Summary of Methane Emission Reduction Opportunities Across North American Oil and Natural Gas Industries

May 2016

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Acknowledgement

ICF received and considered data or commentary from numerous stakeholder organizations, including oil and gas producers, industry associations, pipelines, equipment vendors, service providers, NGOs, and governments in preparing the reports summarized here. No information in this summary or the reports described should be attributed to any single organization, as all data is aggregated from multiple sources and often uses average values. Furthermore, acknowledgement of participation does not imply their agreement with the study assumptions or conclusions, which reflect the professional judgment of ICF. Specific companies that provided input are identified in each country study

1. North American Methane Emissions Summary

Methane is an important greenhouse gas (GHG) with a short-term impact many times greater than carbon dioxide. Throughout North America methane emissions from the oil and gas industries account for a significant portion of total GHG emissions. Recent research also suggests that mitigation of short-term climate forcers such as methane is a critical component of a comprehensive response to climate change[1].

Methane is the primary component of natural gas. As a result, methane emissions occur throughout the oil and gas industries, and are among the largest anthropogenic sources of North American methane emissions. There are effective methods readily available to reduce emissions of fugitive (leaked) and vented (intentionally released) methane from the oil and gas industries and, because of the value of the gas that is conserved, some of these measures could potentially increase revenue (e.g. reduce lost product), or have limited net cost. The United States, Mexico, and Canada have all taken steps to reduce these emissions as part their commitments to international GHG reduction efforts.

The global nonprofit organization Environmental Defense Fund (EDF) commissioned this summary analysis of three previous reports on economic oil and gas methane abatement opportunities performed by ICF International for the United States[2], Canada[3], and Mexico[4]. EDF released the Canada report in partnership with the Pembina Institute and the Mexico report in partnership with the Mario Molina Center. This summary combines the results of these previous reports to summarize the North American methane emission reduction opportunities from the oil and gas industries. This summary estimates current and projected oil and gas methane emissions in North America, the largest abatement opportunities, and the cost of potential reductions achievable through currently available and applicable technologies and practices.

More details and methodological approaches can be found in the individual papers, but the overall approach to each of the studies was to:

- Define a future projection of methane emissions from the oil and gas sectors. The projection was established roughly five years from the date of the analysis as a conservative estimate for when new mitigation technologies could be installed. The projection year was 2018 for the U.S. study and 2020 for the Mexico and Canada studies. Country-specific information was used to develop the projections for each report.
- Review existing literature and conduct further analysis to identify the largest reduction opportunities and validate and refine cost-benefit estimates of mitigation technologies.

[1] Shoemaker, J. et. al., "What Role for Short-Lived Climate Pollutants in Mitigation Policy?". Science Vol 342 13 December 2013
[2] https://www.edf.org/energy/icf-methane-cost-curve-report
[3] https://www.edf.org/climate/icf-report-canadas-oil-and-gas-methane-reduction-opportunity
[4] https://www.edf.org/energy/icf-report-mexicos-oil-and-gas-methane-reduction-opportunity

- Conduct interviews with industry, technology innovators, and equipment vendors with a specific focus to identify additional mitigation options.
- Use this information to develop marginal abatement cost (MAC) curves for methane reductions in these industries.
- Document and present the results.

There are several caveats to the findings:

- Each of the three studies was performed at a different time and some data sources and assumptions are different. For example, the baseline year and the projection year for the U.S. study were 2010 and 2018, respectively, while the baseline year and the projection year for Canada and Mexico were 2013 and 2020, respectively.
- New information that became available on emissions and cost was incorporated into the Mexico and Canada reports and may be different from data used in the U.S. report.
- Since the individual studies were released, countries have committed to additional actions to reduce methane emissions. For example, the United States announced a 40-45% reduction goal and proposed regulations for new sources of oil and gas methane[5]. The province of Alberta, which accounts for roughly 60% of Canadian oil and gas methane emissions, also announced a goal of 45% oil and gas methane reductions backed by regulations for new and existing sources[6]. This summary focuses on reductions associated with a suite of existing technologies and does not analyze the reductions from these policy announcements.
- Emission mitigation cost and performance are highly site specific and variable. The values used in the individual country studies are estimated average values.
- All costs in this Executive Summary are in U.S. dollars.

