Estimate of Safety Impact of Deadweight Load of Aerodynamic Devices

Using a 250 lb. weight of aerodynamic devices per trailer, and a cargo load of 50,000 lb. when tractor-trailer is in Weigh-out mode means that the 250 lb. for extra devices will have to be hauled on an additional trip. [EPA-HQ-OAR-2014-0827-1172-A1 p.7]

250 lb add'l / 50,000 lb cargo per Weigh—out Trip = 0.5% increase in Weigh—out Trips

Approximately 30% of tractor-trailers are operating at or near weigh-out conditions.[13]

0.5% increase in Weigh—out Trips x 30% VMT in Weigh—out Conditions = 0.15% increase in Vehicle Miles Traveled (VMT) [EPA-HQ-OAR-2014-0827-1172-A1 p.7]

Annual VMT for tractor-trailers is 122,705 M VMT/year.[14]

0.15% Increase in VMT x 122,705 M VMT/year = increase of 184 M VMT/Year [EPA-HQ-OAR-2014-0827-1172-A1 p.7]

Collision rate for Tractor-trailers is 134/100 M VMT.[15]

Increase of 184 M VMT/Yr x 134 Collisions/100 M VMT = Increase of 246 collisions/year [EPA-HQ-OAR-2014-0827-1172-A1 p.8]

Approximately 3% of Tractor-trailer Collisions involve fatalities.[16]

Increase of 246 collisions/year x 3% Fatality Involvement/Collision = 7 extra fatal accidents per year [EPA-HQ-OAR-2014-0827-1172-A1 p.8]

In general, the safety impact of additional weight on trailers is 1 extra collision per year for every pound of added trailer weight, and one additional fatality-involved crash per year for every 35 pounds additional trailer weight. [EPA-HQ-OAR-2014-0827-1172-A1 p.8]

Note that since the proposal relies heavily on EPA methodology that favors “technology-forcing” regulation, where regulations are formulated to require devices that do not currently exist, the proposal goes beyond NHTSA’s mandate to reduce deaths, injuries and economic losses resulting from motor vehicle crashes. Some of these devices don’t yet exist in a form that would satisfy the proposal, and those that do have potential safety risks that have not been fully explored. [EPA-HQ-OAR-2014-0827-1172-A1 p.8]

Weight:

As described in our Safety Impact section, increased tare weight contributes to increased VMT. While the safety concerns associated with this are our first concern, we ought to consider the fuel consumption and GHG emission effects of these extra trips. This will serve to reduce benefit from applied devices. Similarly, light-weighting trailers will allow more cargo to be carried and thus result in a reduction in VMT and a corresponding reduction in Fuel consumption and GHG emissions. Based on our reading of the EPA documents, the factors applied to weight reduction strategies do not include this effect and most certainly should. [EPA-HQ-OAR-2014-0827-1172-A1 p.17]

Response:

NHTSA evaluated TTMA's safety impact analysis. NHTSA recognizes that regulatory and market factors that result in changes in trailer weight can potentially have safety ramifications, both positive and negative. NHTSA believes that the appropriate perspective is to evaluate the regulation and market factors in their entirety. One such factor is that incentives in the Phase 2 regulation could result in an average decrease in trailer weight. Since removing weight from trailers allows more cargo to be carried, fewer trips are needed to move the same amount of cargo, and fewer crashes – including fatal crashes – could occur. Fleets and other customers have a natural incentive to request lighter-weight trailers. From the trailer owners' perspective, reducing trailer weight not only allows them to increase cargo when they are near capacity, but also reduces fuel consumption whether the trailer is fully loaded or not. In pre-proposal meetings with trailer manufacturers, companies said that customers are requesting lighter-weight components when possible and manufacturers are installing them.

To further incentivize a shift to lighter weight materials, the Phase 2 program provides two compliance mechanisms, both of which are discussed in the Preamble (Section IV.D(1)(d) and Section IV.F(5)(d), respectively). The first is a list of weight reductions from which manufacturers can select. The list identifies specific lighter-weight components, such as side posts, roof bows, and flooring. Manufacturers using these lighter-weight components achieve fuel consumption and GHG reductions that count toward their compliance calculations. The NPRM identified twelve components, ranging from lighter-weight landing gear (which receives credit for 50 pounds of weight reduction) to aluminum upper coupler assemblies (which receive credit for 430 pounds). See proposed section 1037.515 at 80 FR 40627. The final program includes additional lighter-weight components. In addition, for a lighter-weight component or technology that is not on the list of specific components, the program provides for manufacturers to use the "off-cycle" process to recognize the weight reduction (Section IV.F(5)(d)). Through these mechanisms, the program provides significant flexibility and incentives for trailer light-weighting.

NHTSA also recognizes that the aerodynamic devices we believe may be adopted to meet the Phase 2 trailer standards inherently add weight to trailers. In comments on the NPRM, TTMA stated that they believe that this weight increase will result in added trips and increased numbers of fatal crashes. By its analysis, this additional weight – which TTMA estimates to be 250 pounds per trailer, will cause some trucks to exceed the trailer weight limits, necessitating additional truck trips to transport freight that could not be moved by the "weighed-out" trucks. By TTMA's analysis, these added trips would cause an additional 184 million truck miles per year and would result in 246 accidents and 7 extra fatal crashes, using an assumed accident rate of 134 collisions per 100 million VMT and a 3 percent fatality rate per accident. The agencies evaluated TTMA's estimate of additional fatalities and disagree with some of the assumptions made in the analysis. For example, the fatality rate used was developed in a study conducted for Idaho and is higher than the national average. According to FMCSA's 2014 annual report for "Large Truck and Bus Crash Facts" indicates there are less than 1.67 fatalities per 100 million vehicle miles traveled (VMT) by combination trucks in the U.S. for 2014. When multiplied by an estimated 184 million additional truck miles due to weighed-out trucks, the result is an increase of about 3 fatalities, or 2.7 fatal crashes.

Overall, the potential positive safety implications of weight reduction efforts could partially or fully offset safety concerns from added weight of aerodynamic devices. In fact, we believe that the Phase 2 trailer program could produce a net safety benefit in the long run due to the potentially greater amount of cargo that could be carried on each truck as a result of trailer weight reduction.

Organization: Truck Trailer Manufacturers Association (TTMA)

The Agencies will never achieve their projected savings attributable to aerodynamic devices. This is because the projected reductions are based on assumptions that are completely unrealistic, do not account for actual conditions operators encounter every day, and ignore the increases in greenhouse gases caused by adopting the Proposed Rules. The **net** savings attributed to aerodynamic devices will be marginal, at best. [EPA-HQ-OAR-2014-0827-1183-A1 p.3]

Response:

It is not the agencies' intent or responsibility to project the actual savings for individual vehicles in use. The 2% to 9% emissions decreases are industry-average projected reductions based on our test procedures and driving conditions represented in our model. The assumptions we have built into our projections have incorporated the information available in the public docket for this action, including public comments, for the effectiveness of the likely technologies and their industry-wide adoption rates, as well as accounting for average operational characteristics.

We recognize that the values we projected through this process will not match those of each trailer on the road under their varying technology choices and operating conditions. The values obtained in compliance are meant to provide a relative apples-to-apples comparison between trailers. The majority of the trailers in each of the covered trailer subcategories will experience benefits from these technologies, though the level of the improvement will vary, and the overall fleet-wide benefits should be in the range that we have projected.

In response to the comment about net savings, see also our general response to comments relating to "upstream" or manufacturing emissions in Section 1 and in our previous response on page 970.

Organization: Utility Trailer Manufacturing Company

The Agencies employ unrealistic speed assumptions.

The Agencies premise their projected aerodynamic savings on a computation concerning how much those aerodynamic devices will reduce drag. Drag reduction, of course, is determined both by how much more efficient the particular device is, and – more significantly – the trailer's speed. As mentioned earlier, because aerodynamic drag is a function of velocity squared, aerodynamic drag forces are not relevant at speeds much below cruising speeds. [EPA-HQ-OAR-2014-0827-1183-A1 p.4]

The Agencies' GEM model, however, computes savings based on the completely unrealistic assumption that trailers travel at the following speeds for the following percentage of time: [EPA-HQ-OAR-2014-0827-1183-A1 p.4]

65 mph cruise — 86%

55 mph cruise — 9%

"Transient" — 5%

On their face, these assumptions bear no relationship to how tractors and trailers operate on America's highways. Nor should they, because in reaching these speed assumptions the Agencies decided to ignore the significant amount of time the tractor/trailers spend idling, thus artificially boosting the percentages of time at higher-speed.[EPA-HQ-OAR-2014-0827-1183-A1 p.4]

It is both meaningless and misleading to compute projected fuel savings (and thus greenhouse-gas reductions) based on this unrealistic speed distribution, particularly when real-world data shows a dramatically different speed profile among trailer fleets. Utility Trailer obtained real-world speed data from four fleets showing the percent of time the fleet's tractor spent at each speed; two of the fleets are long-haul, nationwide carriers traveling both in the United States as well as Mexico and Canada; two are regional fleets for food-service customers. All operate long-box trailers and use a mix of refrigerated and dry-van trailers. Data recorders logged the percentage of time the tractor/trailer was operating at each speed between 0 mph and 70 mph. One of the fleets recorded data for 4,000 tractors operating over a 6-month period; another (with the highest average speed) randomly sampled 15 tractors; and a third provided data for 26 randomly sampled tractors. The fourth fleet did not provide detailed speed data recorded by data recorders; instead, it provided its calculations of the amount of fuel saved at various speeds. This was based on data from 342 tractors, which ran between 69,457 and 2,496 miles, with most travelling roughly 30,000 miles during the time records were kept. [EPA-HQ-OAR-2014-0827-1183-A1 p.4-5]

The real-world speed data the fleets provided to Utility Trailer (denominated Fleet 1, Fleet 2, and Fleet 3) differ dramatically from that the EPA used in its GEM model in generating the assumed savings. The following spreadsheet (and graph) shows the difference. The Agencies based their definition of “transient” on that employed by the California Air Resources Board, which defined “transient” as speeds between 0 mph and 47 mph, with an average speed of approximately 15 mph. For purposes of the speed chart, “transient” is listed in the nearest speed category, 17.5 mph. [EPA-HQ-OAR-2014-0827-1183-A1 p.5]

[Table, '% of Time at Speed-EPA vs. Real-World Data', can be found on p.5 of docket number EPA-HQ-OAR-2014-0827-1183-A1, and a graph displaying the data can be found on p.6 of the same docket]

What is plain from the spreadsheet and graph is that the GEM assumption concerning the percent of time the tractor-trailers spend at higher speed dramatically exceeds what the real-world data shows. In fact, the weighted average speed of the GEM model equates to 62 mph and the average speed for these three fleets varies from 30 mph to 45 mph. [EPA-HQ-OAR-2014-0827-1183-A1 p.6]

To demonstrate further how far removed the EPA's GEM model speed assumptions are from the real world, one can focus only on Fleet 2, the Fleet that had the highest average speed of the three fleets. As shown in the following graph, the differences persist even with these assumptions favorable to the EPA's GEM model. Even in this fastest fleet, the single fastest tractor sampled was Truck 65000, which spent just 33.18% of the time at 65 mph, compared to 86% for the GEM model. Its average speed was 49 mph compared to the GEM average speed of 62 mph. And the slowest was Truck 651007 at 39 mph. [EPA-HQ-OAR-2014-0827-1183-A1 p.6]

[Graph, showing percentage of time individual trucks in Fleet 2 spent at each speed, can be found on p.7 of docket number EPA-HQ-OAR-2014-0827-1183-A1]

In addition to the information from the three fleets just summarized, Utility Trailer obtained information from a fourth fleet. This fleet's data did not show amount of time the tractor-trailer operated at each speed. Rather, the data showed the amount of fuel that fleet's tractors burned at various speeds. Tracking data over a total of 68 weeks encompassing 9.47 million miles, that data showed that 93.8% of the fuel consumed by the fleet was consumed at speeds lower than 55 mph. This confirms the relatively small gains available from tractors operating at higher speeds. [EPA-HQ-OAR-2014-0827-1183-A1 p.7]

The vast difference between the GEM assumptions and what happens in the real world is crucial to assessing the validity of the Agencies' projected CO2 reductions. Tractor/trailers with lower average speeds will benefit less from trailer aerodynamic devices. Additionally, to produce valid data, projected speeds must also account for the routes typically driven by a given fleet. Routes in rural areas are likely to be different from urban routes, and routes along the plains will have a higher average speed than mountainous routes. Differences in state speed limits and typical weather conditions also must be factored in. The Agencies' GEM model accounts for none of these factors. [EPA-HQ-OAR-2014-0827-1183 p.7]

Failure to use real-world speed data overstates the benefits of the Proposed Rule.

As noted earlier, the calculated emission benefits are based on speed assumptions that are radically different from those exhibited day-to-day on America's highways. By significantly overstating the amount of time spent at high-speed operations, the speed at which aerodynamic devices actually may provide a real benefit as aerodynamic drag at that point is roughly equivalent to the drag from non-aerodynamic friction, the estimates describe benefits that never will be achieved in the real world. [EPA-HQ-OAR-2014-0827-1183-A1 p.15]

Response:

The agencies have considered these comments from Utility, along with the information that we used to derive the drive cycle weightings in Phase 1. For the Phase 1 program, we developed the sleeper cab cycle weightings (which are also used for long box van trailers in Phase 2) based on three studies that characterized the operation of line haul trucks: An evaluation using the EPA MOVES model, a study conducted by University of California Riverside, and a tire test on line haul trucks conducted by Oak Ridge National Lab.

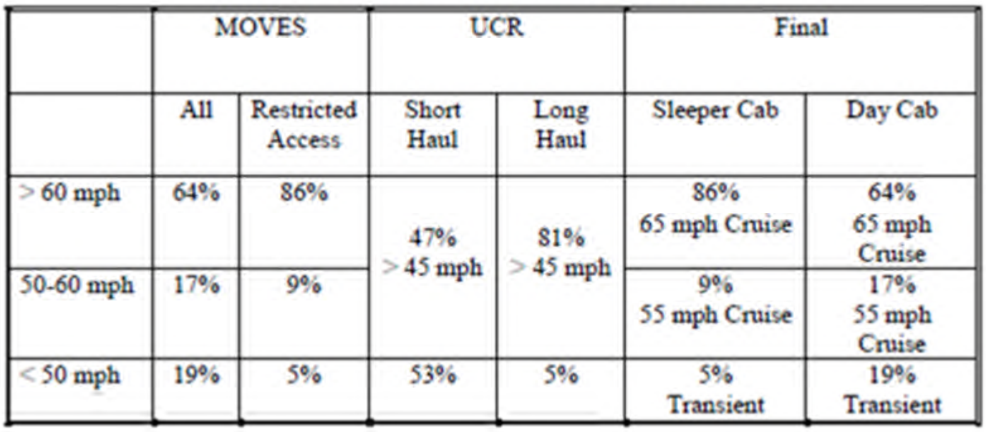
The following discussion, excerpted from the Phase 1 RIA, Chapter 3.4.3, provides more background on the analysis:

The distribution of vehicle miles travelled (VMT) among different speed bins was developed for the EPA MOVES model from analysis of the Federal Highway Administration data. The data is based on highway vehicle monitoring data from FHWA used to develop the distribution of VMT among road types from 1999. The information on speed distributions on the different type of roads at different times of day came from traffic modeling of urban locations and chase car data in rural California. This data was used to characterize the fraction of VMT spent in high speed cruise versus transient operation.

The University of California Riverside and California Air Resource Board evaluated engine control module data from 270 trucks which travelled over one million miles to develop the heavy-duty diesel truck activity report in 2006. The study found that line haul trucks spend approximately 50% of the time cruising at speeds greater than 45 mph, 10% of time in transient stop-and-go driving, and 40% in extended idle operation. After removing the idle portion to establish weightings of only the motive operation, the breakdown looks like 82% of the time cruising at speeds greater than 45 mph and 18% in transient operation.

Oak Ridge National Laboratory evaluated the fuel efficiency effect of tires on Class 8 heavy trucks. The study collected fleet data related to real-world highway environments over a period of two years. The fleet consisted of six trucks which operate widely across the United States. In the Transportation Energy Data Book (2009) Table 5.11 was analyzed and found on average that the line haul trucks spent 5% of *the miles at speeds less than 50 mph, 17% between 50 and 60 mph, and 78% of the miles at speeds greater than 60 mph. The table below summarizes the studies used to develop the weightings.*

Table 3-14: Combination Tractor Drive Cycle Weighting



	MOVES		UCR		Final	
	All	Restricted Access	Short Haul	Long Haul	Sleeper Cab	Day Cab
> 60 mph	64%	86%	47% > 45 mph	81% > 45 mph	86% 65 mph Cruise	64% 65 mph Cruise
50-60 mph	17%	9%			9% 55 mph Cruise	17% 55 mph Cruise
< 50 mph	19%	5%	53%	5%	5% Transient	19% Transient

The fleet data cited by Utility includes weightings of speed records, which represent the fraction of *time* spent at a given speed, as opposed to EPA's drive cycle weightings based on the fraction of vehicle miles traveled (VMT). Heavy-duty vehicle standards, including trailer standards, are expressed on a ton-mile basis (in contrast to a time basis, such as miles per hour) and, as a result, miles traveled is a more appropriate metric to consider than time traveled. For comparison, the agencies used the vehicle speed information provided in the Utility comments and translated the weightings to a VMT basis. Based on our assessment, when converted to the same metric, Utility's findings produce weightings that are closer to those we used in developing the standards, showing 80% or more of the vehicle miles traveled by these three fleets are at speeds of 55 mph or higher, with 12% to 20% at speeds lower than 55 mph. We attribute at least some of the difference to the more limited sample represented by the three fleets Utility examined compared to the broader Phase 1 analyses. See our memo to the docket with more information on our drive cycle comparison.[159]

While our proposed drive cycle weightings place a somewhat larger percentage of operation at 65-mph than does the more limited Utility analysis, trailers traveling at speeds of 55 mph will still experience a significant benefit with aerodynamic improvements regardless of the exact weighting. See Chapter 2.10.2.1.1 (including Figures 2-56 and 2-57). Without additional data representative of the range of national fleets, we continue to conclude that the proposed drive cycle weightings (originally developed for tractor-trailers in Phase 1), are appropriate for the Phase 2 program for trailers.

Organization: Utility Trailer Manufacturing Company

The GEM model significantly overstates anticipated aerodynamic savings.

To estimate accurately the cruise-speed fuel savings of a specific trailer aerodynamic device, first the aerodynamic fuel savings attained at each speed must be multiplied by the average percent of time the

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[159] Memorandum to Docket EPA-HQ-OAR-2014-0827, "Comparison of GEM Drive Cycle Weightings and Fleet Data Provided by Utility Trailer Manufacturing Co. in Public Comments". July 2016.

Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2

Regulatory Impact Analysis

United States Environmental Protection Agency

NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Chapter 1: Industry Characterization

1.1 Introduction

The fuel consumption and CO_2 emissions standards described in the Preamble of this FRM will be applicable to three currently-regulated categories of heavy-duty vehicles: (1) Combination Tractors; (2) Heavy-duty Pickup Trucks and Vans; and (3) Vocational Vehicles, as well as spark-ignition and compression-ignition heavy-duty engines. The industry characterization for these sectors can be found in the RIA for the HD Phase 1 rulemaking.[1] With this rulemaking, the agencies will be setting standards for combination trailers for the first time. Also with this rulemaking, the agencies are setting standards that apply for small businesses for the first time, as well as offering separate standards for vocational custom chassis. The characterization laid out in this chapter focuses on trailers and vocational custom chassis, whereas Chapter 12 of this RIA highlights impacts related to small businesses.

1.2 Trailers

A trailer is a vehicle designed to haul cargo while being pulled by another powered motor vehicle. The most common configuration of large freight trucks consists of a Class 7 or 8 tractor hauling one or more trailers. Vehicles in these configurations are called "combination tractor-trailers" or simply "tractor-trailers." A trailer may be constructed to rest upon the tractor that tows it, or be constructed so part of its weight rests on an auxiliary front axle called a "converter dolly" between two or more trailers. Trailers are attached to tractors by a *coupling pin* (or *king pin*) on the front of the trailer and a horseshoe-shaped coupling device called a *fifth wheel* on the rear of the towing vehicle or on the converter dolly. A tractor can also pull international shipping or domestic *containers* mounted on open-frame chassis, which when driven together on the road function as trailers.

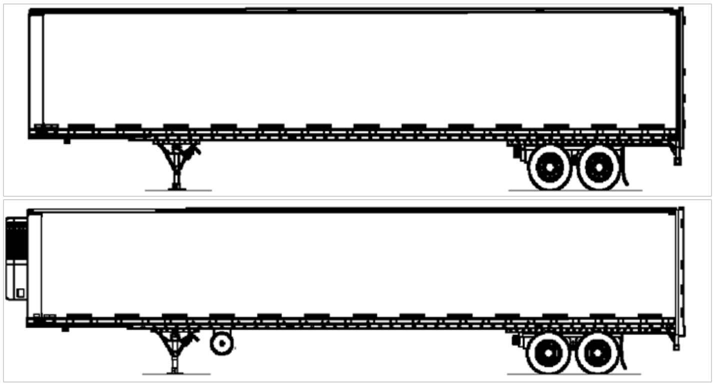
The Truck Trailer Manufacturers Association, an industry trade group primarily for manufacturers of Class 7 and 8 truck trailers, offers publications of recommended practices, technical bulletins and manuals that cover many aspects of trailer manufacture, and serves as a liaison between the industry and government agencies.[2] To date, federal regulations for the trailer industry are limited to those issued by the Department of Transportation (See 49 CFR). These regulations govern trailer dimensions and weight, as well as trailer safety requirements (e.g., lights, reflective materials, bumpers, etc.). In addition, DOT requires that each trailer, like other on-road vehicles, must have a Vehicle Identification Number (VIN).[3] The VIN is displayed on a label that is permanently-affixed to the trailer. It is required to contain the manufacturer identification, make and type of vehicle, model year, type of trailer, body type, length, and axle configuration. Trailer manufactures are responsible for reporting each trailer's VIN information to NHTSA prior to the sale of the trailer.

1.2.1 Trailer Types

Class 7 and 8 tractors haul a diverse range of trailer types. The most common trailer type is the box trailer, which is enclosed and can haul most types of mixed freight. The general rectangular shape of these trailers allows operators to maximize freight volume within the regulated dimensional limits, since the majority of freight shipped by truck cubes-out (is volume-limited) before it grosses-out (is weight-limited). Despite considerable improvements in suspension, material, safety, durability, and other advancements, the basic shape of the box trailer has not changed much over the past decades, although its dimensions have increased incrementally from what used to be the industry's standard length of 40' to today's standard 53' long van trailer. Today, box vans are commonly found in lengths of 28', 48', and 53'and widths of 102" or 96." The 28' vans ("pups") are often driven in tandem and connected by a dolly. Current length restrictions for the total combination tractor-trailer vehicle limit tandem operation to 28' trailers. However, some members of the trucking industry are pushing to increase the length limits to allow trailers as long as 33' to be pulled in tandem, and arguing that these "less than truckload" (LTL) operations could increase capacity per truckload, reduce the number of trucks on the road, reduce the fuel consumption and emissions of these tractor-trailers, and remain within the current weight limits.[4,5]

Trailers are often highly customized for each order. The general structure of the box trailer type is common and consists of vertical support posts in the interior of the trailer covered by a smooth exterior surface. However the exterior of the trailer may be constructed of aluminum or a range of composite materials. Historically, floors were constructed of wood, however many trailer customers are requesting aluminum floors to reduce weight. Semi-trailer axles are commonly a dual tandem configuration, but can also be single, spread tandem (i.e., two axles separated to maximize axle loads), tridem (i.e., three axles equally spaced), tri axles (i.e., three axles consisting of a tandem and a third axle that may be liftable), or multi-axles to distribute very heavy loads. Axles can be fixed in place, or allowed to slide to adjust weight distribution. Doors are commonly located at the rear of the trailer. The most common door is the side-by-side configuration, in which each door opens outward. Roll-up doors, which are more costly, allow truck drivers to pull up to loading docks without first stopping to open the doors. Roll-up doors are common on trailers with temperature-sensitive freight. Additional variations in trailers include side-access doors, or use the underside of the trailer for belly boxes or to store on-demand items such as ladders or spare tires.

The most common box trailer is the standard dry van, which transports cargo that does not require special environmental conditions. In addition to the standard rectangular shape, dry vans come in several specialty variants, such as drop floor, expandable, and curtain-side. Another type of specialty box trailer is the refrigerated van trailer (reefer). This is an enclosed, insulated trailer that hauls temperature sensitive freight, with a transportation refrigeration unit (TRU) or heating unit mounted in the front of the trailer powered by a small (9-36 hp) diesel engine. Figure 1-1 shows an example of the standard dry and refrigerated van.



Adapted from http://www.wbmcguire.com/links/Guides/TruckTrailerGuide.pdf

Figure 1-1 Example of Dry and Refrigerated Van

Many other trailer types are uniquely designed to transport a specific type of freight. Platform trailers carry cargo that may not be easily contained within or loaded and unloaded into a box trailer, such as large, non-uniform equipment or machine components. Platforms come in different configurations including standard flatbed, gooseneck, and drop deck. Tank trailers are pressure-tight enclosures designed to carry liquids, gases or bulk, dry solids and semi-solids. Tank trailers are generally constructed of steel or aluminum. The plumbing for intake and discharge of the contents could be located below the tank or at the rear. There are also a number of other specialized trailers such as grain (with and without hoppers), dump (frameless, framed, bottom dump, demolition), automobile hauler (open or enclosed), livestock trailers (belly or straight), construction and heavy-hauling trailers (tilt bed, hydraulic).

A sizable fraction of U.S. freight is transported in large, steel containers both internationally via ocean-going vessels and domestically via rail cars. Containers are constructed with steel sidewalls and external support beams, which results in a corrugated exterior. These containers haul mixed freight and are designed with similar dimensions to box trailers. Ocean-going international shipping containers are typically 20-feet or 40-feet in length. Domestic containers, which often travel by rail, are 53-feet in length. Transport of these containers from ports or rail to their final destination requires the container to be loaded on a specialty piece of equipment called a chassis. The chassis, which is attached to the fifth wheel of a Class 7 or 8 tractor, consists of a frame, axles, suspension, brakes and wheel assemblies, as well as lamps, bumpers and other required safety components. Fixed chassis vary in length according to the type of container that will be attached, though some chassis adjust to accommodate different sizes. When the chassis and container are assembled the unit serves the same function as a road trailer.[6] However, under customs regulations, the container itself is not considered part of a road vehicle.[7]

ACT Research compiles factory shipment information from a Trailer Industry Control Group that represents 80 percent of the U.S. trailer industry. Figure 1-2 shows the distribution of trailers sold in the U.S. based on ACT Research's 2013 factory shipment data. The most common type of trailer in use today is the dry van trailer, followed by the refrigerated van. Together, these box vans make up greater than 70 percent of the industry. Trailer Body

Builders' annual trailer output report estimates there were over 240,000 trailers sold in North America 2013.

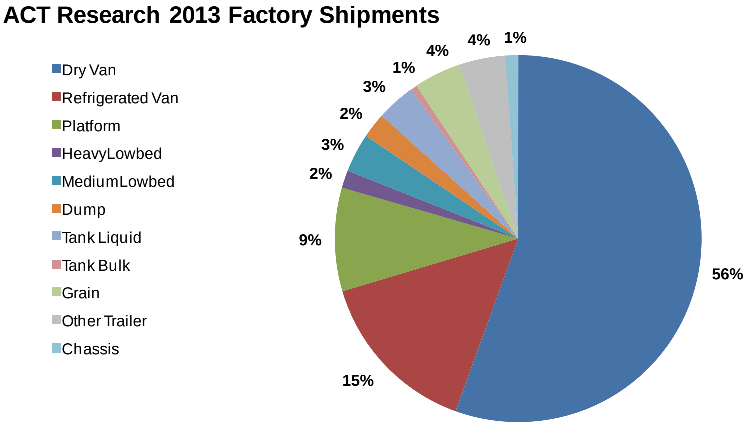


Figure 1-2 ACT Research's 2013 U.S. factory shipments

1.2.2 Trailer Manufacturers

The diverse van, platform, tank and specialty trailers are produced by a large number of trailer manufacturers. EPA estimates there are 178 trailer manufacturers. Trailers are far less mechanically complex than the tractors that haul them, and much of trailer manufacturing is done by hand. This relatively low barrier to entry for trailer manufacturing accounts, in part, for the large number of trailer manufacturers. Figure 1-3 shows the production distribution of the industry for the top 28 companies.[8] While the percentages and ranking vary slightly year-to-year, the top five manufacturers consistently produce over 70 percent of the manufacturing output of the industry.

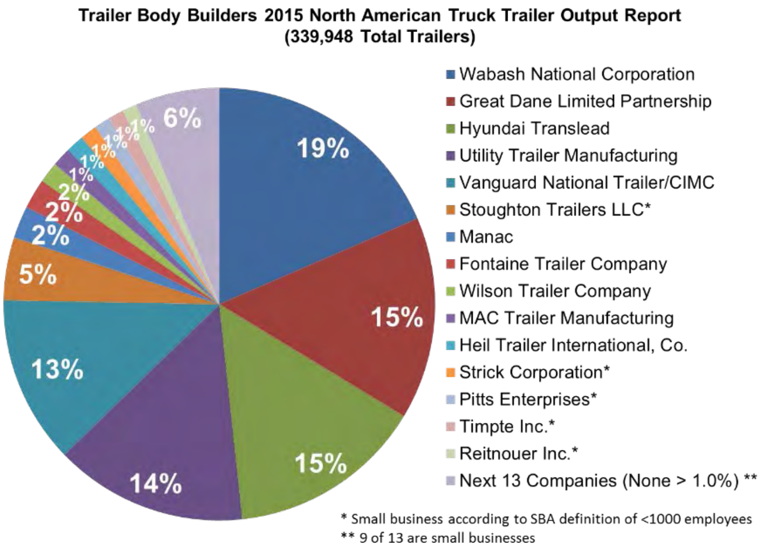


Figure 1-3 2015 Trailer Output Report from Trailer Body Builders

Table 1-1 illustrates the varying revenue among trailer manufacturers and further distinguishes the very different roles in that market played by small and large manufacturers. The revenue numbers were obtained from Hoovers online company database.[9] Over 80 percent of trailer manufacturers meet the Small Business Administration's (SBA) definition of a small business (i.e., less than 1,000 employees), yet these manufacturers make up less than 25 percent of the overall revenue from the industry. In fact, a majority of the small business trailer manufacturers make less than $10 million in revenue per year.

Table 1-1 Summary of 2014 Trailer Industry Revenue by Business Size

REVENUE RANGE	BUSINESS SIZE		
	All Sizes	Large	Small[a]
> 1000M	3	3	0
$500M - $999M	2	2	0
$400M - $499M	1	1	0
$300M - $399M	3	3	0
$200M - $299M	5	4	1
$100M - $199M	3	1	2
$50M - $99M	14	6	8
$40M - $49M	22	2	20
$15M - $19M	8	0	8
$10M - $14M	17	3	14
$5M - $9M	35	4	31
< $5M	65	2	63
Total Companies	178	31	147
Total Revenue ($M)	10841	8543	2298
Average Revenue ($M)	61	276	16
Box Trailer Mfrs	13	8	5
Non-Box Trailer Mfrs	173	29	144

Note:
[a] The Small Business Administration (SBA) defines a trailer manufacturer as a "small business" if it has fewer than 1,000 employees

The trailer industry was particularly hard hit by the recent recession. Trailer manufacturers saw deep declines in new trailer sales of 46 percent in 2009; some trailer manufacturers saw sales drop as much as 71 percent. This followed overall trailer industry declines of over 30 percent in 2008. The 30 largest trailer manufacturers saw sales decline 72 percent from 282,750 in 2006, to only 78,526 in 2009. Several trailer manufacturers shut down entire production facilities and a few went out of business altogether. Trailer production has steadily grown across the industry since 2010 and, although historic production peaks have not been repeated to date, it has now returned to levels close to those seen in the mid-2000s. Figure 1-4 shows the ACT Research's annual factory shipments, which illustrates the unsteady production over the past 17 years. Trailer Body Builders' annual trailer output report estimates there were over 240,000 trailers sold in North America in 2013. Output increased to 292,000 in 2014 and to nearly 340,000 in 2015 (very close to the current record from 1999).

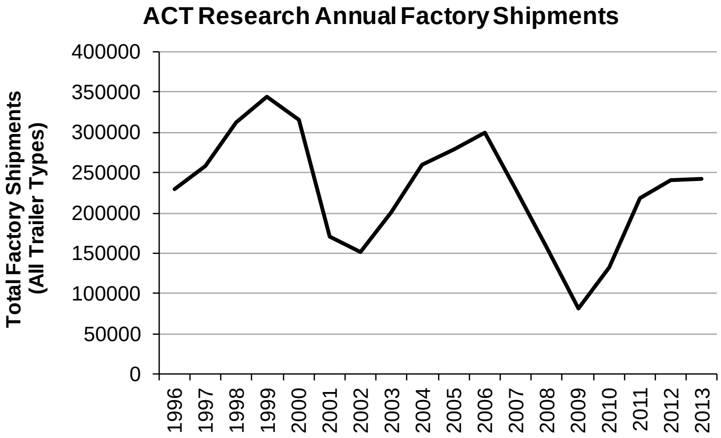


Figure 1-4 Annual Factory Shipments Tracked by ACT Research

1.2.3 Trailer Use

In order to determine the appropriate tractor type for each trailer, the agencies investigated “primary trip length” results from the Vehicle Inventory and Use Survey database to determine the distribution of trailers in short- and long-haul applications.[10] Using a primary trip length of 500 miles or less to represent short-haul use, the agencies found that, of the reported vehicles, over 50 percent of the 53-feet and longer dry vans were used in long-haul and over 80 percent of the shorter vans were used in short-haul applications. Over 70 percent of the reported 53-feet and longer refrigerated vans were long-haul trailers, with 65 percent of the shorter refrigerated vans used in short-haul applications. The survey found that non-box trailers are most frequently used for short-haul. Figure 1-5 summarizes these findings.

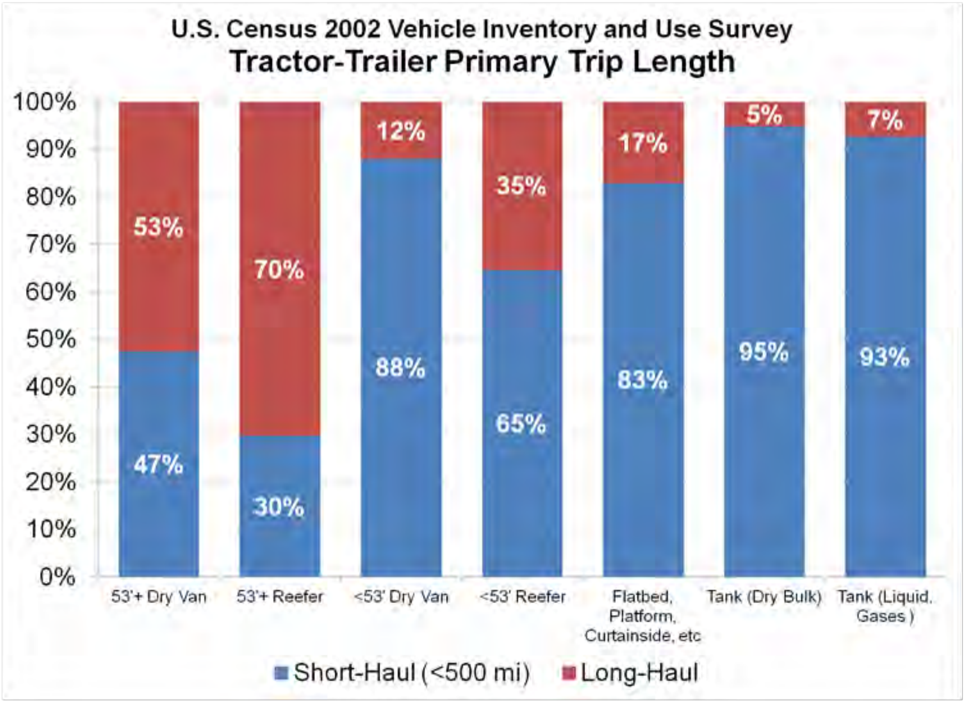


Figure 1-5 2002 Vehicle Inventory and Use Survey Considering Primary Trip Length for Tractor-Trailers

Truck drivers and trucking fleets frequently do not control all or even any of the trailers that they haul. Trailers can be owned by freight customers, large equipment leasing companies, third party logistics companies, and even other trucking companies. Containers on chassis, which function as trailers, are rarely owned by truck operators. Rather, they are owned or leased by ocean-going shipping companies, port authorities or others. This distinction between who hauls the freight and who owns the equipment in which it is hauled means that truck owners and operators have limited ability to be selective about the trailers they carry, and very little incentive or ability to take steps to reduce the fuel use of trailers that they neither own or control.

For refrigerated trailers, the story is slightly different. These trailers are used more intensely and accumulate more annual miles than other trailers. Over time, refrigerated trailers can also develop problems that interfere with their ability to keep freight temperature-controlled. For example, the insulating material inside a refrigerated trailer's walls can gradually lose its thermal capabilities due to aging or damage from forklift punctures. The door seals on a refrigerated trailer can also become damaged or loose with age, which greatly affects the insulation characteristics of the trailer, similar to how the door seal on a home refrigerator can reduce the efficiency of that appliance. As a result of age-related problems and more intense usage, refrigerated trailers tend to have shorter procurement cycles than dry van trailers, which means a faster turnover rate, although still not nearly as fast as for trucks in their first use.

Tractor-trailers are often used in conjunction with other modes of transportation (e.g., shipping and rail) to move goods across the country, known as intermodal shipping. Intermodal traffic typically begins with containers carried on ships, and then they are loaded onto railcars, and finally transported to their end destination via truck. Trucks that are used in intermodal applications are of two primary types. Trailer-on-flatcar (TOFC) involves lifting the entire trailer or the container attached to its chassis onto the railcar. In container-on-flatcar (COFC) applications, the container is removed from the chassis and placed directly on the railcar. The use of TOFCs allows for faster transition from rail to truck, but is more difficult to stack on a vessel; therefore the use of COFCs has been increasing steadily. Both applications are used throughout the U.S. with the largest usage found on routes between West Coast ports and Chicago, and between Chicago and New York.

1.2.4 Trailer Fleet Size Relative to the Tractor Fleet

In 2013, over 800,000 trailers were owned by for-hire fleets and almost 300,000 were owned by private fleets. Trailers that are purchased by fleets are typically kept much longer than are the tractors, so trucks and trailers have different purchasing cycles. Also, many trailers are owned by shippers or by leasing companies, not by the trucking fleets. Because of the disconnect between owners and operators, the trailer owners may not benefit directly from fuel consumption and GHG emission reductions.

The industry generally recognizes that the ratio of the number of dry van trailers in the fleet relative to the number of tractors is typically three-to-one.[11] Typically at any one time, two trailers are parked while one is being transported. Certain private fleets may have ratios as high as six-to-one and owner-operators may have a single trailer for their tractor. The ratio of refrigerated vans to tractors is closer to two-to-one. This is partly due to the fact that it is more expensive to purchase and operate refrigerated vans compared to dry vans. Specialty trailers, such as tanks and flatbeds are often attached to a single trailer throughout much of their life. This characteristic of the trailer fleet impacts the cost effectiveness of trailer technologies. The annual savings achieved due to these technologies are proportional to the number of miles traveled in a year and the analysis for many of the trailers must account for some amount of inactivity, which will reduce the benefits.

1.3 Vocational Vehicles: Custom Chassis

Based on public comments, information on entities who have certified, and stakeholder outreach, we have deepened our understanding of the vocational vehicle market, including the nature of specialization vs diversification among vocational vehicle manufacturers. We have identified seven vocations as shown in Table 1-2, for which there are manufacturers who are not diversified in their products competing for sales with diversified manufacturers. We are calling these custom chassis in this rulemaking.

Table 1-2 Diversification of Vocational Chassis Manufacturers[a]

Vehicle Type	Number of Single-type Chassis Manufacturers	Number of Multiple-type Chassis Manufacturers
Coach (Intercity) Bus	2	3
Motor Home	3	8
School Bus	1	2
Transit Bus	4	4
Refuse Truck	1	6
Cement Mixer	2	7
Emergency Vehicle	6	7

Note:
[a] Includes U.S.-made vehicles and those imported for sale in the U.S.

The diversity of vocational vehicles also includes applications such as terminal tractors, street sweepers, concrete pumpers, asphalt blasters, aircraft deicers, sewer cleaners, mobile medical clinics, bookmobiles, and mobile command centers. Most of these are produced by manufacturers of the vehicles listed in Table 1-2, while some are produced by small, specialized companies.

In terms of total production volume, Table 1-3 summarizes what we know about the sales of the seven custom chassis vehicle types. Of the other miscellaneous vehicles, the ones produced in the highest volume are the terminal tractors, at about 6,000 per year (including those certified with nonroad engines), with typical annual miles of less than 10,000 miles per year.[12]

Phase 2 Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles

Final EIS Summary

August 2016

Docket No. NHTSA-2014-0074

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

SUMMARY

Foreword

The National Highway Traffic Safety Administration (NHTSA) prepared this Environmental Impact Statement (EIS) to analyze and disclose the potential environmental impacts of the Phase 2 fuel efficiency standards for commercial medium-duty and heavy-duty on-highway engines, vehicles, and trailers (hereinafter referred to collectively as "HD vehicles") for model years (MYs) 2018 and beyond (the Final Action).[1] NHTSA prepared this document pursuant to Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) implementing regulations, U.S. Department of Transportation (DOT) Order 5610.1C, and NHTSA regulations.

This EIS compares the potential environmental impacts of five alternatives to regulating HD vehicle fuel efficiency for MYs 2018 and beyond, including Alternative 3 (the Preferred Alternative/Final Action), three other action alternatives, and Alternative 1 (the No Action Alternative), and analyzes the direct, indirect, and cumulative impacts of each action alternative relative to the No Action Alternative. The action alternatives NHTSA selected for evaluation encompass a reasonable range of alternatives to evaluate the potential environmental impacts of the Final Action and alternatives under NEPA. The EIS chapters and appendices provide or reference all relevant supporting information.

Background

The Energy Policy and Conservation Act of 1975 (EPCA) mandated that NHTSA establish and implement a regulatory program for motor vehicle fuel economy. As codified in Chapter 329 of Title 49 of the U.S. Code (U.S.C.), and as amended by the Energy Independence and Security Act of 2007 (EISA), EPCA sets forth specific requirements concerning the establishment of average fuel economy standards for passenger cars and light trucks, which are motor vehicles with a gross vehicle weight rating (GVWR) less than 8,500 pounds and medium-duty passenger vehicles with a GVWR less than 10,000 pounds. This regulatory program, known as the Corporate Average Fuel Economy Program (CAFE), was established to reduce national energy consumption by increasing the fuel economy of these vehicles.

EISA provided DOT—and NHTSA, by delegation—new authority to implement, through rulemaking and regulations, "a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement" for motor vehicles with a GVWR of 8,500 pounds or greater, except for medium-duty passenger vehicles that are already covered under CAFE. This broad sector (HD vehicles, as described above)—ranging from large pickups to sleeper-cab tractors—represents the second-largest contributor to oil consumption and greenhouse gas (GHG) emissions from the transportation sector, after passenger cars and light trucks. EISA directs NHTSA to "adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective, and

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[1] The Final Action establishes new standards beginning with MY 2018 for trailers and MY 2021 for all of the other heavy-duty vehicle and engine categories, with stringency increases through MY 2027 for some segments. Standards will remain at the final stringency levels until amended by a future rulemaking.

technologically feasible for commercial medium- and heavy-duty on-highway vehicles and work trucks." This new authority permits NHTSA to set "separate standards for different classes of vehicles."

Consistent with these requirements and in consultation with the U.S. Environmental Protection Agency (EPA) and Department of Energy (DOE), NHTSA established the first fuel efficiency standards for HD engines and vehicles in September 2011, as part of a comprehensive HD National Program to reduce GHG emissions and fuel consumption for HD vehicles (trailers were not included in that phase). Those fuel-efficiency standards constitute the first phase (Phase 1) of the NHTSA HD Fuel Efficiency Improvement Program. They were established to begin in MY 2016 and remain stable through MY 2018, consistent with EISA's requirements. Although EISA prevented NHTSA from enacting mandatory standards before MY 2016, NHTSA established voluntary compliance standards for MYs 2014–2015 prior to mandatory regulation in MY 2016. Throughout this EIS, NHTSA refers to the rulemaking and EIS associated with the MY 2014–2018 HD vehicle fuel efficiency standards described in this paragraph as "Phase 1" or the "Phase 1 HD National Program."

In February 2014, the president directed NHTSA and EPA to develop and issue the next phase of HD vehicle fuel efficiency and GHG standards by March 2016, as stated in the White House's 2014 report *Improving the Fuel Efficiency of American Trucks – Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation*. Consistent with this directive, NHTSA is establishing fuel efficiency standards for HD vehicles for MYs 2018 and beyond as part of a joint rulemaking with EPA to establish what is referred to as the Phase 2 HD National Program (also referred to as "Phase 2"). As with Phase 1 and as directed by EISA, NHTSA conducted the Phase 2 rulemaking in consultation with EPA and DOE.

Pursuant to NEPA, federal agencies proposing "major federal actions significantly affecting the quality of the human environment" must, "to the fullest extent possible," prepare "a detailed statement" on the environmental impacts of the proposed action, including alternatives to the proposed action. To inform its development of the Phase 2 standards, NHTSA prepared this EIS, which analyzes, discloses, and compares the potential environmental impacts of a reasonable range of action alternatives including the No Action Alternative. This EIS also identifies a Preferred Alternative, pursuant to CEQ NEPA implementing regulations, DOT Order 5610.1C, and NHTSA regulations. The Draft EIS was issued together with the Phase 2 Notice of Proposed Rulemaking (NPRM) on June 19, 2015. NHTSA is issuing this Final EIS concurrently with the Final Rule (Record of Decision), pursuant to 49 U.S.C. 304a (Pub. L. 114-94, 129 Stat. 1312, Section 1311(a)) and U.S. Department of Transportation *Final Guidance on MAP-21 Section 1319 Accelerated Decisionmaking in Environmental Reviews*.