The key conclusions of the summary include:

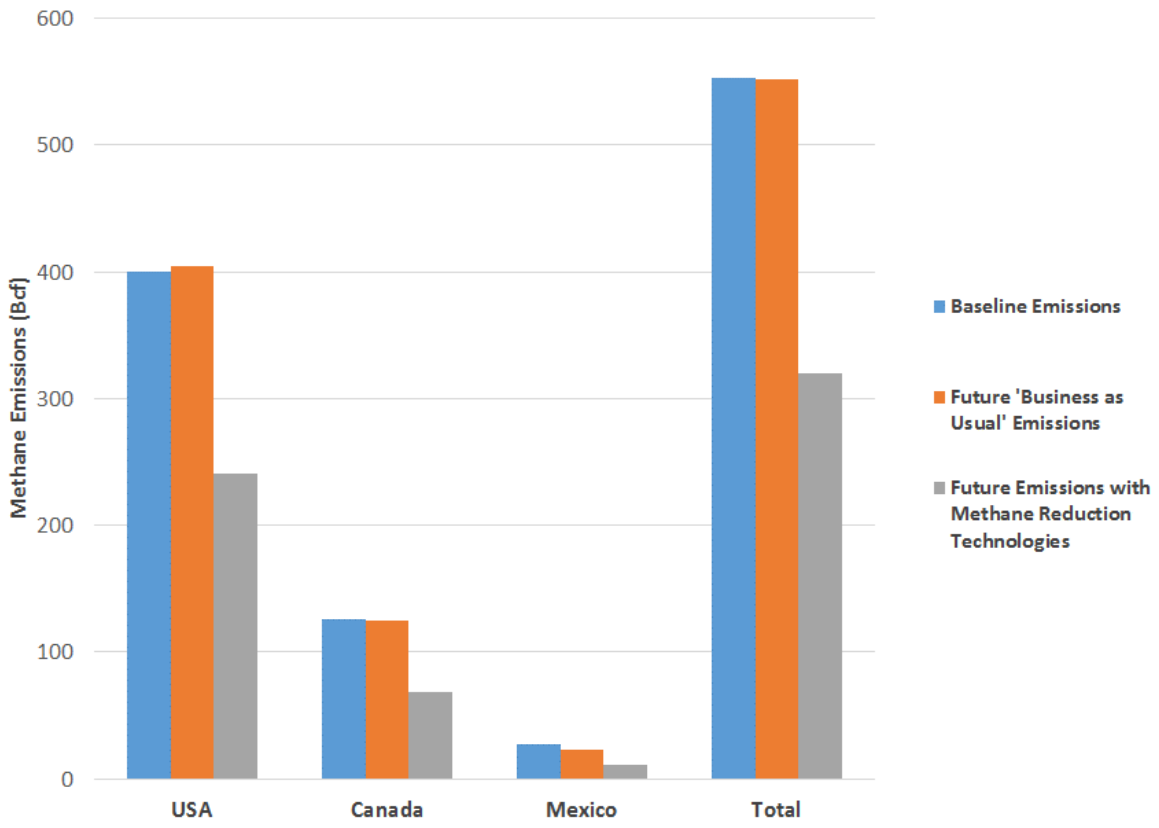
- **Total North American Emissions Stay Constant** – Methane emissions from North American oil and gas activities are estimated to be relatively constant between 2010/2013 and 2018/2020 at 266 million metric tons CO_2e[7] or 552 Bcf. A breakdown of baseline emissions, projections, and reduction opportunities is shown in Figure 1-1.

[5] https://www.whitehouse.gov/the-press-office/2015/01/14/fact-sheet-administration-takes-steps-forward-climate-action-plan-anno-1

[6] http://alberta.ca/climate-methane-emissions.cfm

[7] All values of CO_2e in this study are calculated using 100-yr global warming potential (GWP) value of 25 for methane according to the AR-4 report unless stated otherwise.