Purpose and Need for the Action

NEPA requires that agencies develop alternatives to a proposed action based on the action's purpose and need. The purpose of this rulemaking is to continue to promote EPCA's goals of energy independence and security, as well as to improve environmental outcomes and national security, by continuing to implement an HD Fuel Efficiency Improvement Program that is "designed to achieve the maximum feasible improvement." Congress specified that, as part of the HD Fuel Efficiency Improvement Program, NHTSA must adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols. These required aspects of the program must be appropriate, cost effective, and technologically feasible for HD vehicles. In developing Phase 2, NHTSA has continued to consider these EISA requirements as well as relevant environmental and safety considerations.

Although the standards established under the Phase 1 HD National Program have locked in long-lasting gains in fuel efficiency, HD vehicle fuel consumption is still projected to grow as more trucks are driven more miles. For this reason, new standards extending beyond Phase 1 are needed to further improve energy security, save money for consumers and businesses, reduce harmful air pollution, and lower costs for transporting goods. The Final Action and alternatives analyzed in this EIS have, therefore, been developed to reflect the purpose and need specified by EPCA, EISA, the Phase 1 HD National Program, and the president's 2014 directive on developing Phase 2 HD vehicle fuel efficiency and GHG standards.

Final Action and Alternatives and Analysis Methodologies

NEPA requires an agency to compare the potential environmental impacts of its proposed action and a reasonable range of alternatives. NHTSA's Action is to set HD vehicle fuel efficiency standards for MYs 2018 and beyond as part of joint rulemaking with EPA to establish what is referred to as the Phase 2 HD National Program, in accordance with EPCA, as amended by EISA. The specific alternatives NHTSA selected, described below and in Section 2.2 of this EIS, encompass a reasonable range within which to set HD vehicle fuel efficiency standards and evaluate potential environmental impacts under NEPA. Pursuant to CEQ regulations, the agency has included a No Action Alternative (Alternative 1), which assumes that NHTSA would not issue a rule regarding HD vehicle fuel efficiency standards beyond Phase 1, and assumes that NHTSA's Phase 1 HD standards and EPA's Phase 1 HD vehicle GHG standards would continue indefinitely. This alternative provides an analytical baseline against which to compare the environmental impacts of the four action alternatives.

Alternatives

The specific alternatives selected by NHTSA encompass a reasonable range of alternatives by which to evaluate the potential environmental impacts of Phase 2 of the HD Fuel Efficiency Improvement Program under NEPA. At one end of this range is the No Action Alternative, which assumes that no action would occur under the HD National Program. In addition to the No Action Alternative, NHTSA examined four action alternatives, each of which would regulate the separate segments of the HD vehicle fleet differently. Each of these action alternatives would include fuel consumption standards for engines used in Classes 2b–8 vocational vehicles and tractors (specified as gallons of fuel per horsepower-hour [gal/100 bhp-hr]); overall vehicle standards for HD pickups and vans (specified as gal/100 miles), Classes 2b–8 vocational vehicles, and Classes 7–8 tractors (specified as gallons of fuel per 1,000 ton payload miles [gal/1,000 ton-miles]); and standards for certain trailers pulled by Classes 7–8 tractors (specified as gal/1,000 ton-miles associated with "standard" reference tractors).

In the Proposed Rule and Draft EIS, the Preferred Alternative and Alternative 4 were designed to achieve similar fuel efficiency and GHG emissions levels in the long term, but with Alternative 4 being accelerated in its implementation timeline. In practice, this meant that Alternative 4 was more stringent than the Preferred Alternative in the Draft EIS. In response to comments received on the Proposed Rule and

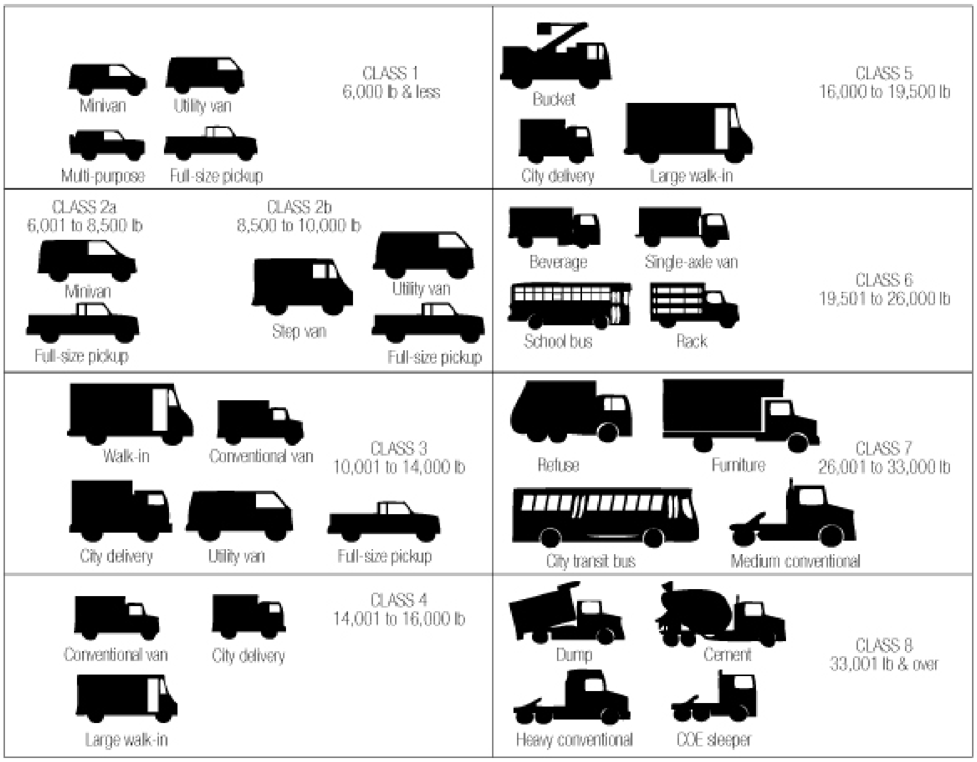
Draft EIS, the agencies revised the Preferred Alternative. As a result, the Final EIS standards for the Preferred Alternative are more stringent than the Draft EIS proposed standards for the Preferred Alternative. Standards for Alternative 4 in this Final EIS are the same as the Alternative 4 standards in the Draft EIS in order to provide a benchmark for comparison of the revised Preferred Alternative. Now, the Preferred Alternative is more stringent than Alternative 4 in this Final EIS for some vehicle categories. Under Alternative 2, standards are less stringent than the Preferred Alternative or Alternative 4. Alternative 5 represents more stringent standards compared to Alternatives 3 and 4. Alternatives 2 through 5 would regulate the same vehicle categories, with Alternative 2 being the least stringent alternative and Alternative 5 being the most stringent.

Table S-1 and Figure S-1 show the vehicle categories that are the subject of the Final Rule. Section I of the Final Rule and Section 2.2 provide more details about these vehicle categories and the specific standards for the Preferred Alternative and other action alternatives.

Table S-1. HD Vehicle Categories by Gross Vehicle Class Weight Rating (pounds)

Class 2b	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
8,501–10,000	10,001–14,000	14,001–16,000	16,001–19,500	19,501–26,000	26,001–33,000	>33,000
HD Pickups and Vans (work trucks)						
Vocational Vehicles (*e.g.,* van trucks, utility "bucket" trucks, tank trucks, refuse trucks, buses, fire trucks, flat-bed trucks, and dump trucks)						
					Tractors (for combination tractor-trailers)	

Figure S-1. HD Vehicle Categories



Potential Environmental Consequences

This section describes how the Final Action and alternatives could affect energy use, air quality, and climate (including non-climate impacts of carbon dioxide [CO_2]), as reported in Chapters 3, 4, and 5 of the EIS, respectively. The EIS also provides a life-cycle impact assessment of vehicle energy, materials, and technologies, as reported in Chapter 6 of the EIS. This EIS also qualitatively describes potential additional impacts on hazardous materials and regulated wastes, historic and cultural resources, safety impacts on human health, noise, and environmental justice, as reported in Chapter 7 of the EIS.

The impacts on energy use, air quality, and climate described in the EIS include *direct*, *indirect*, and *cumulative impacts*. Direct impacts occur at the same time and place as the action. Indirect impacts occur later in time and/or are farther removed in distance. Cumulative impacts are the incremental direct and indirect impacts resulting from the action added to those of other past, present, and reasonably foreseeable future actions.

To derive the impacts of the action alternatives, NHTSA compares the action alternatives to the No Action Alternative. The action alternatives in the direct and indirect impacts analysis and the cumulative impacts analysis are the same, but the No Action Alternative under each analysis reflects different assumptions to distinguish between direct and indirect impacts versus cumulative impacts.

- The analysis of direct and indirect impacts compares action alternatives with a No Action Alternative that generally reflects a small forecast improvement in the average fuel efficiency of new HD vehicles after 2018 due to market-based incentives for improving fuel efficiency. In this way, the analysis of direct and indirect impacts isolates the portion of the fleet-wide fuel efficiency improvement attributable directly and indirectly to the rule, and not attributable to reasonably foreseeable future actions by manufacturers after 2018 to improve new HD vehicle fuel efficiency even in the absence of new regulatory requirements.
- The analysis of cumulative impacts compares action alternatives with a No Action Alternative that generally reflects no forecast improvement in the average fuel efficiency of new HD vehicles after 2018. As a result, the difference between the environmental impacts of the action alternatives and the cumulative impacts baseline reflects the combined impacts of market-based incentives for improving fuel efficiency after 2018 (i.e., reasonably foreseeable future changes in HD vehicle fuel efficiency) and the direct and indirect impacts of the Phase 2 standards associated with each action alternative. Therefore, this analysis reflects the cumulative impacts of reasonably foreseeable improvements in fuel efficiency after 2018 due to market-based incentives in addition to the direct and indirect impacts of the Phase 2 HD standards associated with each action alternative.

Energy

NHTSA’s Phase 2 standards regulate HD vehicle fuel efficiency and, therefore, affect U.S. transportation fuel consumption. Transportation fuel comprises a large portion of total U.S. energy consumption and energy imports and has a significant impact on the functioning of the energy sector as a whole. Because transportation fuel consumption will account for most U.S. net energy imports through 2040 (as explained in Chapter 3 of the EIS), the United States has the potential to achieve large reductions in imported oil use and, consequently, in net energy imports during this time by improving the fuel efficiency of HD vehicles. Reducing dependence on energy imports is a key component of President

Obama's May 29, 2014, *All-of-the-Above Energy Strategy*, which states that the development of HD Phase 2 standards "will lead to large savings in fuel, lower carbon dioxide (CO_2) emissions, and health benefits from reduced particulate matter and ozone."

Energy intensity measures the efficiency at which energy is converted to Gross Domestic Product (GDP), with a high value indicating an inefficient conversion of energy to GDP and a lower value indicating a more efficient conversion. From 2000 to 2011, the United States recorded substantial GDP growth with almost no increase in energy consumption because of reductions in energy intensity. The Annual Energy Outlook (AEO) 2015 forecasts ongoing declines in U.S. energy intensity, with average 2013–2040 GDP growth of 2.4 percent per year resulting in average annual energy consumption growth of just 0.3 percent.

Although U.S. energy efficiency has been increasing and the U.S. share of global energy consumption has been declining in recent decades, total U.S. energy consumption has been increasing over that same period. Most of the increase in U.S. energy consumption over the past decades has not come from increased domestic energy production but instead from the increase in imports, largely for use in the transportation sector. Transportation fuel consumption has grown steadily on an annual basis. Transportation is now the largest consumer of petroleum in the U.S. economy and a major contributor to U.S. net imports.

Petroleum is by far the largest source of energy used in the transportation sector. In 2012, petroleum supplied 92 percent of transportation energy demand, and in 2040, petroleum is expected to supply 87 percent of transportation energy demand. Consequently, transportation accounts for the largest share of total U.S. petroleum consumption. In 2012, the transportation sector accounted for 79 percent of total U.S. petroleum consumption. In 2040, transportation is expected to account for 75 percent of total U.S. petroleum consumption.

With petroleum expected to account for all U.S. net energy imports in 2040 and transportation expected to account for 75 percent of total petroleum consumption, U.S. net energy imports in 2040 are expected to result primarily from fuel consumption by light-duty and HD vehicles. The United States is poised to reverse the trend of the last 4 decades and achieve large reductions in net energy imports through 2040 due to continuing increases in U.S. energy efficiency and recent developments in U.S. energy production. Stronger fuel efficiency standards for HD vehicles have the potential to increase U.S. energy efficiency in the transportation sector further and reduce U.S. dependence on petroleum.

In the future, the transportation sector will continue to be the largest component of U.S. petroleum consumption and the second-largest component of total U.S. energy consumption, after the industrial sector. NHTSA's analysis of fuel consumption in this EIS assumes that fuel consumed by HD vehicles will consist predominantly of gasoline and diesel fuel derived from petroleum for the foreseeable future.

Key Findings for Energy Use

To calculate fuel savings for each action alternative, NHTSA subtracted projected fuel consumption under each action alternative from the level under the No Action Alternative. The fuel consumption and savings figures presented below are for 2019–2050 (2050 is the year by which nearly the entire U.S. HD vehicle fleet will most likely be composed of vehicles that are subject to the Phase 2 standards).

Direct and Indirect Impacts

As the alternatives increase in stringency, total fuel consumption decreases. Table S-2 shows total 2019–2050 fuel consumption for each alternative and the direct and indirect fuel savings for each action alternative compared with the No Action Alternative through 2050. This table reports total 2019–2050 fuel consumption in diesel gallon equivalents (DGE) for diesel, gasoline, natural gas (NG), and E85 fuel for HD pickups and vans (Classes 2b–3), vocational vehicles (Classes 2b–8), and tractor-trailers (Classes 7–8) for each alternative. Gasoline accounts for approximately 56 percent of HD pickup and van fuel use, 21 percent of vocational vehicle fuel use, and just 0.0001 percent of tractor-trailer fuel use. E85 accounts for less than 0.4 percent of HD pickup and van fuel use, and NG accounts for less than 1 percent of vocational vehicle and HD pickup and van fuel use. Diesel accounts for approximately 43 percent of HD pickup and van fuel use, 78 percent of vocational vehicle fuel use, and 100 percent of tractor trailer fuel use.

Table S-2. Direct and Indirect HD Vehicle Fuel Consumption and Fuel Savings Impacts by Alternative, 2019–2050

	Billion Diesel Gallon Equivalents (DGE)				
	Alt. 1 – No Action	Alt. 2	Alt. 3 – Preferred	Alt. 4	Alt. 5
Fuel Consumption					
HD Pickups and Vans	296.5	282.7	272.1	271.2	267.5
Vocational Vehicles	364.1	344.8	324.3	330.3	316.5
Tractor Trucks and Trailers	1,182.9	1,130.1	1,015.9	1,041.7	972.4
All HD Vehicles	**1,843.6**	**1,757.6**	**1,612.4**	**1,643.3**	**1,556.4**
Fuel Savings Compared to Alt. 1 – No Action					
HD Pickups and Vans	--	13.8	24.4	25.3	29.0
Vocational Vehicles	--	19.3	39.8	33.8	47.6
Tractor Trucks and Trailers	--	52.8	167.0	141.2	210.6
All HD Vehicles	**--**	**85.9**	**231.2**	**200.3**	**287.1**

Total fuel consumption from 2019 through 2050 across all HD vehicle classes under the No Action Alternative is projected to amount to 1,843.6 billion DGE. Total projected 2019–2050 fuel consumption across the action alternatives ranges from 1,757.6 billion DGE under Alternative 2 to 1,556.4 billion DGE under Alternative 5. Less fuel would be consumed under each of the action alternatives than under the No Action Alternative, with total 2019–2050 direct and indirect fuel savings ranging from 85.9 billion DGE under Alternative 2 to 287.1 billion DGE under Alternative 5. Under the Preferred Alternative, total projected fuel consumption from 2019–2050 would be 1,612.4 billion DGE, and direct and indirect fuel savings compared with the No Action Alternative would be 231.2 billion DGE.

Cumulative Impacts

As with direct and indirect impacts, fuel consumption under each action alternative would decrease with increasing stringency under the cumulative impacts analysis, which incorporates other past, present, and reasonably foreseeable future actions that would lead to improvements in HD vehicle fuel efficiency. Table S-3 shows total 2019–2050 fuel consumption for each alternative and the cumulative fuel savings for each action alternative compared with the No Action Alternative through 2050. Total 2019–2050 fuel consumption for each action alternative in this table is the same as shown for the corresponding action alternative in Table S-2. The No Action Alternative's fuel consumption is higher in Table S-3 than in Table S-2 because the No Action Alternative's fuel consumption in Table S-3 generally does not reflect forecast improvements in the average fuel efficiency of new HD vehicles MYs 2018 and beyond due to market forces. The cumulative impact fuel savings resulting from each action alternative are higher in Table S-3 than the direct and indirect impact fuel savings reported in Table S-2 because the fuel savings in Table S-3 reflect the cumulative impact of market-based incentives for improving fuel efficiency after 2018, plus the direct and indirect impacts of the Phase 2 HD standards associated with each action alternative.

Table S-3. Cumulative HD Vehicle Fuel Consumption and Fuel Savings Impacts by Alternative, 2019–2050

	Billion Diesel Gallon Equivalents (DGE)				
	Alt. 1 – No Action	**Alt. 2**	**Alt. 3 – Preferred**	**Alt. 4**	**Alt. 5**
Fuel Consumption					
HD Pickups and Vans	298.6	282.7	272.1	271.2	267.5
Vocational Vehicles	364.1	344.8	324.3	330.3	316.5
Tractor Trucks and Trailers	1,203.2	1,130.1	1,015.9	1,041.7	972.4
All HD Vehicles	**1,865.9**	**1,757.6**	**1,612.4**	**1,643.3**	**1,556.4**
Fuel Savings Compared to Alt. 1 – No Action					
HD Pickups and Vans	--	15.9	26.5	27.4	31.1
Vocational Vehicles	--	19.3	39.8	33.8	47.6
Tractor Trucks and Trailers	--	73.0	187.3	161.4	230.8
All HD Trucks	**--**	**108.3**	**253.5**	**222.6**	**309.4**

Total fuel consumption from 2019 through 2050 across all HD vehicle classes under the No Action Alternative in Table S-3 is projected to amount to 1,865.9 billion DGE. Total 2019–2050 projected fuel consumption across alternatives ranges from 1,757.6 billion DGE under Alternative 2 to 1,556.4 billion DGE under Alternative 5. Less fuel would be consumed under each of the action alternatives than under the No Action Alternative, with total 2019–2050 cumulative fuel savings ranging from 108.3 billion DGE under Alternative 2 to 309.4 billion DGE under Alternative 5. Under the Preferred Alternative, total projected fuel consumption from 2019–2050 would be 1,612.4 billion DGE, and cumulative fuel savings compared with the No Action Alternative would be 253.5 billion DGE.

Air Quality

Air pollution and air quality can affect public health, public welfare, and the environment. The Final Action and alternatives under consideration would affect air pollutant emissions and air quality. The EIS air quality analysis assesses the impacts of the alternatives in relation to emissions of pollutants of concern from mobile sources, the resulting impacts on human health, and the monetized health benefits of emissions reductions. Although air pollutant emissions generally decline under the action alternatives compared with the No Action Alternative, the magnitudes of the declines are not consistent across all pollutants (and some air pollutant emissions might increase). This inconsistency reflects the complex interactions between tailpipe emissions rates of the various vehicle types, the technologies NHTSA assumes manufacturers will incorporate to comply with the standards, upstream emissions rates, the relative proportions of gasoline and diesel in total fuel consumption reductions, and increases in vehicle miles traveled (VMT).

Under the authority of the Clean Air Act and its amendments, EPA has established National Ambient Air Quality Standards (NAAQS) for six relatively common air pollutants, known as "criteria" pollutants because EPA regulates them by developing human health-based or environmentally based criteria for setting permissible levels. The criteria pollutants are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), lead, and particulate matter (PM) with an aerodynamic diameter equal to or less than 10 microns (PM10) and 2.5 microns (PM2.5, or fine particles). Ozone is not emitted directly from vehicles but is formed from emissions of ozone precursor pollutants such as nitrogen oxides (NO_X) and volatile organic compounds (VOCs).

In addition to criteria pollutants, motor vehicles emit some substances defined by the 1990 Clean Air Act amendments as hazardous air pollutants. Hazardous air pollutants include certain VOCs, compounds in PM, pesticides, herbicides, and radionuclides that present tangible hazards based on scientific studies of human (and other mammal) exposure. Hazardous air pollutants from vehicles are known as mobile-source air toxics (MSATs). The MSATs included in this analysis are acetaldehyde, acrolein, benzene, 1,3-butadiene, diesel particulate matter (DPM), and formaldehyde. EPA and the Federal Highway Administration have identified these air toxics as the MSATs that typically are of greatest concern when analyzing impacts of highway vehicles. DPM is a component of exhaust from diesel-fueled vehicles and falls almost entirely within the PM2.5 particle-size class.

Health Effects of the Pollutants

The criteria pollutants assessed in the EIS have been shown to cause a range of adverse health effects at various concentrations and exposures, including:

- Damage to lung tissue
- Reduced lung function
- Exacerbation of existing respiratory and cardiovascular diseases
- Difficulty breathing
- Irritation of the upper respiratory tract
- Bronchitis and pneumonia
- Reduced resistance to respiratory infections
- Alterations to the body's defense systems against foreign materials
- Reduced delivery of oxygen to the body's organs and tissues
- Impairment of the brain's ability to function properly
- Cancer and premature death

MSATs are also associated with adverse health effects. For example, EPA classifies acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and certain components of DPM as either known or probable human carcinogens. Many MSATs are also associated with non-cancer health effects, such as respiratory irritation.

Contribution of U.S. Transportation Sector to Air Pollutant Emissions

The U.S. transportation sector is a major source of emissions of certain criteria pollutants or their chemical precursors. Emissions of these pollutants from on-road mobile sources have declined dramatically since 1970 as a result of pollution controls on vehicles and regulation of the chemical content of fuels. Nevertheless, the U.S. transportation sector remains a major source of emissions of certain criteria pollutants or their chemical precursors. On-road mobile sources (i.e., highway vehicles, including vehicles covered by the Final Rule) are responsible for 24,796,000 tons per year of CO (34 percent of total U.S. emissions), 185,000 tons per year (3 percent) of PM2.5 emissions, and 268,000 tons per year (1 percent) of PM10 emissions. HD vehicles contribute 6 percent of U.S. highway emissions of CO, 66 percent of highway emissions of PM2.5, and 55 percent of highway emissions of PM10. Almost all of the PM in motor vehicle exhaust is PM2.5; therefore, this analysis focuses on PM2.5 rather than PM10. On-road mobile sources also contribute 2,161,000 tons per year (12 percent of total nationwide emissions) of VOCs and 5,010,000 tons per year (38 percent) of NO_X emissions, which are chemical precursors of ozone. HD vehicles contribute 8 percent of U.S. highway emissions of VOCs and 50 percent of NO_X. In addition, NO_X is a PM2.5 precursor, and VOCs can be PM2.5 precursors. SO_2 and other oxides of sulfur (SO_X) are important because they contribute to the formation of PM2.5 in the atmosphere; however, on-road mobile sources account for less than 0.56 percent of U.S. SO_2 emissions. With the elimination of lead in automotive gasoline, lead is no longer emitted from motor vehicles in more than negligible quantities and is therefore not assessed in this analysis.