Figure 1-1 – 42% Methane Reduction Possible Across North America



- This estimate does not include all methane emissions. U.S. and Canadian offshore production emissions are excluded while Mexican offshore emissions are included[8]. Methane emissions from Canadian oil sands production are also excluded from the analysis[9]. This study also does not account for some insignificant emissions from oil transportation and refinery operations.

[8] Significant amounts of both oil and gas are produced from U.S. offshore facilities. While these facilities report significant methane emissions, the reports do not have the detail and specificity of the rest of the methane inventory and therefore could not be included in the same methodology applied to the rest of the U.S. inventory for this analysis. Therefore, the U.S. study focused only on onshore oil and gas industry operations. In contrast, Mexican offshore operations have a higher degree of concentration and it was possible to characterize offshore methane emissions with a higher degree of confidence so they were included in the analysis. Canadian offshore emissions were not included because of the relatively low level of offshore activity.

[9] The Canadian emission reduction analysis addressed emissions from Steam Assisted Gravity Drainage (SAGD) tankage and flaring and venting sources from oil sands, but due to the limited data on other sources (e.g. mining, tailings ponds, bitumen processing, etc.), these other oil sands sources were excluded from the analysis.

- **Concentrated Reduction Opportunities** – Across North America, roughly 20% of emission source categories account for over 80% of the 2018/2020 emissions, primarily at facilities in operation in the base year.
- **Across North America 42% Emissions Reduction Achievable with Proven Technologies** – This 42% reduction of oil and gas methane is equal to 232 Bcf of methane or 111.7 million metric tons CO_2e using the 100 year global warming potential (GWP), which is the GWP value used in the national GHG inventories. Using the 20 year GWP[10], which highlights the short-term impact of methane, the projected North American emission reductions are equal to 375.3 million metric tons CO_2e. (This 20 year GWP reduction value should not be compared to the inventories for the U.S., Mexico, and Canada and baseline values for these studies, which use the 100 year GWP.) The percentage reduction is similar for each country. This reduction:
  - Comes at a net annualized cost of $1.52/metric tons CO_2e reduced – ranging from $0.06/metric ton CO_2e reduced for Mexico, $1.38/metric ton CO_2e reduced in the U.S., and $2.22/metric ton CO_2e reduced for Canada. The technologies available to reduce these emissions can capture almost $1 billion ($983.1 million) worth of gas per year, assuming the natural gas is valued at $4/Mcf.[11]
  - Equals $0.73 /Mcf methane reduced or on average less than $0.01/Mcf of gas produced across North America[12], taking into account savings that accrue directly to companies implementing methane reduction measures (Figure 1-2).
  - Is achievable at a net annualized cost of $169.5 million USD per year if the full economic value of recovered natural gas is taken into account and not including savings that do not directly accrue to companies implementing methane reduction measures[13].
  - If the additional savings that do not accrue to companies are included, the 42% reduction is achievable at a net savings to the North American economies of $156.7 million USD per year.
  - Is in addition to regulations and projected voluntary actions that existed at the time of these studies. Subsequent goals and regulations are not included.
  - Comes for an initial capital cost of $2.88 billion or 0.7% of the approximately $430 billion combined oil and gas capital expenditures (CAPEX) across the three countries for these industries in 2014[14].

[10] Using an AR-5 20-yr GWP value of 84.