Methodology

To analyze air quality and human health impacts, NHTSA calculated the emissions of criteria pollutants and MSATs from HD vehicles that would occur under each alternative. NHTSA then estimated the resulting changes in emissions under each action alternative by comparing emissions under that alternative to those under the No Action Alternative. The resulting changes in air quality and effects on human health were assumed to be proportional to the changes in emissions projected to occur under each action alternative.

The air quality results, including impacts on human health, are based on a number of assumptions about the type and rate of emissions from the combustion of fossil fuels. In addition to tailpipe emissions, this analysis accounts for upstream emissions from the production and distribution of fuels. To estimate Classes 2b–3 upstream emissions changes resulting from the decreased downstream fuel consumption, the analysis uses the Volpe HD model, which incorporates emissions factors from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model (GREET) model (2013 version developed by the U.S. Department of Energy Argonne National Laboratory). The Volpe HD model uses the decreased volumes of the fuels along with the emissions factors from GREET for the various fuel production and transport processes to estimate the net changes in upstream emissions as a result of fuel consumption changes. To estimate Classes 4–8 upstream emissions, the analysis uses a spreadsheet model developed by EPA that uses an identical methodology based on GREET emissions factors.

Key Findings for Air Quality

The findings for air quality effects are shown for 2040 in this summary, a mid-term forecast year by which time a large proportion of HD vehicle miles traveled would be accounted for by vehicles that meet the Phase 2 standards. The EIS provides findings for air quality effects for 2018, 2025, 2040, and 2050. In general, emissions of criteria air pollutants decrease with increased stringency across alternatives, with few exceptions. The changes in emissions reflect the complex interactions among the tailpipe emissions rates of the various vehicle types, the technologies assumed to be incorporated by manufacturers in response to the Phase 2 standards, upstream emissions rates, the relative proportions of gasoline and diesel in total fuel consumption reductions, and increases in VMT. To estimate the reduced incidence of PM2.5-related adverse health effects and the associated monetized health benefits from the emissions reductions, NHTSA multiplied direct PM2.5 and PM2.5 precursor (NO_X, SO_2, and VOCs) emissions reductions by EPA-provided pollutant-specific benefit-per-ton estimates. Reductions in adverse health outcomes include reduced incidences of premature mortality, acute bronchitis, respiratory emergency room visits, and work-loss days.

Direct and Indirect Impacts

Criteria Pollutants

- Emissions of criteria pollutants are highest under the No Action Alternative; they decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternative 4 for some pollutants and years, and CO emissions which increase slightly under all action alternatives in 2018 (Figure S-2). Many of the emissions changes are relatively small, especially for CO and PM2.5, which were reduced by less than 13 percent in 2040 under all alternatives.
- Emissions reductions were greatest under Alternative 5 for all criteria pollutants (except CO in 2018). By 2050 these reductions ranged from 7 percent for CO to 22 percent for SO_2.
- Under the Preferred Alternative, emissions of all criteria pollutants in 2040 are reduced compared to emissions under the No Action Alternative. By 2050 these reductions ranged from 4 percent for CO to 19 percent for SO_2.

Hazardous Air Pollutants

- Emissions of MSATs are highest under the No Action Alternative; they decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternatives 2, 4, and 5 for acrolein and 1,3-butadiene (Figure S-3). The emissions changes are relatively small, less than 8 percent for all MSATs under all alternatives and years.
- Emissions changes were greatest under Alternatives 4 and 5 for all MSATs, with the exception that changes in acetaldehyde and acrolein emissions were greatest under the Preferred Alternative in some years. By 2050 these changes ranged from a reduction of 8 percent for benzene (under Alternative 5) to an increase of 5 percent for 1,3-butadiene (under Alternative 4).

Figure S-2. Nationwide Criteria Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Direct and Indirect Impacts

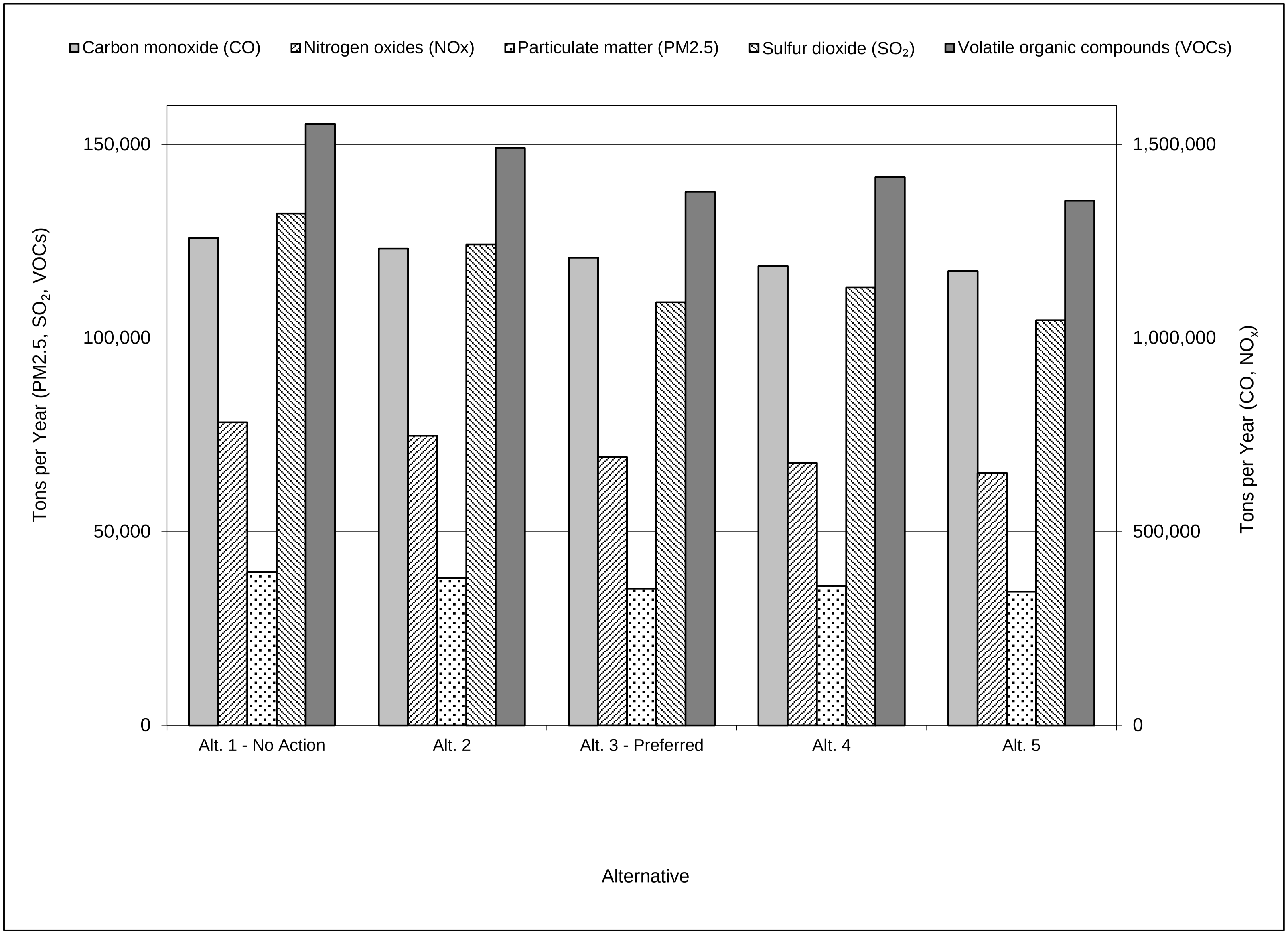
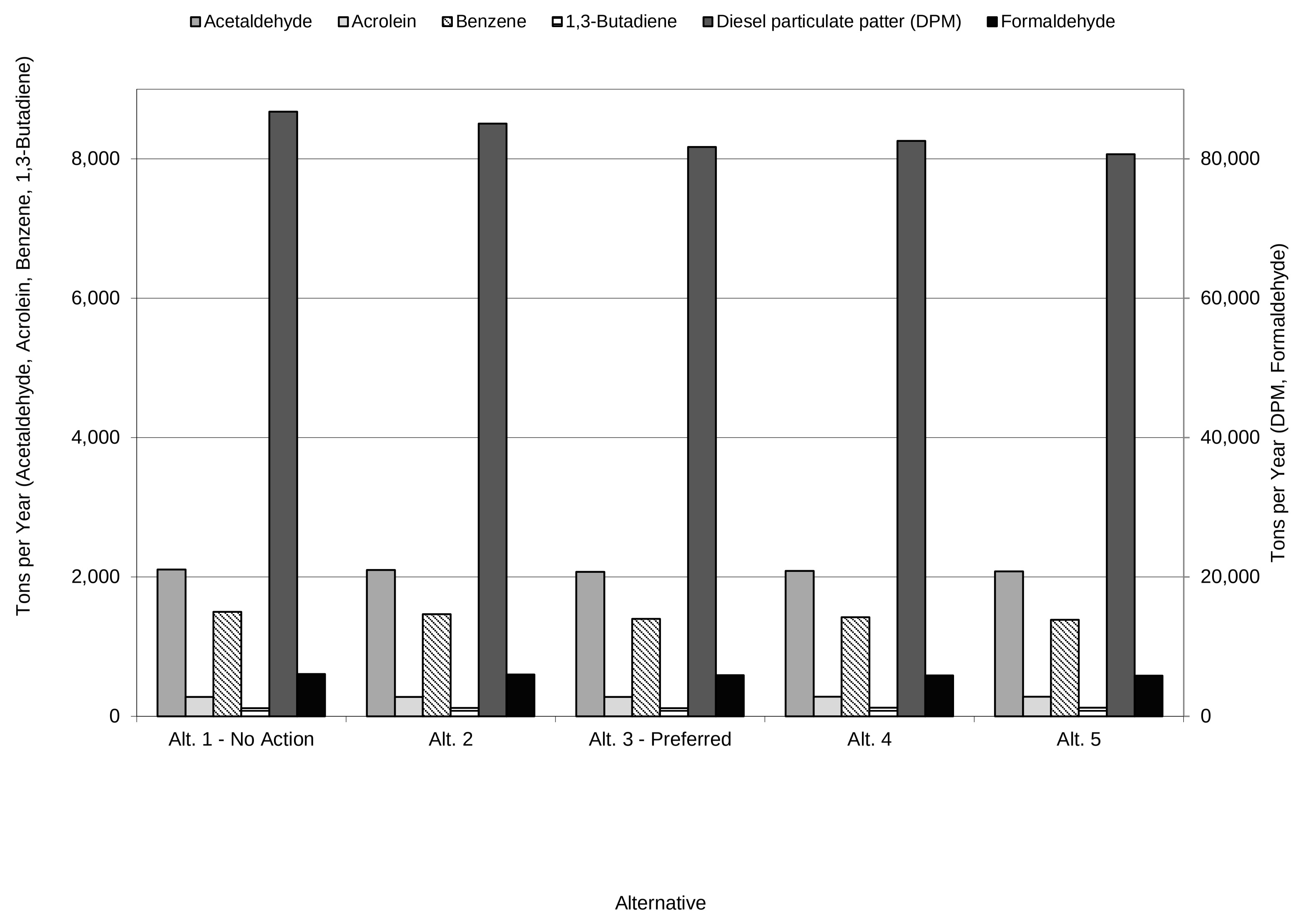


Figure S-3. Nationwide Toxic Air Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Direct and Indirect Impacts



- Under the Preferred Alternative, emissions of all MSATs in 2040 are reduced compared to emissions under the No Action Alternative. Under the Preferred Alternative by 2050, emissions of 1,3-butadiene were reduced by less than 1 percent, emissions of acrolein by 1 percent, emissions of acetaldehyde by 2 percent, emissions of formaldehyde by 3 percent, emissions of DPM by 6 percent, and emissions of benzene by 7 percent.

Health and Monetized Health Benefits

- All action alternatives would generally result in reduced adverse health effects (mortality, acute bronchitis, respiratory emergency room visits, and work-loss days) nationwide compared with the No Action Alternative, with increasing reductions from the least stringent (Alternative 2) to the most stringent (Alternative 5) alternatives, with the exception of Alternative 4 in some analysis years.
- Because monetized health benefits increase with reductions in adverse health effects, monetized benefits increase across alternatives along with increasing HD vehicle fuel efficiency standards, again with the exception of Alternative 4 in some analysis years. When estimating quantified and monetized health impacts, EPA relies on results from two PM2.5-related premature mortality studies it considers equivalent: Krewski et al. (2009) and Lepeule et al. (2012). EPA recommends that monetized benefits be shown by using incidence estimates derived from each of these studies and valued using a 3 percent and a 7 percent discount rate to account for an assumed lag in the occurrence of mortality after exposure, for a total of four separate calculations of monetized health benefits. Using these four calculations, estimated monetized health benefits in 2040 range from $1.8 billion to $15.5 billion under all action alternatives.
- Estimated monetized health benefits in 2040 range from $1.8 to $4.4 billion under Alternative 2, $5.0 to $12.4 billion under the Preferred Alternative, $4.5 to $11.2 billion under Alternative 4, and $6.2 to $15.5 billion under Alternative 5.

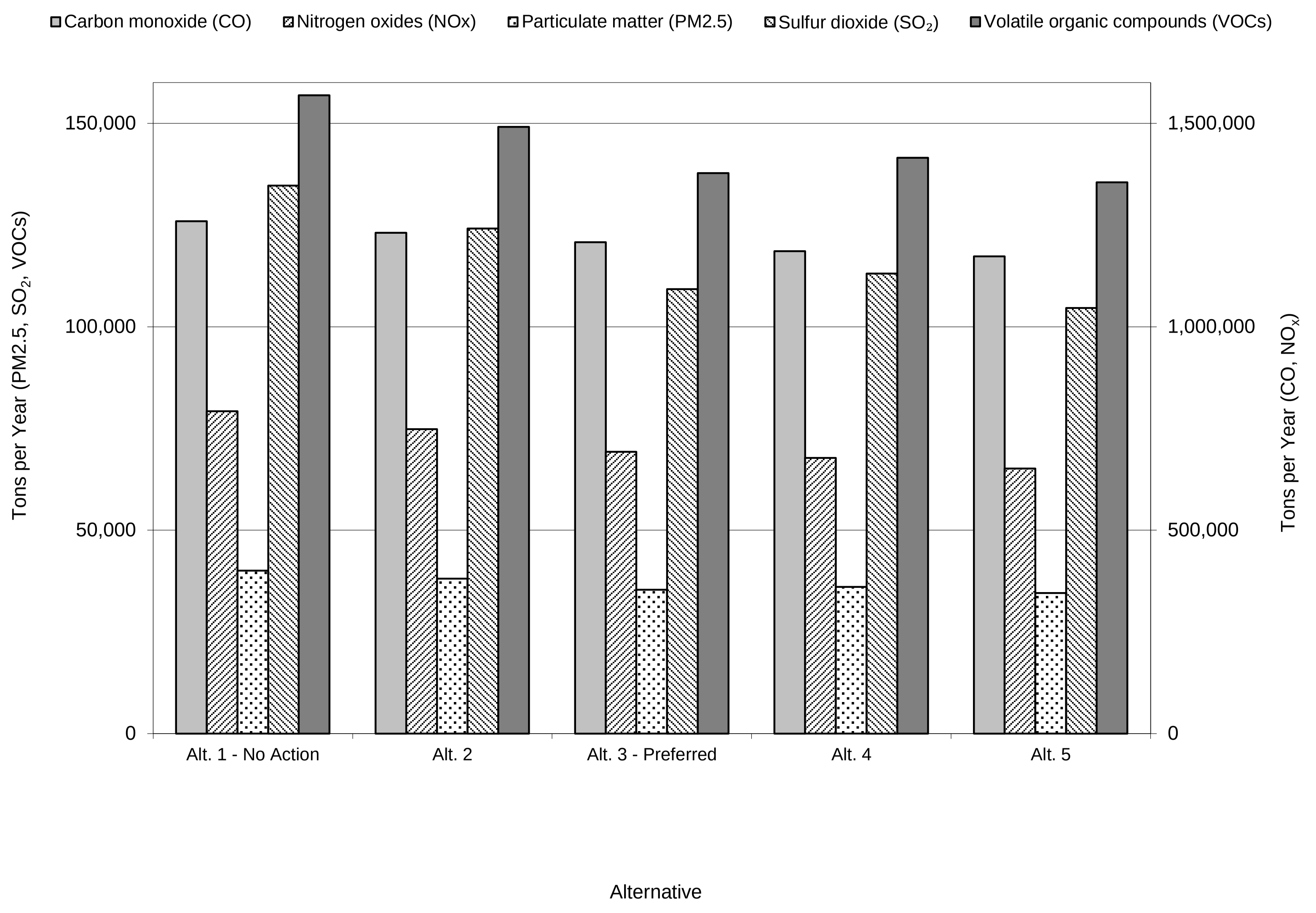
See Section 4.2.1 of this EIS for data on the direct effects of criteria and hazardous air pollutant emissions and the monetized health benefits for the alternatives.

Cumulative Impacts

Criteria Pollutants

- Cumulative emissions of criteria pollutants are highest under the No Action Alternative; they decline as fuel consumption decreases across the action alternatives, with the exception of Alternative 4 for some pollutants and years, and CO emissions which increase slightly under all action alternatives in 2018. Many of the emissions changes are relatively small, especially for CO and PM2.5, which were reduced by 14 percent or less in 2040 under all alternatives (Figure S-4).
- Emissions reductions were greatest under Alternative 5 for all criteria pollutants (except CO in 2018). By 2050 these reductions ranged from 7 percent for CO to 24 percent for SO_2.
- Under the Preferred Alternative, emissions of all criteria pollutants in 2040 are reduced compared to emissions under the No Action Alternative. By 2050 these reductions ranged from 4 percent for CO to 17 percent for SO_2**.**

Figure S-4. Nationwide Criteria Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Cumulative Impacts



Hazardous Air Pollutants

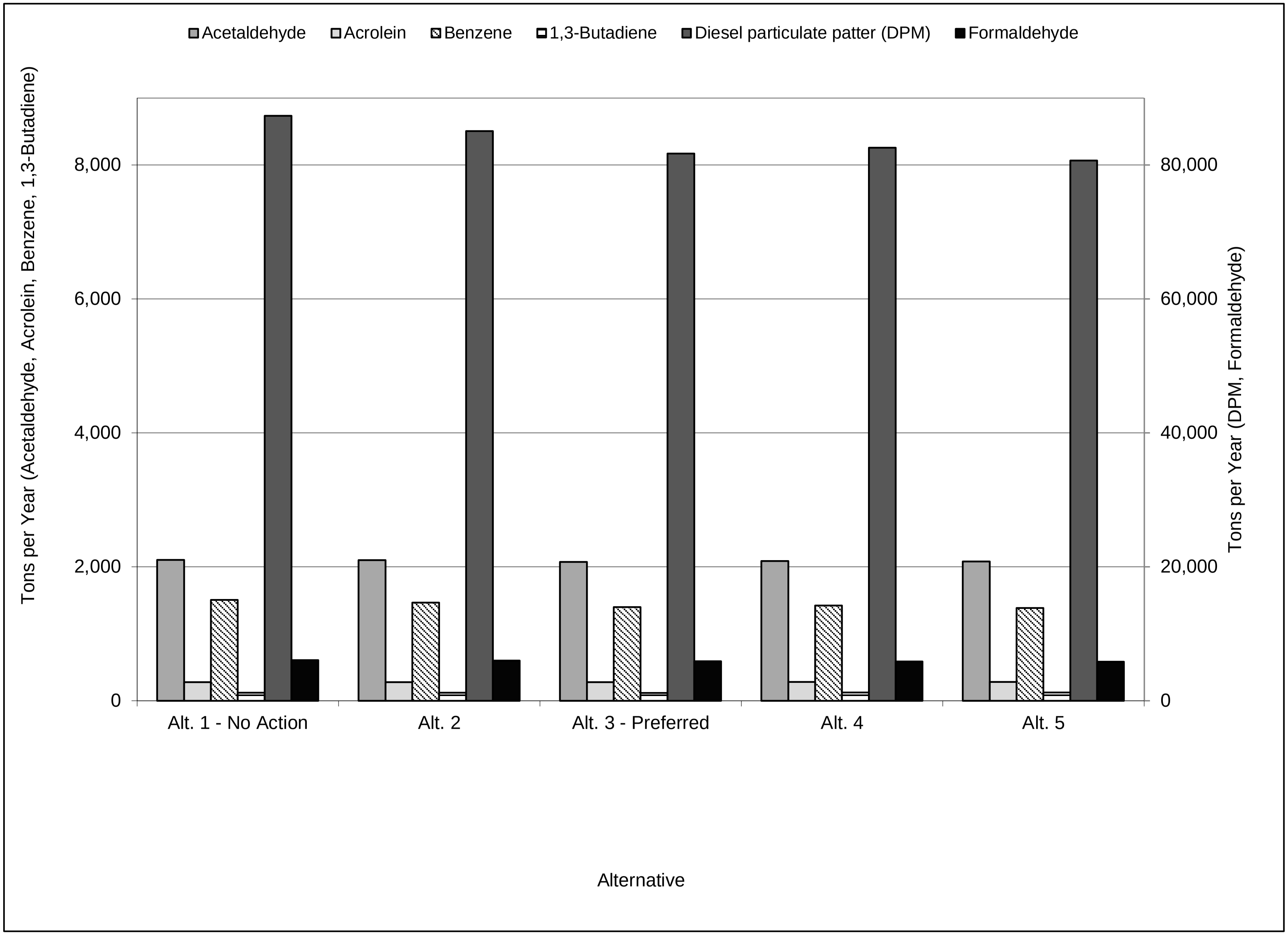
- Emissions of MSATs are highest under the No Action Alternative; they generally decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternatives 2, 4, and 5 for acrolein and 1,3-butadiene (Figure S-5). The emissions changes are relatively small, less than 9 percent for all MSATs under all alternatives and years.
- Emissions changes were greatest under Alternatives 4 and 5 for all MSATs, with the exception that changes in acetaldehyde and acrolein emissions were greatest under the Preferred Alternative in some years. By 2050 these reductions ranged from a reduction of 9 percent for benzene (under Alternative 5) to an increase of 4 percent for 1,3-butadiene (under Alternative 4).
- Under the Preferred Alternative, emissions of all MSATs in 2040 are the same or reduced compared to emissions under the No Action Alternative. By 2050, emissions of 1,3-butadiene were reduced by less than 1 percent, emissions of acrolein by 1 percent, emissions of acetaldehyde by 1 percent, emissions of formaldehyde by 3 percent, emissions of DPM by 7 percent, and emissions of benzene by 8 percent.

Health and Monetized Health Benefits

- All action alternatives would generally result in reduced adverse health effects (mortality, acute bronchitis, emergency room visits for asthma, and work-loss days) nationwide compared with the No Action Alternative, with the same or increasing reductions from the least stringent (Alternative 2) to the most stringent (Alternative 5) alternatives, with the exception of Alternative 4 in some analysis years.
- Estimated monetized health benefits in 2040 range from $2.3 to $17.0 billion for all alternatives.
- Estimated monetized health benefits in 2040 range from $2.3 to $5.8 billion under Alternative 2, $5.6 to $13.9 billion under the Preferred Alternative, $5.1 to $12.6 billion under Alternative 4, and $6.8 to $17.0 billion under Alternative 5.

See Section 4.2.2 of this EIS for cumulative impacts data on criteria and hazardous air pollutant emissions and the monetized health benefits for the alternatives.

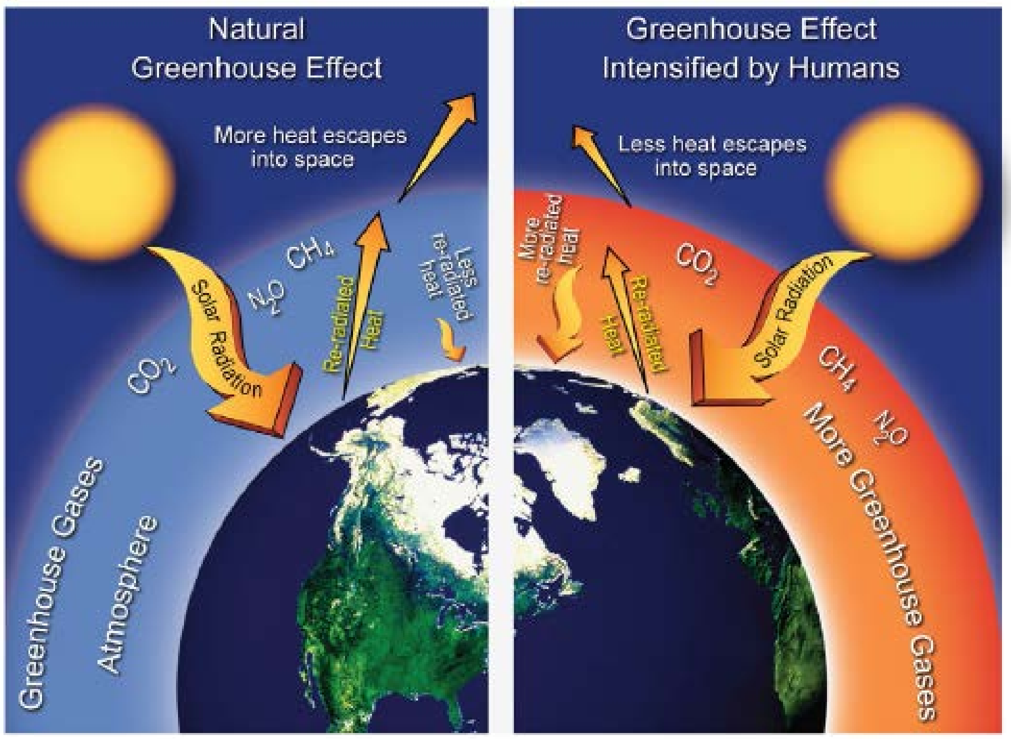
Figure S-5. Nationwide Toxic Air Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Cumulative Impacts



Climate

Earth absorbs heat energy from the sun and returns most of this heat to space as terrestrial infrared radiation. GHGs trap heat in the lower atmosphere (the atmosphere extending from Earth's surface to approximately 4 to 12 miles above the surface) by absorbing heat energy emitted by Earth's surface and lower atmosphere, and reradiating much of it back to Earth's surface, thereby causing warming. This process, known as the *greenhouse effect*, is responsible for maintaining surface temperatures that are warm enough to sustain life. Most GHGs, including CO_2, methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone, occur naturally. Human activities, particularly fossil-fuel combustion, lead to the presence of increased concentrations of GHGs in the atmosphere, thereby intensifying the warming associated with the Earth's greenhouse effect (Figure S-6).

Figure S-6. Human Influence on the Greenhouse Effect



Source: GCRP (U.S. Global Change Research Program) 2014. Global Climate Change Impacts in the United States. 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. Washington, DC.

Since the industrial revolution, when fossil fuels began to be burned in increasing quantities, concentrations of GHGs in the atmosphere have increased. Atmospheric concentrations of CO_2 have increased by more than 40 percent since pre-industrial times, while the concentration of CH_4 is now 150 percent above pre-industrial levels. This buildup of GHGs in the atmosphere is changing the Earth's energy balance and causing the planet to warm, which in turn affects sea levels, precipitation patterns, cloud cover, ocean temperatures and currents, and other climatic conditions. Scientists refer to this phenomenon as "global climate change."

During the past century, Earth's surface temperature has risen by approximately 0.8 degree Celsius (°C) (1.4 degrees Fahrenheit [°F]), and sea levels have risen 19 centimeters (7.5 inches), with a rate of increase of approximately 3.2 millimeters (0.13 inch) per year from 1993 to 2010. These observed changes in the global climate are largely a result of GHG emissions from human activities. The United Nations Environment Programme and the World Meteorological Organization established Intergovernmental Panel on Climate Change (IPCC) has concluded that "[H]uman influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea-level rise, and in changes in some climate extremes…It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century."

Throughout this EIS, NHTSA has relied extensively on findings of the IPCC, U.S. Climate Change Science Program (CCSP), National Research Council (NRC), Arctic Council, U.S. Global Change Research Program (GCRP), and EPA. This discussion focuses heavily on the most recent thoroughly peer-reviewed and credible assessments of global and U.S. climate change. *See* Section 5.1 of this EIS for more detail.

Impacts of Climate Change

Climate change is expected to have a wide range of effects on temperature, sea level, precipitation patterns, and severe weather events, which in turn could affect human health and safety, infrastructure, food and water supplies, and natural ecosystems. For example:

- Impacts on freshwater resources could include changes in water demand such as significant increases in irrigation needs, water shortages, general variability in water supply, and increasing flood risk in response to flooding, drought, changes in snowpack and the timing of snow melt, changes in weather patterns, and saltwater intrusions from sea-level rise.
- Impacts on terrestrial and freshwater ecosystems could include shifts in the range and seasonal migration patterns of species, relative timing of species' life-cycle events, potential extinction of sensitive species that are unable to adapt to changing conditions, increases in the occurrence of forest fires and pest infestations, and changes in habitat productivity due to increased atmospheric concentrations of CO_2.
- Impacts on ocean systems, coastal, and low-lying areas could include the loss of coastal areas due to submersion and/or erosion, reduction in coral reefs and other key habitats thereby affecting the distribution, abundance, and productivity of many marine species, increased vulnerability of the built environment and associated economies to severe weather and storm surges, and increased salinization of estuaries and freshwater aquifers.
- Impacts on food, fiber, and forestry could include increasing tree mortality, forest ecosystem vulnerability, productivity losses in crops and livestock, and changes in the nutritional quality of pastures and grazelands in response to fire, insect infestations, increases in weeds, drought, disease outbreaks, and/or extreme weather events. Many marine fish species could migrate to deeper and/or colder water in response to rising ocean temperatures. Impacts on food, including yields, food processing, storage, and transportation, could affect food prices and food security globally.
- Impacts on rural and urban areas could include affecting water and energy supplies, wastewater and stormwater systems, transportation, telecommunications, provision of social services, agricultural incomes, and air quality. The impacts could be greater for vulnerable populations such as lower-income populations, the elderly, those with existing health conditions, and young children.

- Impacts on human health could include increased mortality and morbidity due to excessive heat, increases in respiratory conditions due to poor air quality and aeroallergens, increases in water and food-borne diseases, changes in the seasonal patterns of vector-borne diseases, and increases in malnutrition. The most disadvantaged groups such as children, elderly, sick, and low-income populations are especially vulnerable.
- Impacts on human security could include increased threats in response to adversely affected livelihoods, compromised cultures, increased and/or restricted migration, increased risk of armed conflicts, reduction in providing adequate essential services such as water and energy, and increased geopolitical rivalry.

Climate change has been projected to have a direct impact on stratospheric ozone recovery, although there are large elements of uncertainty within these projections.

In addition to its role as a GHG in the atmosphere, CO_2 is transferred from the atmosphere to water, plants, and soil. In water, CO_2 combines with water molecules to form carbonic acid. When CO_2 dissolves in seawater, a series of well-known chemical reactions begins that increases the concentration of hydrogen ions and makes seawater more acidic, which adversely affects corals and other marine life.

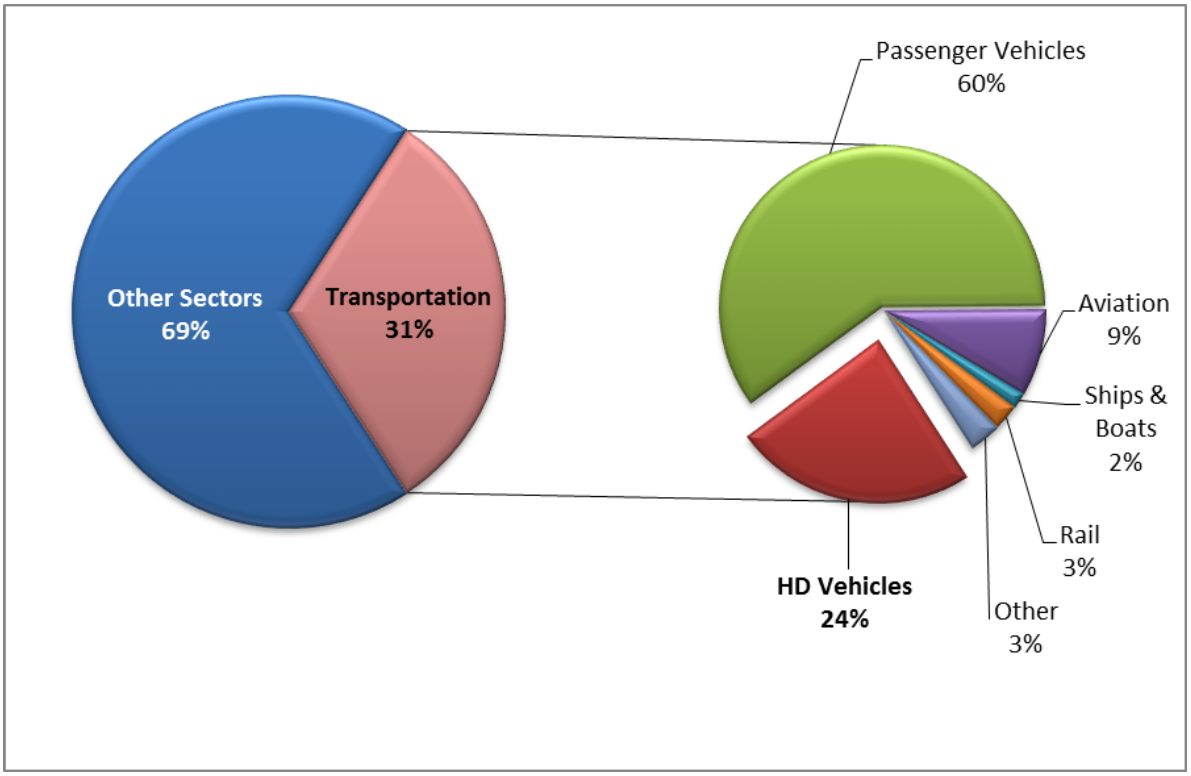
Increased concentrations of CO_2 in the atmosphere can also stimulate plant growth to some degree, a phenomenon known as the CO_2 fertilization effect. The available evidence indicates that different plants respond in different ways to enhanced CO_2 concentrations under varying climatic conditions.

Contribution of the U.S. Transportation Sector to U.S. and Global CO_2 Emissions

Contributions to the buildup of CO_2 and other GHGs in the atmosphere vary greatly from country to country and depend heavily on the level of industrial and economic activity. Emissions from the United States account for approximately 15.1 percent of total global CO_2 emissions (according to the World Resources Institute's Climate Analysis Indicators Tool).

As shown in Figure S-7, the U.S. transportation sector accounted for 31.3 percent of total U.S. CO_2 emissions in 2014, with HD vehicles accounting for 24.2 percent of total U.S. CO_2 emissions from transportation. Therefore, approximately 7.6 percent of total U.S. CO_2 emissions were from HD vehicles. These U.S. HD vehicles account for 1.1 percent of total global CO_2 emissions, based on the comprehensive global CO_2 emissions data available for 2012 (WRI 2016).

Figure S-7. Contribution of Transportation to U.S. CO_2 Emissions and Proportion Attributable by Mode, 2014



Source: EPA 2016c. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014. EPA 430-R-16-002.

Key Findings for Climate

The action alternatives would decrease the growth in global GHG emissions compared with the No Action Alternative, resulting in reductions in the anticipated increases in CO_2 concentrations, temperature, precipitation, and sea level that would otherwise occur. They would also, to a small degree, reduce the impacts and risks of climate change.

Under the No Action Alternative, total CO_2 emissions from HD vehicles in the United States will increase substantially between 2018 and 2100.[2] Growth in the number of HD vehicles in use throughout the United States, combined with assumed increases in their average use, is projected to result in growth in VMT. Because CO_2 emissions are a direct consequence of total fuel consumption, the same result is projected for total CO_2 emissions from HD vehicles.

NHTSA estimates that the action alternatives will reduce fuel consumption and CO_2 emissions compared with what they would be in the absence of the standards (i.e., fuel consumption and CO_2 emissions under the No Action Alternative) (Figure S-8).

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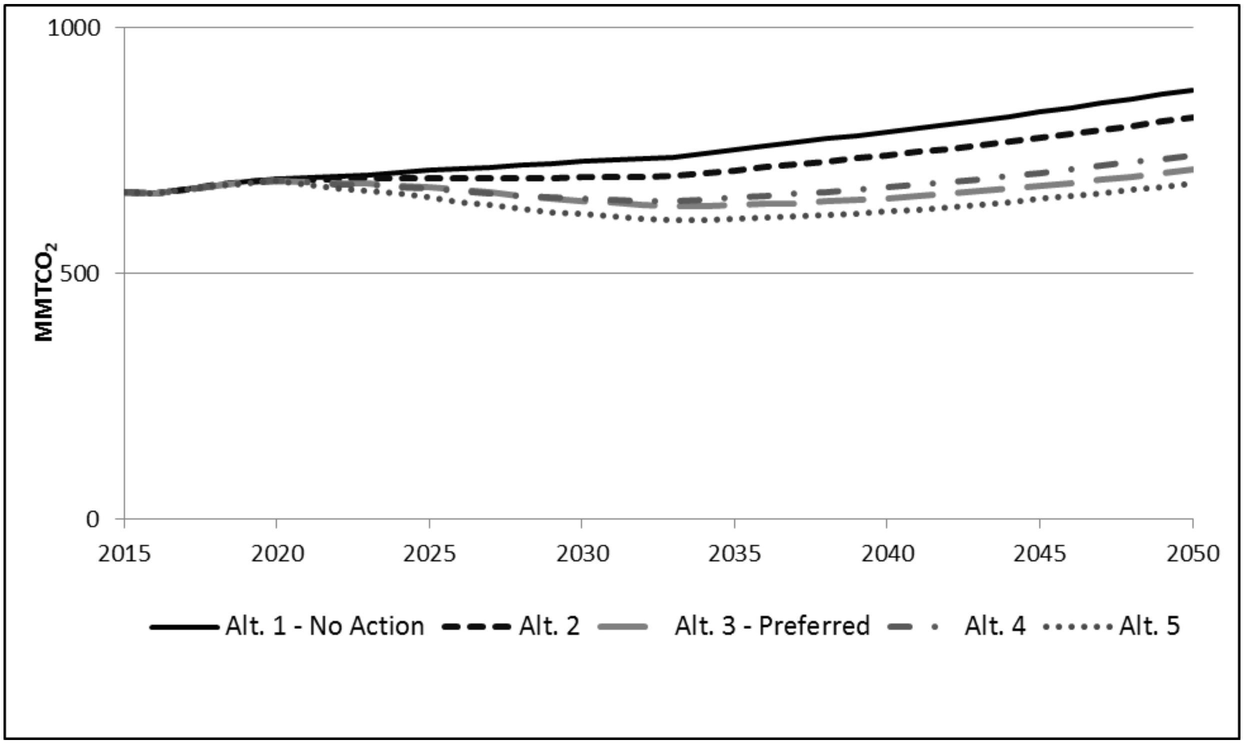
[2] Because CO_2 accounts for such a large fraction of total GHGs emitted during fuel production and use—more than 97 percent, even after accounting for the higher GWPs of other GHGs—NHTSA's consideration of GHG impacts focuses on reductions in CO_2 emissions expected under the action alternatives.

Figure S-8. Projected Annual CO_2 Emissions ($MMTCO_2$) from All HD Vehicles by Alternative, Direct and Indirect Impacts



The global emissions scenario used in the cumulative impacts analysis (and described in Chapter 5 of this EIS) differs from the global emissions scenario used for climate change modeling of direct and indirect impacts. In the cumulative impacts analysis, the Reference Case global emissions scenario used in the climate modeling analysis reflects reasonably foreseeable actions in global climate change policy; in contrast, the global emissions scenario used for the analysis of direct and indirect impacts assumes that no significant global controls on GHG emissions will be adopted. *See* Section 5.3.3.3.2 of the EIS for more explanation of the cumulative impacts methodology.

Estimates of GHG emissions and reductions (direct and indirect impacts and cumulative impacts) are presented below for each of the five alternatives. Key climate effects, such as mean global increase in surface temperature and sea-level rise, which result from changes in GHG emissions, are also presented for each of the five alternatives. These effects are typically modeled to 2100 or longer because of the amount of time required for the climate system to show the effects of the GHG emissions reductions. This inertia reflects primarily the amount of time required for the ocean to warm in response to increased radiative forcing.

The impacts of the action alternatives on global mean surface temperature, precipitation, or sea-level rise are small in relation to the expected changes associated with the emissions trajectories that assume that no significant global controls on GHG emissions are adopted. This is because of the global and multi-sectoral nature of the climate problem. Although these effects are small, they occur on a global scale and are long lasting; therefore, in aggregate, they can have large consequences for health and welfare and can make an important contribution to reducing the risks associated with climate change.

Direct and Indirect Impacts

Greenhouse Gas Emissions

- HD vehicles are projected to emit 67,500 million metric tons of carbon dioxide ($MMTCO_2$) in the period 2018–2100 under the No Action Alternative. Alternative 2 would reduce these emissions by 6 percent by 2100, the Preferred Alternative by 16 percent, Alternative 4 by 13 percent, and Alternative 5 by 19 percent. Figure S-8 shows projected annual CO_2 emissions from HD vehicles under each alternative. As shown in the figure, emissions are highest under the No Action Alternative, while Alternatives 2 through 5 show increasing reductions in emissions compared with emissions under the No Action Alternative (with the exception of Alternative 4, which would have lower emissions reductions than the Preferred Alternative for certain analysis years).
- Compared with total projected CO_2 emissions of 801 $MMTCO_2$ from all HD vehicles under the No Action Alternative in 2100, the action alternatives are expected to reduce CO_2 emissions from HD vehicles in 2100 by 6 percent under Alternative 2, 18 percent under the Preferred Alternative, 15 percent under Alternative 4, and 22 percent under Alternative 5.
- Compared with total global CO_2 emissions from all sources of 5,063,078 $MMTCO_2$ under the No Action Alternative from 2018 through 2100, the action alternatives are expected to reduce global CO_2 emissions between 0.1 and 0.3 percent by 2100.

The emissions reductions in 2025 under each of the action alternatives compared with emissions under the No Action Alternative are approximately equivalent to the annual emissions from 0.5 million HD vehicles under Alternative 2, 1.1 million HD vehicles under the Preferred Alternative, 1.2 million HD vehicles under Alternative 4, and 1.8 million HD vehicles under Alternative 5.

CO_2 Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation

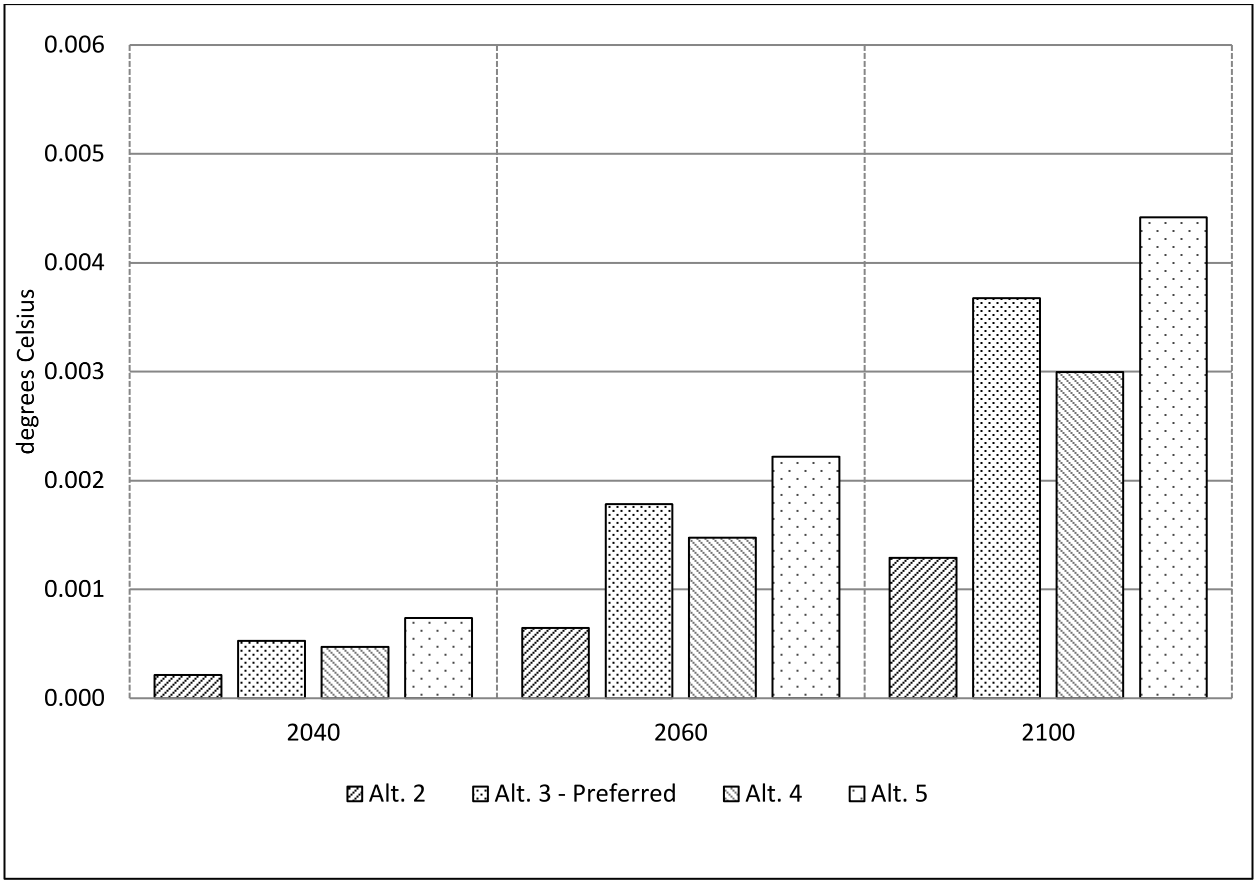
CO_2 emissions affect the concentration of CO_2 in the atmosphere, which in turn affects global temperature, sea level, and precipitation patterns. For the analysis of direct and indirect impacts, NHTSA used the Global Change Assessment Model Reference scenario (*see* Section 5.3.3.3.1 of this EIS for more details) to represent the Reference Case emissions scenario (i.e., future global emissions assuming no additional climate policy).

- Estimated CO_2 concentrations in the atmosphere for 2100 would range from 788.0 parts per million (ppm) under Alternative 5 to approximately 789.1 ppm under the No Action Alternative, indicating a maximum atmospheric CO_2 reduction of approximately 1.1 ppm compared to the No Action Alternative. The Preferred Alternative would reduce global CO_2 concentrations by approximately 1.0 ppm from CO_2 concentrations under the No Action Alternative.
- Global mean surface temperature is anticipated to increase by approximately 3.48°C (6.27°F) under the No Action Alternative by 2100. Implementing the most stringent alternative (Alternative 5) would reduce this projected temperature increase by 0.004°C (0.008°F), while implementing the least stringent alternative (Alternative 2) would reduce projected temperature increase by up to 0.001°C (0.002°F). The Preferred Alternative would decrease projected temperature increase under the No Action Alternative by 0.004°C (0.008°F). Figure S-9 shows the reduction in projected global

mean surface temperature under each action alternative compared with temperatures under the No Action Alternative.

- Projected sea-level rise in 2100 ranges from a high of 76.28 centimeters (30.03 inches) under the No Action Alternative to a low of 76.19 centimeters (30.00 inches) under Alternative 5. Therefore, the most stringent alternative would result in a maximum reduction in sea-level rise equal to 0.09 centimeter (0.03 inch) by 2100 compared with the level projected under the No Action Alternative. Sea-level rise under the Preferred Alternative would be reduced by 0.07 centimeter (0.03 inch) compared with the No Action Alternative.
- Global mean precipitation is anticipated to increase by 5.85 percent by 2100 under the No Action Alternative. Under the action alternatives, this increase in precipitation would be reduced by less than 0.01 percent.

Figure S-9. Reduction in Global Mean Surface Temperature Compared with the No Action Alternative, Direct and Indirect Impacts

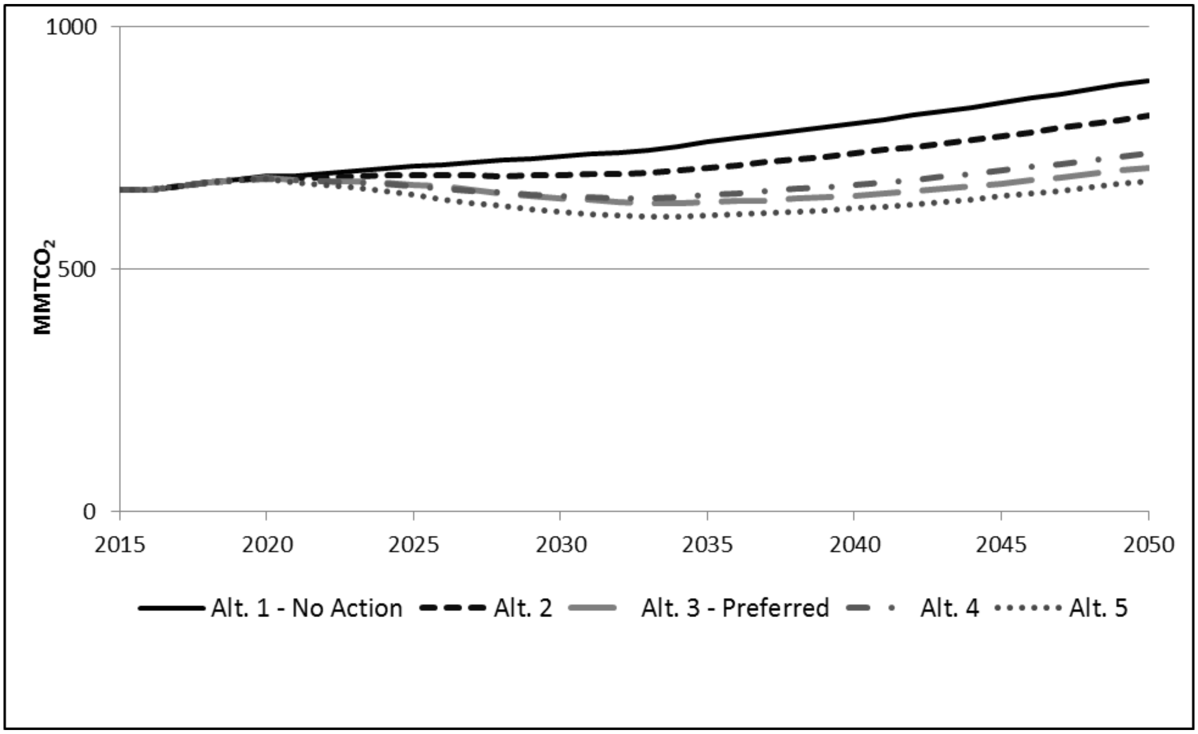


Cumulative Impacts

Greenhouse Gas Emissions

- Projections of total emissions reductions over the 2018–2100 period under the action alternatives and other reasonably foreseeable future actions (i.e., forecast HD vehicle fuel efficiency increases resulting from market-driven demand) compared with the No Action Alternative range from 5,000 $MMTCO_2$ (under Alternative 2) to 14,200 $MMTCO_2$ (under Alternative 5). Falling between these two extremes, the Preferred Alternative would reduce emissions by 12,100 $MMTCO_2$. The action alternatives would reduce total HD vehicle emissions by between 7 percent (under Alternative 2) and 21 percent (under Alternative 5) by 2100. Again falling between these two extremes, the Preferred Alternative would reduce total HD vehicle emissions by 18 percent by 2100. Figure S-10 shows projected annual CO_2 emissions from HD vehicles by alternative compared with the No Action Alternative.
- Compared with projected total global CO_2 emissions of 4,154,831 $MMTCO_2$ from all sources from 2018–2100, the incremental impact of this rulemaking is expected to reduce global CO_2 emissions between 0.1 and 0.3 percent by 2100.

Figure S-10. Projected Annual CO_2 Emissions ($MMTCO_2$) from HD Vehicles by Alternative, Cumulative Impacts

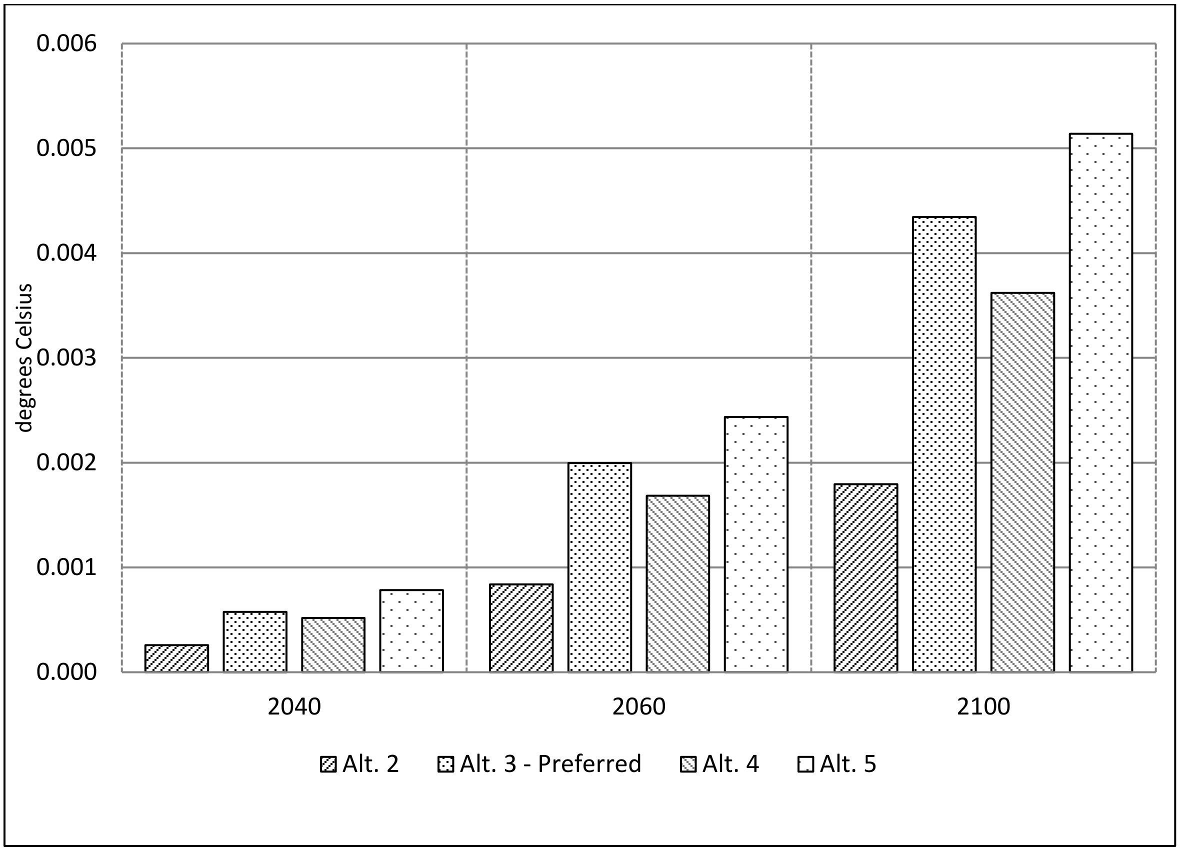


CO$_2$ Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation

- Estimated atmospheric CO$_2$ concentrations in 2100 range from a low of 686.1 ppm under Alternative 5 to a high of 687.3 ppm under the No Action Alternative. The Preferred Alternative would result in CO$_2$ concentrations of 686.3 ppm, a reduction of 1.0 ppm compared with the No Action Alternative.
- The reduction in global mean temperature increase for the action alternatives compared with the No Action Alternative in 2100 ranges from a low of 0.002°C (0.004°F) under Alternative 2 to a high of 0.005°C (0.009°F) under Alternative 5. The Preferred Alternative would result in a reduction of 0.004°C (0.007°F) from the projected temperature increase of 2.838°C (5.108°F) under the No Action Alternative. Figure S-11 illustrates the reductions in the increase in global mean temperature under each action alternative compared with the No Action Alternative.
- Projected sea-level rise in 2100 ranges from a high of 70.22 centimeters (27.65 inches) under the No Action Alternative to a low of 70.12 centimeters (27.61 inches) under Alternative 5, indicating a maximum reduction of sea-level rise equal to 0.10 centimeter (0.04 inch) by 2100 from the level that could occur under the No Action Alternative. Sea-level rise under the Preferred Alternative would be 70.14 centimeters (27.62 inches), a 0.09-centimeter (0.04-inch) reduction compared with the No Action Alternative.

See Section 5.4 of this EIS for more details about direct, indirect, and cumulative impacts on climate.

Figure S-11. Reduction in Global Mean Surface Temperature Compared with the No Action Alternative, Cumulative Impacts



Health, Societal, and Environmental Impacts of Climate Change

The action alternatives would reduce the impacts of climate change that would otherwise occur under the No Action Alternative. The magnitude of the changes in climate effects that would be produced by the most stringent action alternative (Alternative 5) by the year 2100 is roughly 1.2 ppm less CO_2, a few thousandths of a degree difference in temperature increase, a small percentage change in the rate of precipitation increase, and about 1 millimeter (0.03 inch) of sea-level rise. Although the projected reductions in CO_2 and climate effects are small compared with total projected future climate change, they are quantifiable and directionally consistent and would represent an important contribution to reducing the risks associated with climate change. Although NHTSA does quantify the reductions in monetized damages that can be attributable to each action alternative (in the social cost of carbon analysis), many specific impacts on health, society, and the environment cannot be estimated quantitatively. Therefore, NHTSA provides a detailed discussion of the impacts of climate change on various resource sectors in Section 5.5 of the EIS. Section 5.6 discusses the changes in non-climate impacts (such as ocean acidification by CO_2) associated with the alternatives.

TTMA
TRUCK TRAILER Manufacturers Association
TTMAnet.org Since 1941

Jeffrey M. Sims • President
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April 3, 2017

Scott Pruitt, Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Elaine L. Chao, Secretary
US Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

Re: Request to Reconsider and Stay Phase 2 GHG and Fuel Efficiency Standards for Truck Trailers

Dear Administrator Pruitt and Secretary Chao:

I am writing to request your immediate intervention to resolve a pending petition filed by the Truck Trailer Manufacturers Association (TTMA) in the US Court of Appeals for the District of Columbia Circuit to review the greenhouse gas fuel economy standards for heavy-duty truck trailers. TTMA's members manufacture nearly all of the heavy-duty truck trailers sold and operated in the United States. We represent over 70 trailer manufacturers with offices and plants located in over 33 states. Most of these manufacturing companies are closely-held, family-owned businesses. Our members' customers comprise cargo shippers and motor carrier fleets, large and small, as well as independent owner-operators, who together move nearly all of the nation's commercial truck freight.

The new greenhouse gas standards unlawfully treat trailers as "motor vehicles" and unwisely mandate installation of aerodynamic equipment on the vast majority of trailers, regardless of actual use. Because the industry already installs this equipment in those uses where it saves fuel, the standards will substantially burden the motor carrier industry and produce little or no additional greenhouse gas or fuel economy gain. Moreover, we believe that the President's March 28, 2017 Executive Order requiring review and, as appropriate, suspension, revision or rescission of actions arising from President Obama's June 2013 Climate Action plan directly applies to these standards. We therefore ask that EPA and NHTSA review, reconsider and begin a process to rescind these standards. We further ask EPA and NHTSA to take steps to suspend or stay the effectiveness of the standards in the interim, due to the burden of imminent steps that trailer manufacturers otherwise must take to comply. We ask to meet with you or your designees at your earliest convenience to address this matter, which is urgent for our members, their employees and customers.

* * *

1. *The Standards*. On October 25, 2016, EPA and NHTSA promulgated "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (GHGP2), which the agencies expressly described as having been "called for" in the 2013 Climate Action Plan. 81 Fed. Reg. 73,478, 73,480 (Oct. 25, 2016). Beginning with 2018 trailer production, the new GHGP2 standards will mandate installation of side skirts, trailer tails, low-rolling resistance tires and tire monitoring/inflation systems on most trailers manufactured and sold in the United States by TTMA's members. Trailer manufacturers must install and sell this equipment even if the trucking operations of their customers will not achieve any fuel economy benefits (such as circumstances in which the trailers will not be hauled over long distances at highway speeds sufficient to produce any benefits).

2. *Petition for Review and Deficiencies in Rule*. On December 22, 2016, TTMA petitioned for review of the trailer standards in the United States Court of Appeals for the District of Columbia Circuit (Case No. 16-1430). TTMA intends to raise several objections to the rule:

The agencies lack statutory authority. EPA's authority under the Clean Air Act to set standards for mobile sources is limited to engines and "motor vehicles," defined in the statute to mean "self-propelled vehicle[s] designed for transporting persons or property on a street or highway." 42 U.S.C. § 7550(2). Trailers are not self-propelled. Trailers are not equipped with engines that provide the power needed to transport cargo and thereby consume fuel or cause air emissions. EPA's contention that trailers are part of the motor vehicle tractor-trailer combination makes no sense. Tractors and trailers are manufactured and sold separately by different sets of manufacturers to customer populations that are not the same; a single trailer is likely to be hauled by multiple tractors during its lifetime and, conversely, a single tractor is likely to haul multiple trailers. Moreover, in the nearly fifty years since EPA has been regulating emissions from heavy-duty engines and trucks, it has never treated the trailer as part of a truck so as to fall within the definition of "motor vehicle," and there is no evidence Congress ever intended such a result. Likewise, NHTSA lacks statutory authority. Its governing authority for fuel economy standards, the Energy Independence and Security Act (EISA), also does not define heavy-duty "vehicle" to include a trailer. In the rulemaking, NHTSA has erroneously relied instead on definitions in the Motor Vehicle Safety Act, which separately authorizes NHTSA to adopt safety regulations but does not address fuel efficiency or emissions of any kind. *See* 49 U.S.C. § 30101.

The standards are arbitrary and capricious. The GHGP2 standards for trailers, if implemented, will do little to reduce greenhouse gas emissions or improve fuel economy. TTMA members and the trucking industry already participate extensively in EPA's voluntary Smartway program to develop and incorporate aerodynamic equipment in trailers where there are benefits from doing so. This is particularly true for trailers hauled regularly over long distances at highway speeds, where aerodynamic efficiency makes a measurable difference. But aerodynamic devices such as side skirts and trailer tails also add significant weight to trailers and thus are counterproductive in multiple short-run operations and at lower speeds (where most of the trailers' moving time occurs). In lower speed operations, aerodynamic efficiency is not achieved and the equipment is only counter-productive dead weight. EPA and NHTSA erroneously assumed in the rulemaking that tractor-trailers, on average, operate near highway speeds most of the time. Moreover, heavy-duty trucks are subject to an 80,000-pound maximum combined weight limit for tractor, trailer and cargo. Because the GHGP2 rule will mandate aerodynamic equipment on trailers, trucking companies who already haul loads that are at or near this limit in order to maximize efficiency will have to reduce the cargo in each load and haul the excess on additional trailers. The result will be more (and heavier) tractor-trailers on the nation's highways to haul the same total amount of freight. In addition to the costs of the aerodynamic equipment, this will add more trucks burning more fuel with more emissions, especially in low-speed service for which the additional equipment has no material benefits. It will also result in more accidents and more injuries and fatalities involving tractor-trailers, which is contrary to NHTSA's primary mission under the Motor Vehicle Safety Act. 81 Fed Reg. at 73,642.

3. *The Executive Order Requires Review, Reconsideration and Rescission*. Section 3(d) of President Trump's March 28, 2017 Executive Order mandates that all agencies review and identify actions that are related to or arose from President Obama's June 2013 Climate Action Plan. As noted above, the GHGP2 rule, including the trailer standards, are clearly within the scope of this Order. The Order further directs that each agency shall, as soon as practicable, publish for notice and comment proposed rules suspending, revising, or rescinding any such actions, as appropriate and consistent with law and the policies stated in Section 1 of the Order. The Order states in its very first sentence as policy to avoid regulatory burdens that unnecessarily constrain economic growth and prevent job creation. Section 1 goes on to elaborate as policy that environmental regulations must comply with the law, have greater benefits than costs, and rely on the best available peer-reviewed science and economics. For the reasons described above, the trailer requirements in the GHGP2 rule conflict with these policies.

Furthermore, we note that in seeking to justify the costs as outweighing the benefits of the GHGP2 rule, EPA relied on the Obama Administration's "social cost of carbon." *See* 81 Fed. Reg. at 73,875 (explaining that the agencies "estimate the global social benefits of CO_2 emission reductions expected from the heavy-duty GHG and fuel efficiency standards using the social cost of carbon"). The March 28 Executive Order directed that the prior Administration's social cost of carbon analyses be withdrawn, and that, effective immediately, agencies shall ensure that estimates used in valuing the GHG impacts of regulations be consistent with OMB Circular A-4 (Sept. 17, 2003). The Order specifically directed that this include the approach to considering domestic versus international impacts and the consideration of the appropriate discount rates. Accordingly, the Order directs a new approach, effective immediately, that is different from and in conflict with the approach EPA used to justify the GHGP2 standards, which the Order makes clear is "no longer representative of government policy." Not only does this constitute a further policy reason to revisit the trailer requirements, but it constitutes centrally relevant new information warranting reconsideration of the rule under Section 307(d)(7)(B) of the Clean Air Act, 42 U.S.C. § 7607(d)(7)(B).

4. *EPA Action is Urgent to Avoid Substantial Economic Impacts*. As anticipated in the directive of Section 3(d) of the Executive Order that the agencies take action "as soon as practicable," this matter is of great time sensitivity to TTMA's members. Although the GHGP2 standards apply to trailers manufactured after January 1, 2018, the standards will have costly impacts on trailer manufacturers in the latter half of 2017. The manufacturers will soon have to quote and commit in advance to trailer orders for production in 2018, and they will soon begin incurring substantial expenditures for parts inventory and for reconfiguring manufacturing plants and assembly lines to enable installation of the required devices. These are, in many cases, small- to medium-sized businesses throughout the country who can ill afford the unnecessary burdens of these standards, which will impact them, their employees, customers and the economy at large.

TTMA would like to meet with you or your designees to seek an immediate path to reconsideration of the GHGP2 trailer requirements and an approach to stay the effectiveness of the rule in the interim to avoid the burden and disruption of imminent steps to comply. We very much appreciate your attention to this important matter and your consideration of our requests on an expedited basis.

Sincerely,

Jeffy Sims

Jeff Sims, President

ARNOLD & PORTER
KAYE SCHOLER

Jonathan S. Martel
+1 202.942.5470 Direct
Jonathan.Martel@apks.com

June 26, 2017

VIA EMAIL AND U.S. MAIL

Mr. Scott Pruitt, Administrator
Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Mail Code: 1101A
Washington, DC 20460

Mr. Jack Danielson, Acting Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Ave., S.E.
Washington, DC 20590

Re: Truck Trailer Manufacturers Association Petition for Reconsideration and Stay of GHG and Fuel Efficiency Standards -- Docket No. EPA-HQ-OAR-2014-0827

Dear Administrator Pruitt and Acting Deputy Administrator Danielson:

Enclosed please find the Truck Trailer Manufacturer Association's supplemental petition for reconsideration and a stay of the EPA and NHTSA final rule titled "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2." A copy of this petition has been electronically mailed to the Office of Air and Radiation Docket Center for filing in Docket No. EPA-HQ-OAR-2014-0827 and has been mailed to NHTSA's Docket Operations office for filing in Docket No. NHTSA-2014-0132.

Please contact me if you have any questions.

Sincerely,

Jonathan S. Martel

Enclosure

Docket No.: EPA-HQ-OAR-2014-0827; NHTSA-2014-0132

BEFORE THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

In re: Greenhouse Gas Emissions }
and Fuel Efficiency Standards for }
Medium- and Heavy-Duty Engines }
and Vehicles - Phase 2 }
__________________________________}

SUPPLEMENT TO PETITION FOR RECONSIDERATION AND STAY

Pursuant to Section 307(d)(7)(B) of the Clean Air Act ("CAA")[1] and Sections 553 and 705 of the Administrative Procedure Act ("APA"),[2] the Truck Trailer Manufacturers Association, Inc. ("TTMA") hereby supplements its April 3, 2017 request[3] that the U.S. Environmental Protection Agency ("EPA") and National Highway Traffic Safety Administration ("NHTSA") (collectively, the "Agencies") reconsider and rescind the greenhouse gas ("GHG") and fuel economy standards applicable to heavy-duty truck trailers, as promulgated in the final rule entitled *Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2*, 81 Fed. Reg. 73,478 (Oct. 25, 2016) ("Final Rule"). TTMA further requests in the interim that EPA stay the implementation date of the new GHG standards applicable to trailers, currently set for January 1, 2018.

This is the first time that EPA and NHTSA have sought to impose emissions and fuel economy standards on trailers, which by design are pulled by another vehicle and therefore emit no GHGs and consume no fuel. The Agencies should rescind these standards for the simple reason that they lack legal authority to adopt such standards. The Clean Air Act authorizes EPA to regulate "motor vehicles," expressly defined as vehicles that are "self-propelled." A trailer is not self-propelled. The rationale EPA offered in the Final Rule—that trailers may be regulated as "incomplete vehicles"— reads the definition of "motor vehicle" out of the statute. A "motor vehicle" that is "incomplete" because it is not "self-propelled" and requires a tractor to pull it is not a motor vehicle. Likewise, the Energy Independence and Security Act extends NHTSA's fuel economy regulatory authority to "commercial medium- and heavy-duty on-highway vehicle[s]," defined to mean "an on-highway vehicle with a GVWR of 10,000 lbs or more." GVWR, or gross *vehicle* weight rating, is the maximum load that can be carried by a vehicle,

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[1] 42 U.S.C. § 7407.

[2] 5 U.S.C. §§ 553(e), 705.

[3] On April 3, 2017, TTMA sent a letter to EPA Administrator Scott Pruitt and Department of Transportation ("DOT") Secretary Elaine Chao requesting that the Agencies reconsider and rescind the GHG standards applicable to trailers. TTMA resubmitted the April 3 letter to EPA on April 13, 2017 in response to EPA's Request for Comment on regulations that may be appropriate for repeal, replacement, or modification under Executive Order 13777, "Enforcing the Regulatory Reform Agenda." *See* 82 Fed. Reg. 17,793 (Apr. 13, 2017). On June 1, 2017, TTMA sent a similar request to Jeffrey Rosen, DOT Regulatory Reform Officer, following his appointment to the position of Chairman of the DOT Regulatory Reform Task Force.

including the weight of the vehicle. Heavy-duty vehicles also have a gross *combined* weight rating (GCWR), which describes the maximum load that the vehicle can haul, including the weight of a loaded trailer. The vehicles subject to NHTSA's fuel economy authority, defined by reference to GVWR, therefore exclude trailers, and TTMA fully anticipates that the D.C. Circuit would reject a theory that allows administrative agencies unilaterally to expand their regulatory reach to products that Congress expressly excluded from regulation. Beyond that, the trailer standards are arbitrary and capricious. The Agencies employed unrealistic assumptions about the speeds that trailers hauled by heavy-duty tractors travel. In addition, the Agencies failed properly to account for the additional weight of aerodynamic devices that in many circumstances would *increase* fuel consumption and also displace cargo, which would result in more trips and more emissions. Those additional trips also translate into more injuries and fatalities on U.S. roads in order to achieve negligible if any global climate benefits.

In short, the Agencies have offered a rationale that is unsupported by the statutory language and that vastly expands their regulatory reach to products that are not encompassed in the enabling statutes and that have never been subject to air pollution, GHG or fuel economy regulation before. The regulations that the Agencies have imposed will have irreparable and immediate harmful effects on the trailer manufacturing members of TTMA. Reconsideration and a stay are therefore warranted.

BACKGROUND

In October 2016, the Agencies promulgated a Final Rule establishing "Phase 2" GHG and fuel economy standards for on-road medium- and heavy-duty vehicles and engines. *See* 81 Fed. Reg. 73,478 (Oct. 25, 2016). The Final Rule includes standards applicable to a range of heavy-duty vehicles and engines, including combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles. *Id.* at 73,478. As relevant here, however, the Final Rule also includes, for the first time, GHG and fuel economy standards that apply directly to *trailers* that are hauled by heavy-duty tractors. *Id.* at 73,642 ("The HD Phase 2 program represents the first time CO_2 emission and fuel consumption standards have been established for manufacturers of new trailers."). Prior to the Final Rule, neither EPA nor NHTSA regulated the GHG and fuel economy impacts of trailers, instead relying on voluntary programs (such as EPA's SmartWay Program) and market incentives to encourage manufacturers to adopt aerodynamic and other technologies that, under limited operating conditions, can reduce GHG emissions and improve fuel economy from tractors when hauling trailers equipped with these technologies.

A. The Trailer Standards and EPA Compliance Program

The new GHG and fuel economy standards mandate that certain types of trailers manufactured after January 1, 2018 (in the case of the EPA GHG standards)[4] or January 1, 2021

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[4] *See* 81 Fed. Reg. at 74,049; 40 C.F.R. § 1037.5(h)(4). Qualifying "small manufacturers," defined to include manufacturers with fewer than 1,000 employees, are not subject to the GHG manufacturing standards until January 1, 2019, although they still must register with EPA and label as "exempt" all trailers manufactured in 2018. 81 Fed. Reg. at 74,059; 40 C.F.R. § 1037.150(c).

(in the case of the NHTSA fuel economy standards)[5] comply with specified emission limits. These emission limits are expressed in grams of carbon dioxide ("CO_2") per ton-mile[6] and gallons per 1,000 ton-miles for the GHG and fuel economy standards, respectively.[7] Of course, trailers do not themselves emit CO_2 or consume fuel for propulsion. Thus, the Final Rule requires manufacturers to calculate estimated CO_2 emissions levels and fuel consumption rates using a "compliance equation" that is specified in the regulations.[8] According to the Agencies, this compliance equation was developed using "standard" reference tractors and thus "the regulatory standards refer to the simulated emissions and fuel consumption of a standard tractor pulling the trailer being certified."[9] To meet the new emission standards, trailer manufacturers must install aerodynamic devices (such as side skirts and trailer tails), low-rolling resistance tires and automatic tire inflation systems. Depending on specific trailer designs, and as the standards tighten over time under the regulations, trailer manufacturers may also be forced to utilize lightweight materials. All of these options are assigned inputs to the compliance equation.[10]

Trailer manufacturers must perform several steps in advance of 2018 to ensure that their trailers manufactured after January 1, 2018 comply with the new EPA GHG standards. In particular, trailer manufacturers must register on-line with the EPA Verify access system, obtain a manufacturer code, and develop and submit applications for certificates of conformity,[11] although the EPA has not yet developed or implemented the procedures that allow manufacturers to make these applications and does not expect to do so until roughly the end of the summer. These steps require manufacturers to assess their trailer model lines and make plans for incorporating the mandated equipment (side skirts, trailer tails, low-rolling resistance tires, automatic tire inflation and tire pressure monitoring systems, etc.) into projected customer orders. Manufacturers also must evaluate, and in some cases test, the equipment to be installed to determine the applicable inputs for the compliance equation used to calculate GHG emissions and fuel consumption for various trailer types and configurations.[12] They must project sales for 2018 and obtain a certificate of conformity from EPA before selling any Model 2018 trailers, and then they must negotiate or re-negotiate sales orders and complete custom engineering for those trailers to incorporate the necessary equipment even if their customers would not otherwise purchase it. The manufacturers must acquire GHG inventory, train employees, and re-configure

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[5] *See* 81 Fed. Reg. at 74,238; 49 C.F.R. 535.3(d)(5)(iv) (NHTSA standards go into effect January 1, 2021 and are voluntary for model years 2018 through 2020).

[6] *See* 81 Fed. Reg. at 74,054; 40 C.F.R. § 1037.107.

[7] *See* 81 Fed. Reg. at 74,255; 49 C.F.R. § 535.5(e).

[8] *See* 81 Fed. Reg. at 74,073, 74259; 40 C.F.R. § 1037.515(a)(1); 49 C.F.R. § 535.6(e).

[9] 81 Fed. Reg. at 73,647.

[10] Under the EPA rules, for model years through 2026, trailer manufacturers may designate a limited number of trailers as exempt from the standards and certification requirements. *See* 81 Fed. Reg. at 74,060; 40 C.F.R. § 1037.150(v). As a practical matter, however, nearly all trailers will be required to meet the new GHG standards starting in 2018 (or 2019 for "small" manufacturers).

[11] *See* 81 Fed. Reg. at 74,062; 40 C.F.R. § 1037.205.

[12] *See, e.g.*, 81 Fed. Reg. at 74,081; 40 C.F.R. § 1037.526.

assembly lines to enable production, and they must develop data collection and reporting systems to ensure compliance. Trailer manufacturers would not have to incur these costs and disruptions in customer relations and manufacturing processes but for the GHG standards for trailers.

B. TTMA Petition for Review and Correspondence with the Agencies

On December 22, 2016, TTMA filed a petition for review of the Final Rule in the U.S. Court of Appeals for the D.C. Circuit on the grounds that (1) the Agencies lack statutory authority to regulate trailers with respect to GHG emissions and fuel consumption, and (2) the Final Rule, as applied to trailers, is arbitrary and capricious because, among other reasons, the Agencies utilized unrealistic assumptions in their cost/benefit analysis and failed properly to account for the additional weight and cost of aerodynamic devices, which increase fuel consumption and displace cargo, thereby resulting in more trips, more emissions, and more accidents. *See Truck Trailer Manufacturers Association v. EPA, et al.*, No. 16-1430. That litigation is pending and, as of the date of this Petition, no briefing schedule has been set.

On April 3, 2017, TTMA sent a letter to EPA Administrator Scott Pruitt and Department of Transportation ("DOT") Secretary Elaine Chao requesting that the Agencies reconsider and rescind the Phase 2 GHG and fuel economy standards applicable to trailers. TTMA resubmitted the April 3 letter to EPA on April 13, 2017 in response to EPA's Request for Comment on regulations that may be appropriate for repeal, replacement, or modification under Executive Order 13777, "Enforcing the Regulatory Reform Agenda." *See* 82 Fed. Reg. 17,793 (Apr. 13, 2017). In light of TTMA's request, the Agencies moved for a 90-day abeyance of the D.C. Circuit litigation, which the Court granted on May 8, 2017.

ISSUES MERITING RECONSIDERATION

EPA and NHTSA should reconsider the Final Rule; in fact, they are required to do so. On March 28, 2017, President Trump issued Executive Order 13777 on Promoting Energy Independence and Economic Growth. Section 3(d) of the Executive Order mandates that all agencies review and identify actions that are related to or arose from President Obama's June 2013 Climate Action Plan. The GHG and fuel economy trailer standards contained in the Final Rule are clearly within the scope of this Order, because the Final Rule is related to and arose from the 2013 Climate Action Plan. *See* Executive Office of the President, *The President's Climate Action Plan* at 8 (June 2013) (addressing increased fuel economy standards for heavy-duty vehicles); *see also* 81 Fed. Reg. at 73,480 (describing the Final Rule as having been "called for" in the 2013 Climate Action Plan). The Executive Order further directs that each agency shall, as soon as practicable, publish for notice and comment proposed rules suspending, revising, or rescinding any such actions, as appropriate and consistent with law and the policies stated in Section 1 of the Order. The Order states in its very first sentence a policy to avoid regulatory burdens that unnecessarily constrain economic growth and prevent job creation. Section 1 goes on to elaborate as policy that environmental regulations must comply with the law, have greater benefits than costs, and rely on the best available peer-reviewed science and economics. For the reasons summarized above and detailed below, the trailer requirements in the Final Rule are unlawful and conflict with these policies.

Furthermore, in seeking to justify the costs as outweighing the benefits of the Final Rule, the Agencies relied on the Obama Administration's "social cost of carbon." *See* 81 Fed. Reg. at 73875 (explaining that the Agencies "estimate the global social benefits of CO_2 emission reductions expected from the heavy-duty GHG and fuel efficiency standards using the social cost of carbon"). The March 28 Executive Order directed that the prior Administration's social cost of carbon analyses be withdrawn, and that, effective immediately, agencies shall ensure that estimates used in valuing the GHG impacts of regulations be consistent with OMB Circular A-4 (Sept. 17, 2003). The Order specifically directed that this include considering the societal benefits of reducing carbon in the United States but not the rest of the world, and a different approach to considering the appropriate discount rates. Accordingly, the Order directs a new approach, effective immediately, that is different from and in conflict with the approach the Agencies used to justify the Final Rule, including the trailer standards. The Order makes clear that the Agencies' approach is "no longer representative of government policy." Not only does this constitute a further policy reason to revisit the trailer requirements, but it constitutes centrally relevant new information requiring reconsideration of the rule under Section 307(d)(7)(B) of the Clean Air Act, 42 U.S.C. § 7607(d)(7)(B). Indeed, such reconsideration is especially acute here, where the Agencies judged the requirements as worthwhile after weighing benefits of reducing carbon—including such benefits outside of the United States—against costs that include an increase in traffic accidents and several additional highway fatalities in the United States.

REQUEST FOR CAA 307(D) STAY PENDING RECONSIDERATION

Section 307(d)(7)(B) of the CAA authorizes EPA to stay the effectiveness of a rule that it is reconsidering "for a period not to exceed three months." 42 U.S.C. § 7607(d)(7)(B). Such a stay gives the Agency time to reconsider its position and review the rule's requirements without imposing unnecessary compliance costs on regulated entities. EPA also may use a section 307(d) stay to avoid any confusion caused by the Agency implementing and then subsequently revising its regulatory requirements. Staying—or, in this case, extending—the implementation date of the new GHG standards for trailers until EPA completes its reconsideration process thus avoids the otherwise imminent compliance burdens and uncertainty for the regulated industry.

TTMA respectfully requests that EPA exercise its authority under the CAA to stay the effectiveness of the GHG standards for trailers pending reconsideration to the fullest extent permissible by the Clean Air Act. The Final Rule imposes imminent and substantial compliance obligations on trailer manufacturers that have more than 1,000 employees. The new GHG standards for trailers require compliance by TTMA's members beginning January 1, 2018. *See* 81 Fed. Reg. at 74049; 40 C.F.R. § 1037.5(h)(4). For 2018 trailer production, these new GHG standards will mandate installation of side skirts, trailer tails, low rolling resistance tires, and tire pressure inflation/monitoring systems on nearly all trailers manufactured and sold in the United States by TTMA's members.[13] As explained in more detail below, trailer manufacturers must

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[13] As noted, qualifying small manufacturers are exempt from the GHG manufacturing standards until January 1, 2019, although they must still register with EPA and label their 2018 Model trailers as exempt. *See* 81 Fed. Reg. at 74,059; 40 C.F.R. § 1037.150(c). Other manufacturers

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take steps well before January 1, 2018 to comply with these new EPA requirements. Staying the rule during reconsideration—by extending the January 1, 2018 implementation date for the EPA trailer standards —will avoid imposing these compliance costs prematurely and avoid confusion and disruption among the regulated industry. In short, a stay would afford EPA the time necessary fully to reconsider the Final Rule without adversely affecting the regulated industry.

REQUEST FOR APA 705 STAY PENDING JUDICIAL REVIEW

In addition to this petition for reconsideration, TTMA has filed a petition for review in the U.S. Court of Appeals for the D.C. Circuit challenging the Final Rule on the grounds that the new GHG and fuel economy standards applicable to trailers exceed the scope of EPA and NHTSA's statutory authorities and the Agencies did not adequately consider costs or properly assess benefits when promulgating these new standards. While judicial review is pending, Section 705 of the APA allows EPA to stay the effective date of a final rule if it "finds that justice so requires." 5 U.S.C. § 705. TTMA requests that EPA make such a finding here.

Both EPA and the courts have applied a four-part test to determine whether "justice so requires" a stay of agency action pending judicial review. Under that test, the Agency must consider: (1) whether there is a likelihood of success on the merits of the judicial challenge, (2) irreparable harm to the moving party if the stay is not granted, (3) the potential for harm to others if the stay is granted, and (4) whether the public interest weighs in favor of granting the stay. *Sierra Club v. Jackson*, 833 F. Supp. 2d 11, 30 (D.D.C. 2012). As explained below, each of these factors weighs in favor of staying this Final Rule as applied to trailers until the resolution of judicial review.

A. TTMA's Challenge is Likely to Succeed on the Merits

The TTMA's petition for review is likely to succeed on the merits. Principally, the Clean Air Act makes manifestly clear that EPA lacks authority to regulate trailers. Even if EPA had such authority, the rule would be invalid because it is arbitrary and capricious.

1. EPA Lacks Authority To Regulate Trailers

EPA claims that it has authority to regulate trailers under Section 202 of the Clean Air Act, which authorizes EPA to prescribe "standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines ..., whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution." 42 U.S.C. § 7521(a)(1). But the Act defines the term "motor vehicle" to mean "any self-propelled vehicle designed for transporting persons or property on a street or highway." *Id.* § 7550(2). It is undisputed that a trailer is not self-propelled. That should be the end of the matter. If a trailer is not self-propelled, it is not a motor vehicle under § 7550(2), and the EPA may not regulate it under § 7521(a)(1).

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can exempt up to 20 percent of their annual production, subject to caps of 350 units for box van trailers and 250 units for non-box trailers. *See* 81 Fed. Reg. at 74,060; 40 C.F.R. § 1037.150(v).

In the Final Rule, EPA argues that a trailer is something called an "incomplete vehicle," a term that appears nowhere in the Clean Air Act. EPA argues that it can regulate "incomplete vehicles" because the Act applies "whether [motor vehicles] and [motor vehicle] engines are designed as complete systems or incorporate devices to prevent or control such pollution." § 7521(a)(1). This statutory language does just what it says: it provides authority to regulate motor vehicles or engines that are not complete *systems*, in the sense that they incorporate pollution-controlling devices. But a vehicle that is not "designed as [a] complete system[]" because it contains a pollution-controlling device is nonetheless self-propelled, and it is still a motor vehicle. The Act's grant of regulatory power over motor vehicles that incorporate pollution-controlling devices does not somehow implicitly signal that EPA also can regulate products that are *not* motor vehicles. Indeed, if EPA's analysis were correct, the phrase "motor vehicle engine" in § 7521(a)(1) would be entirely superfluous. After all, under EPA's theory, an engine is as much an "incomplete vehicle" as a trailer. If Congress had intended to authorize the regulation of "incomplete vehicles" in a manner that would encompass trailers, the statute would have said so.

The Final Rule describes three other statutory provisions as "incomplete vehicle provisions," 81 Fed. Reg. 73,514, but the provisions each expressly require that "motor vehicles" meet specified requirements, rather than imposing requirements on components. *See* § 7521(a)(6) (EPA must require that "new light-duty vehicles … be equipped with" onboard vapor recovery systems); § 7521(a)(5)(A) ("fill pipe standards for new motor vehicles"); § 7521(k) (regulations "applicable to evaporative emissions of hydrocarbons from all gasoline-fueled motor vehicles"). EPA's statement that these provisions concern "incomplete vehicles" is puzzling at best. Of course regulating a "motor vehicle" may *impact* or even necessitate additional components or parts of that vehicle, but no normal speaker of English would conclude that, for example, a provision requiring a vehicle to contain an onboard vapor recovery system constitutes a regulation of an "incomplete vehicle." But it is academic in any event. If EPA is correct that the Act contains specific provisions targeted at specific types of equipment that are not "motor vehicles" but rather "incomplete vehicles," that only confirms that the grant of authority in § 7521(a) does not extend generally to *anything* the EPA might term an "incomplete vehicle."

Even if EPA could regulate an "incomplete vehicle" under the convoluted theory that § 7521(a) refers to "systems" that are not "complete," a trailer would not qualify. A trailer may sometimes be attached to a tractor, but that no more makes it an "incomplete vehicle" than a wagon is an "incomplete horse." The term "incomplete" means "lacking a usually necessary part, element, or step."[14] A trailer is not a "necessary part" of a vehicle, and obviously is not "necessary" for purposes of self-propulsion, which is the defining feature of the term "motor vehicle" in the Clean Air Act. Trailers are manufactured and sold separately to different ultimate purchasers from tractors, and the same trailers are routinely attached to and hauled by many different tractors over the course of their useful life. Each tractor likewise hauls many different trailers. A particular tractor-trailer combination is thus in no sense a single motor vehicle. In fact, the EPA itself in previous rulemakings has made clear its interpretation that that trailers are

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[14] https://www.merriam-webster.com/dictionary/incomplete

not vehicles, incomplete or otherwise; instead, the tractor is the vehicle, and the trailer is not. *E.g.*, 76 Fed. Reg. 57,106, 57,114 (Sept. 15, 2011) (explaining that "gross combined weight rating … describes the maximum load that the vehicle can haul, including the weight of a loaded trailer *and the vehicle itself*") (emphasis added).

Indeed, the United States government has repeatedly and successfully taken the common-sense position that a trailer is not a vehicle for purposes of federal criminal laws precisely because it is not "self-propelled," *see* 18 U.S.C. § 2311, and that this *does not change* when the trailer is attached to the truck. This theory that a trailer attached to a tractor is not a vehicle has enabled the government to charge individuals who steal a combination tractor-trailer with two crimes—stealing a vehicle (the tractor) and stealing a "good" (the trailer)—and obtain consecutive sentences. *E.g.*, *Bernard v. United States*, 872 F.2d 376, 377 (11th Cir. 1989); *United States v. Lofty*, 455 F.2d 506, 506 (4th Cir. 1972); *United States v. Kidding*, 560 F.2d 1303, 1308 (7th Cir. 1977). As the Seventh Circuit explained in adopting the United States' argument in that context, "[c]learly a trailer, if it stands alone, is not a motor vehicle," and the combination of the trailer and tractor does not change that result, because the "trailer was not indispensable to making the tractor a 'vehicle.'" *Id.*

EPA's theory that Congress silently authorized the regulation of trailers via § 7521(a)(1)'s "complete systems" language is also irreconcilable with the language of numerous other federal statutes that define the term "motor vehicle" to reach trailers expressly. *E.g.*, 40 U.S.C. § 17101(2) ("'motor vehicle' means a vehicle, self-propelled or drawn by mechanical power…"); 40 U.S.C. § 17501(2) ("'motor vehicle means … a vehicle self-propelled or drawn by mechanical power"); 18 U.S.C. § 31(a)(6) ("'motor vehicle' means every description of carriage or other contrivance propelled or drawn by mechanical power"); 49 U.S.C. § 30102(7) ("'motor vehicle' means a vehicle driven or drawn by mechanical power …"); 49 U.S.C. 32101(7) (same); 49 U.S.C. § 30301 ("'motor vehicle' means a vehicle, machine, tractor, trailer, or semitrailer propelled or drawn by mechanical power"). Congress "knew how to provide for" regulation of trailers, *Meghrig v. KFC Western, Inc.*, 516 U.S. 479, 485 (1996), and its omission of language like "drawn by mechanical power" in the Clean Air Act confirms that it did not intend to do so here.

Finally, the "incomplete vehicle" theory would render EPA's regulatory authority essentially limitless. EPA protests that interpreting § 7521(a)(1) to cover "incomplete vehicles" "is not to say that the Act authorizes emission standards for any part of a motor vehicle, however insignificant." 81 Fed. Reg. 73514. But under EPA's interpretation in the Final Rule, the Act *does* authorize the EPA to set emissions standards for any part of a motor vehicle. Nothing in the Act provides any basis upon which to distinguish between a trailer and any other component; there is no "intelligible principle" contained within the Act itself. *Mistretta v. United States*, 488 U.S. 361, 372 (1989). The Final Rule announces that a trailer "properly fall[s] on the vehicle side of the line," 81 Fed. Reg. 73515, but this is just ipse dixit. The absence of any "intelligible principle" in the Act that sets the limits of EPA's authority to decide what constitutes an "incomplete vehicle" is a strong indication that the Act does not in fact permit regulation of an "incomplete vehicle." Indeed, if EPA's interpretation were correct, the Act would be unconstitutional under the nondelegation doctrine. *Mistretta*, 488 U.S. at 372.[15]

At bottom, EPA's "incomplete vehicle" theory would vastly expand its regulatory reach to equipment that Congress expressly excluded from regulation, namely, equipment that is not self-propelled. Dubbing something an "incomplete vehicle" is just another way of saying that it is *not* a vehicle. EPA's argument is highly unlikely to succeed on the merits.

2. The Rules are Arbitrary and Capricious

Even if EPA did have authority under the Clean Air Act to regulate trailers—and it does not—the trailer standards are arbitrary and capricious.

First, the Agencies overstated the GHG and fuel economy benefits of the trailer standards by using unrealistic and unsupported assumptions regarding the speeds at which trailers hauled by heavy-duty tractors travel. The Agencies projected GHG and fuel economy benefits from, among other things, drag reduction achieved by aerodynamic devices, which is primarily a function of vehicle speed.[16] In performing their analysis, the Agencies used drive cycle weightings from the Phase 1 heavy-duty vehicle rule to characterize the percentage of vehicle miles traveled at certain speeds—below 55 miles per hour ("mph"), between 55 and 65 mph, and above 65 mph—by different types of trailers.[17] Those drive cycle weightings, however, are not supported by the underlying data. In fact, although the Agencies characterized the percentage of vehicle miles traveled at speeds exceeding 65 mph, not one of the studies upon which the Agencies relied actually included a "greater than 65 mph" speed category.

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[15] TTMA has also petitioned for review of the fuel economy standards in the Final Rule, on the ground that NHTSA too lacked authority to regulate trailers. The Energy Independence and Security Act, which authorized NHTSA's participation in the rulemaking, applies to "commercial medium- and heavy-duty on-highway vehicle[s]," 49 U.S.C. § 32902(k)(2), and defines that term to mean "an on-highway vehicle with a GVWR of 10,000 lbs or more," *id.* § 32901(a)(7). That definition excludes a trailer. As EPA has recognized in prior rulemakings: "GVWR describes the maximum load that can be carried by a vehicle, including the weight of the vehicle itself. Heavy-duty vehicles also have a gross combined weight rating (GCWR), which describes the maximum load that the vehicle can haul, including the weight of a loaded trailer and the vehicle itself." 76 Fed. Reg. 57,106, 57,114 (Sept. 15, 2011). Congress's reference to GVWR thus excludes trailers as a textual matter. However, because TTMA is only seeking a stay of the emissions standards promulgated by the EPA because NHTSA's mandatory standards do not take effect until January 1, 2021, there is no need to consider the TTMA's likelihood of success on its challenge to NHTSA's authority at this time.

[16] Speed matters exponentially, as the basic drag equation uses velocity *squared.* Adding another 5 miles per hour to 50 mph input data produces a result much greater than a 10% increase. Reductions in drag calculated for aerodynamic equipment on trailers that are assumed to operate at higher than actual speeds will similarly overstate benefits.

[17] EPA/NHTSA, Response to Comments for Joint Rulemaking, EPA-420-R-16-901, at 1030-31 (Aug. 2016).

The Agencies assumed that long (53-foot) dry-freight and refrigerated vans are operated at speeds exceeding 65 mph for 86 percent of the vehicle miles traveled and at speeds between 55 and 65 mph for 9 percent of the vehicle miles traveled.[18] The Agencies further assumed that short dry-freight and refrigerated vans are operated at speeds exceeding 65 mph for 64 percent of the vehicle miles traveled and at speeds between 55 and 65 mph for 17 percent of the vehicle miles traveled.[19] The Agencies explained that these ranges were derived from three studies: (1) an EPA MOVES analysis of Federal Highway Administration data from 1999; (2) a University of California Riverside (UCR) evaluation in 2006 of data from 270 trucks; and (3) an Oak Ridge National Laboratory study of a fleet of six trucks published in 2009.[20] Critically, however, not one of these studies included a "greater than 65 mph" speed category—the EPA MOVES and Oak Ridge analyses reported the fraction of vehicle miles traveled at speeds exceeding 60 mph, and the UCR analysis reported the fraction of vehicle miles traveled at speeds exceeding 45 mph.[21] Moreover, the actual percentages used by the Agencies (86 and 9 percent for long van trailers and 64 and 17 percent for short van trailers) come directly from the EPA MOVES analysis. But the speed ranges reported in the EPA MOVES analysis were actually five mph slower—greater than 60 mph and 50 to 60 mph, respectively.[22] In other words, the Agencies assumed that long van trailers travel at speeds exceeding **55** mph for 95 percent of the vehicle miles traveled based solely on data reporting that such trailers travel at speeds exceeding **50** mph for 95 percent of the vehicle miles traveled. Simply put, the Agencies selected the highest percentages for miles traveled from only one of the three cited data sources, in effect ignoring the other two, and then inflated the speed threshold for those miles traveled. As a consequence, the Agencies' own data do not support the speed distribution ranges they used to evaluate the purported benefits of the trailer standards, thus rendering those standards themselves arbitrary and capricious.[23]

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[18] *See* 81 Fed. Reg. at 73,654.

[19] *Id.*

[20] EPA/NHTSA, Response to Comments for Joint Rulemaking, EPA-420-R-16-901, at 1030 (Aug. 2016).

[21] *Id.* at 1031 (Table 3-14).

[22] *Id.*

[23] Moreover, even if the Agencies accurately characterized the data from the EPA MOVES analysis, those data are not representative of real-world operation. The EPA MOVES data for long van trailers, for example, were recorded on "restricted access" highways. EPA/NHTSA, Response to Comments for Joint Rulemaking, EPA-420-R-16-901, at 1030 (Aug. 2016). Long van trailers are operated on all types of highways, not just those with restricted access. In fact, most non-restricted rural highways do not even allow speeds in excess of 65 mph. Utility Trailer Manufacturing Company ("Utility") submitted data from three long-haul trucking fleets that more accurately reflect real-world operation. Comments of Utility Trailer Manufacturing Co., EPA-HQ-OAR-2014-0827-1183, at 4-7. The Agencies erroneously concluded that "the fleet data provided by Utility is not substantially different than the current GEM drive cycle weightings." Memorandum to Docket EPA-HQ-OAR-2014-0827, "Comparison of GEM Drive Cycle Weightings and Fleet Data Provided by Utility Trailer Manufacturing Co. in Public Comments" (July 2016). The record does not support that conclusion. Whereas the Agencies

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Second, the Agencies failed to account fully for the additional weight of aerodynamic devices, which increase fuel consumption and displace cargo, resulting in more trips, more emissions, and more accidents. As described above, the GHG trailer standards will mandate that trailer manufacturers install side skirts and trailer tails, among other devices, on nearly all of the trailers they manufacture. Side skirts add, on average, about 250 pounds to the weight of a typical 53-foot trailer, and trailer tails add an additional 150 pounds.[24] The Agencies attempted to evaluate the impact of additional vehicle weight due to the use of aerodynamic devices,[25] but failed to address the effect of cargo displacement. Because motor carriers must operate below an 80,000-pound maximum weight limit for the tractor, trailer and cargo combined,[26] the addition of side skirts and tails would cause some trucks to "weigh-out." Consequently, motor carriers will have to shift cargo from some of their trucks, resulting in additional trips to transport freight that could not be moved by the "weighed-out" trucks. TTMA estimates that these additional trips would cause an additional 184 million truck miles traveled per year, resulting in additional emissions as well as 246 more accidents and 7 additional fatal crashes per year.[27]

In response to these concerns, the Agencies summarily explained that the additional weight from aerodynamic devices "can easily be offset by substituting lightweight components" elsewhere in the trailer designs.[28] This response is not sufficient. Motor carriers already demand that trailers weigh and cost as little as possible while still being capable of carrying the expected freight loads`. Lighter-weight alternative materials (such as aluminum) are considerably more expensive than standard materials (such as steel), and often are not desired by customers. The Agencies' unreasonably assume that trailer manufacturers required to add several hundred pounds of aerodynamic equipment to their trailers will voluntarily offset that weight by installing more expensive, light-weight technologies. If the cost of the light-weight material is not worthwhile to customers in the first instance to make room for more cargo, there is no reason to believe that they will be willing to bear that additional cost to make room for more cargo just

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determined that long van trailers travel at speeds exceeding 55 mph for 95 percent of the vehicle miles traveled, Utility's data show that such trailers travel at speeds exceeding 55 mph for only 84 percent of the vehicle miles traveled—a difference of 11 percentage points. *Id.* at 2. The Agencies' decision to disregard the real-world fleet data submitted by Utility was arbitrary and capricious.

[24] *See* Comments of Truck Trailer Manufacturers Association, EPA-HQ-OAR-2014-0827-1172-A1, at 7-8.

[25] *See* Memorandum to Docket EPA-HQ-OAR-2014-0827, "Impact of Additional Weight Due to Trailer Aerodynamic Devices" (July 18, 2016).

[26] *See* 23 CFR § 658.17(b).

[27] *See* Comments of Truck Trailer Manufacturers Association, EPA-HQ-OAR-2014-0827-1172-A1, at 7-8. The Agencies disagree with certain of TTMA's assumptions and conclude that the additional truck miles will result in an increase of about three fatalities per year. EPA/NHTSA, Response to Comments for Joint Rulemaking, EPA-420-R-16-901, at 1019 (Aug. 2016).

[28] EPA/NHTSA, Response to Comments for Joint Rulemaking, EPA-420-R-16-901, at 1016 (Aug. 2016).

because the total cargo capacity is reduced by the aerodynamic equipment. In fact, the aerodynamic equipment consumes weight and cargo capacity, which will inexorably lead to more (and heavier) trucks in the U.S. fleet to carry the same total cargo, with the additional trucks emitting additional pollutants, adding to total truck miles traveled, and causing more accidents, injuries and fatalities.

B. TTMA's Members Will Suffer Irreparable Harm

TTMA's members face a substantial loss of business, market share, and goodwill as a consequence of the regulations, as well as irreparable compliance costs. Although the GHG regulations take effect on January 1, 2018, TTMA's members face these harms imminently. Trailers are manufactured to each customer's unique specifications, and new orders must be placed about six months in advance of actual production. Accordingly, TTMA members' customers are putting in orders for delivery in January 2018 beginning now, in June 2017.

To be in a position to produce trailers that are compliant with the GHG regulations by January 2018, TTMA's members must make far-reaching and costly changes to their business, starting now. They must identify component suppliers for the required equipment, evaluate and, where necessary, test that equipment, revise pricing and trailer option books and train sales representatives to explain the compliant option combinations to customers, add manufacturing floor space and reconfigure assembly lines, train production employees to install the new GHG equipment, and develop data collection and reporting systems to ensure compliance. One TTMA member, for example, estimates that it will incur over $7.5 million in costs in 2017-2018 simply to provide inventory storage areas, transport the GHG equipment to its plants, modify plant facilities to enable installation of this equipment on trailers as part of its assembly lines, and secure trained employees to install the new GHG equipment on the requisite number of trailers. That figure omits costs for engineering work to evaluate all possible trailer configurations for compatibility with the new GHG regulations, the cost of administrative work needed to apply for certification and operate a compliance program, and the cost of the GHG equipment itself, and the business disruption and significant loss of efficiency while changes are made to production lines, supply chains, manufacturing protocols, and storage options. Other manufacturers, depending on their size, anticipate spending between $300,000 and $6.3 million in 2017-2018 on developing compliance systems and procuring and installing GHG equipment. In addition, TTMA estimates that the material and delivery costs of purchasing the new GHG equipment will exceed $100 million annually. Even EPA assumes that its new regulations will create substantial compliance costs, including redesign, re-engineering, and identifying new suppliers.

These compliance costs qualify as irreparable harm. "[C]omplying with a regulation later held invalid almost always produces the irreparable harm of nonrecoverable compliance costs." *Texas v. United States Envtl. Prot. Agency*, 829 F.3d 405, 433 (5th Cir. 2016) (quoting *Thunder Basin Coal Co. v. Reich*, 510 U.S. 200, 220–21, 114 S.Ct. 771, 127 L.Ed.2d 29 (1994) (Scalia, J., concurring in part and in the judgment)). For example, being forced to undertake "difficult, time-consuming, and expensive safety testing regarding the safety … of their products" and to spend "more time and significantly more money" in development is irreparable harm that "can never be recouped." *Bracco Diagnostics, Inc. v. Shalala*, 963 F. Supp. 20, 28-29 (D.D.C. 1997). No matter what, TTMA's members will "be forced to incur large costs which, if [they] manage[]

to survive those, will disrupt and change the whole nature of [their] business in ways that most likely cannot be compensated with damages alone." *Am. Trucking Associations, Inc. v. City of Los Angeles*, 559 F.3d 1046, 1058 (9th Cir. 2009) (finding irreparable harm where companies would be forced to begin complying with a regulation they alleged was preempted); *see also Portland Cement Ass'n v. E.P.A.*, 665 F.3d 177, 189 (D.C. Cir. 2011) (staying portion of EPA rule because "industry should not have to build expensive new containment structures until the standard is finally determined"). TTMA's members have no mechanism to recover these costs from the government if the GHG regulations are later held to be invalid.

Beyond compliance costs, TTMA's members also face an irreparable loss of business relationships, market share, and goodwill. As noted, motor carriers who wish to purchase trailers equipped with side-skirts and other fuel-saving devices are already doing so; other carriers have concluded that purchasing these trailers makes no economic sense for their trucking operations. Because TTMA's members must begin accepting orders six months ahead of delivery, most of TTMA's members are now required to quote only compliant products to prospective customers, most of whom have so far not wanted this added equipment. Those customers will look to other trailer manufacturers who can offer exempt trailers. Preventing companies from delivering their products to customers "almost inevitably creates irreparable damage to … good will." *Reuters Ltd. v. UPI, Inc.*, 903 F.2d 904, 908 (2d Cir. 1990); *id.* at 909 ("irreparable harm has often consisted of the loss of customers and the competitive disadvantage that resulted from a distributor's inability to supply its customers with the terminated product"); *Register.com, Inc. v. Verio, Inc.*, 356 F.3d 393, 404 (2d Cir. 2004) ("irreparable harm through loss of reputation, good will, and business opportunities"). The harm is especially irreparable here because not all trailer manufacturers are subject to the new regulations. Smaller manufacturers need not begin selling and installing GHG-control equipment until 2019, which means they are currently free to accept orders without the unwanted and expensive equipment. In other words, some of TTMA's members face an imminent risk of loss of market share because, as a consequence of the new rules, their customers will *only* be able to purchase the products they prefer from other manufacturers. "It is well-established that a movant's loss of current or future market share may constitute irreparable harm." *Grand River Enter. Six Nations, Ltd. v. Pryor*, 481 F.3d 60, 67 (2d Cir. 2007); *Freedom Holdings, Inc. v. Spitzer*, 408 F.3d 112, 114 (2d Cir. 2005). "In a competitive industry where consumers are brand-loyal, we believe that loss of market share is a 'potential harm which cannot be redressed by a legal or an equitable remedy following a trial.'" *Novartis Consumer Health, Inc. v. Johnson & Johnson-Merck Consumer Pharm.*, 290 F.3d 578, 596 (3d Cir. 2002).

C. No Third Parties Will Be Harmed If There is A Stay

Granting a temporary stay of the trailer standards would not cause harm to third parties because the trailer standards, even if implemented, would achieve little if any benefit to global climate change. This is because trailer manufacturers *already* install and sell the mandated technologies where those technologies are most likely to improve fuel economy and thereby reduce GHG emissions. The motor carrier industry is an extremely competitive, low-margin industry that is particularly sensitive to fuel costs and trailer weight (which impacts the amount of cargo the tractor-trailer combination can haul in light of the 80,000-pound weight limit). Consequently, motor carrier customers already pressure their trailer manufacturer suppliers to install low-rolling resistance tires and aerodynamic equipment where the nature of their trucking operations will enable them to realize measureable fuel savings, and to reduce trailer weight where cost-effective to enable them to haul additional cargo.

Thus, because trailers are used in a variety of applications, trailer manufacturers must customize the trailers they manufacture and sell to meet their customers' specific needs. Market forces already dictate that trailer manufacturers install and sell technologies designed to reduce aerodynamic drag and road friction for applications in which such technologies are likely to materially improve fuel economy (and thus GHG emissions performance). For trailers used in long-haul applications, for example—where the tractor-trailer combination will travel long distances at high speeds—these technologies can have a significant impact on fuel consumption. A customer operating a truck fleet engaged in long-haul operations thus has a significant incentive to demand aerodynamic and friction-reducing technologies on its trailers to reduce overall fuel costs.

In contrast, aerodynamic and friction-reducing technologies do not materially reduce fuel consumption or GHG emissions during short-haul operations at lower speeds (*e.g.*, in-city deliveries, food service, etc.). For these applications, customers typically do not request, and trailer manufacturers do not install, aerodynamic and friction-reducing technologies because the costs of doing so significantly outweigh any potential benefits. The trailer standards, however, would mandate that trailer manufacturers install and sell these technologies on nearly all heavy-duty trailers, including those designated for short-haul operations. The trailer standards thus create compliance costs for trailer manufacturers and their customers without providing corresponding fuel economy or GHG benefits to third parties and the environment. Indeed, the added weight of the aerodynamic equipment in those operations will cause *greater* fuel consumption and *increased* GHG emissions.

In short, because the trailer standards provide no demonstrable benefit to third parties or the environment beyond what the trailer industry already is achieving due to market forces, this factor weighs in favor of granting a stay.

D. A Stay is In the Public Interest

Staying the effective date of the Final Rule's trailer standards also is in the public interest. If the trailer standards remain in effect during the pendency of judicial review, they will impose substantial compliance costs on regulated entities that cannot be recouped, without providing any material benefit to the general public or the environment. As addressed above, trailer manufacturers already install and sell aerodynamic and friction-reducing technologies where such technologies are likely to achieve GHG and fuel economy benefits. The Agencies have not demonstrated that mandating trailer manufacturers to install and sell such technologies on additional trailers—beyond what the trailer industry already is doing—will benefit the public. Indeed, as described above, the new trailer standards actually will have the opposite effect —they will needlessly force manufacturers to add heavy aerodynamic devices to their trailers, thereby displacing cargo and resulting in more trips to deliver the same amount of cargo, leading to increased fuel consumption, increased emissions, and increased trucking accidents in the United States. With negligible benefits for global climate change even when calculated by the

Agencies on a global basis, the American public must bear these additional costs and indeed at least several additional fatalities due to the need for more trucks on the Nation's roads to carry the same total cargo. This is contrary to the interest of the American public.

CONCLUSION

In sum, EPA and NHTSA should reconsider and rescind the GHG and fuel economy standards for heavy-duty truck trailers because such trailers are not motor vehicles and so the agencies lack authority impose such regulations on them. Even if the agencies did have such authority, they should reconsider and rescind these regulations because they arbitrarily impose requirements without properly considering whether additional aerodynamic equipment is productive at the speeds these trailers are hauled or the additional weight of such equipment that displaces cargo that must then be carried by additional trailers. Finally, EPA should immediately stay the effect of its GHG requirements for trailers, which are causing immediate and irreparable harm as trailer manufacturers must now take steps to comply with these rules for Model Year 2018.

E. SCOTT PRUITT
ADMINISTRATOR

August 17, 2017

Mr. Jonathan S. Martel
Arnold & Porter Kaye Scholer LLP
601 Massachusetts Avenue, NW
Washington, D.C. 20001-3743

Mr. Jeffrey M. Sims, President
Truck Trailer Manufacturers Association
7001 Heritage Village Plaza, Suite 220
Gainesville, Virginia 20155

Dear Mr. Martel and Mr. Sims:

On April 3, 2017, Mr. Jeffrey Sims sent a letter on behalf of the Truck Trailer Manufacturers Association to the U.S. Environmental Protection Agency asking the EPA to reconsider and issue an administrative stay of the greenhouse gas emission standards for heavy-duty truck trailers in the final rule entitled "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2" (81 FR 73478, October 25, 2016) ("Phase 2 Rule"). On June 26, 2017, Mr. Jonathan Martel submitted a supplemental petition for reconsideration and stay on behalf of TTMA. In these letters, TTMA questioned the EPA's authority under the Clean Air Act to regulate truck trailers as well as the EPA's analysis of the costs and benefits of the standards. More specifically:

- TTMA noted that the Clean Air Act definition of "motor vehicle" refers to "self-propelled" vehicles, and TTMA challenges the EPA's authority to regulate truck trailers because they are not self-propelled.
- TTMA challenges the EPA's authority to regulate truck trailers as incomplete motor vehicles.
- TTMA disputes the EPA's projection of greenhouse gas and fuel economy benefits because of concerns about the vehicle speed profile assumed by the EPA.
- TTMA projects that weight of the new emission components will decrease available payload which would cause an increase in the number of trucks on the road. TTMA estimates that this would increase both greenhouse gas emissions and fatal crashes.

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In light of these issues, the EPA has decided to revisit the Phase 2 trailer provisions in general, and the issue of the EPA's authority to regulate trailers in particular. We intend to develop and issue a Federal Register notice of proposed rulemaking on this matter, consistent with the requirements of the Clean Air Act.

The EPA has made no decision at this time regarding your request for an administrative stay.

If you have any questions regarding our response, you may contact Bill Charmley in the Office of Transportation and Air Quality at (734) 214-4466.

Respectfully Yours,

E. Scott Pruitt

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

August 17, 2017

Jeffrey M. Sims, President
Truck Trailers Manufacturers Association
7001 Heritage Village Plaza
Suite 220
Gainesville, VA 20155

Dear Mr. Sims,

I am writing in response to the Truck Trailer Manufacturers Association's (TTMA) letters seeking reconsideration of the Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2 (Phase 2) rulemaking, published on October 25, 2016 (81 FR 73478).

The National Highway Traffic Safety Administration (NHTSA) received two letters from TTMA requesting reconsideration of the Phase 2 rulemaking—one on April 4, 2017, and a supplemental letter on June 26, 2017. Pursuant to NHTSA's regulations, petitions for reconsideration must be received by the agency not later than 45 days following publication of the rule. 49 CFR § 553.35. Petitions filed after that timeframe are to be considered as petitions for rulemaking under 49 CFR § 552. Id.

After reviewing your letters, NHTSA has decided to grant your petition for rulemaking.

The agency notes that its granting of this petition does not prejudge the outcome of the rulemaking or necessarily mean that a final rule will be issued. The determination of whether to issue a rule will be made in accordance with statutory criteria.

Sincerely,

Jack Danielson
Acting Deputy Administrator

CERTIFICATE OF SERVICE

I hereby certify that on June 9, 2020, the foregoing appendix was electronically filed with the Court via the appellate CM/ECF system, and that copies were served on counsel of record by operation of the CM/ECF system on the same date.

Dated: June 9, 2020

/s/ Elisabeth S. Theodore
Elisabeth S. Theodore