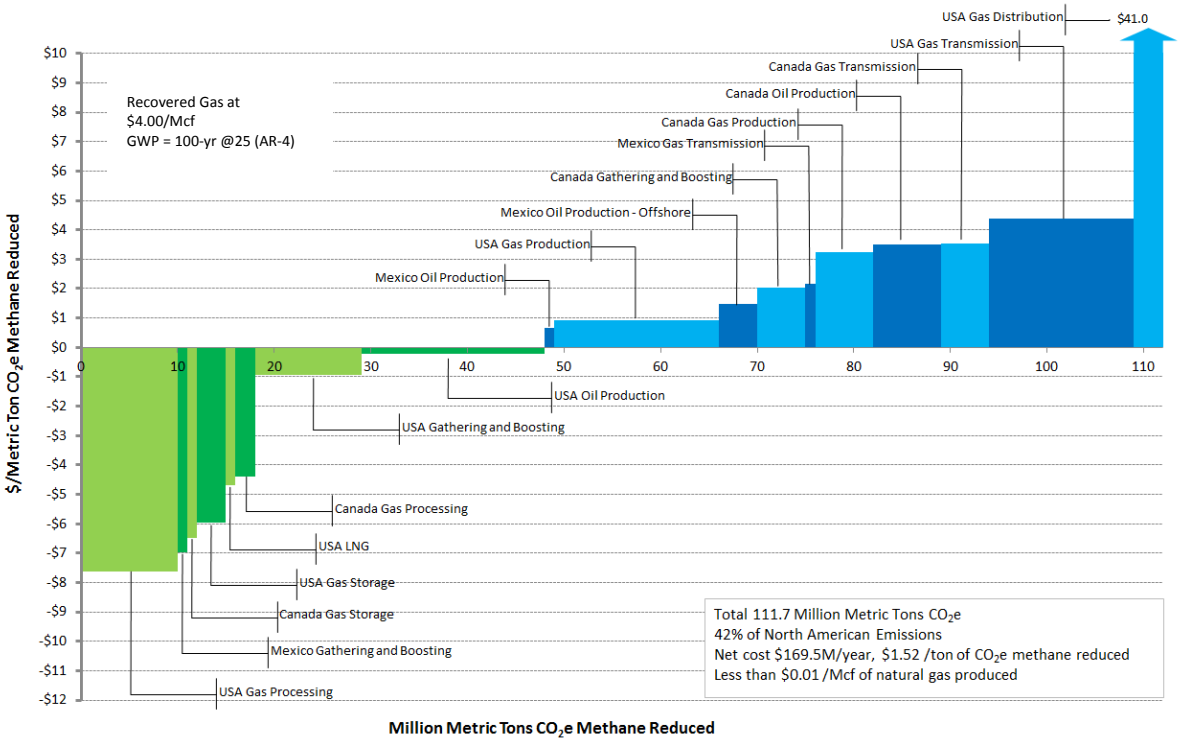
[11] Value is calculated based on whole gas and not just methane and excludes flaring.

[12] Based on natural gas production across the United States, Mexico, and Canada.

[13] Does not include or take into account potential social cost of methane emissions. As discussed later, typically reduction benefits do not accrue to Transmission and Distribution companies.

[14] Oil & Gas Journal, March 3, 2014. Available at: http://www.ogj.com/articles/print/volume-112/issue-3/special-report-capital-spending-outlook/e-amp-p-capital-spending-to-rebound-in-north-america.html

Figure 1-2 - Marginal Abatement Cost Curve for Methane Reductions by North American Segment[15]



- **Largest Abatement Opportunities**[16] –By volume, the top five largest sources of North American oil and gas methane emission reductions are responsible for almost half (48%) of potential emissions reduction opportunities, including:
  - Reciprocating Compressor Fugitives – opportunity to reduce emissions by 33.1 Bcf by implementing leak detection and repair programs.
  - Venting from High Bleed Pneumatic Devices – opportunity to reduce emissions by 28.0 Bcf by replacing high bleed devices with low bleed varieties or instrument air.
  - Centrifugal Compressors (Wet Seals) - opportunity to reduce emissions by 19.2 Bcf by replacing wet seals with dry seals or implementing wet seal degassing recovery.

[15] Although included in the baseline inventory and overall reduction opportunities, the following segments are not visually represented in Figure 2-2 due to the relative small size of methane reductions in the respective segments: Canada Gas Distribution, Canada LNG-Import, Canada LNG-Storage, Mexico Gas Distribution, Mexico Gas Processing, Mexico Gas Production, and Mexico LNG.

[16] Economic analysis in this summary does not include cost of CO_2 allowance or credit

- Stranded Gas Venting from Oil Wells - opportunity to reduce emissions by 18.3 Bcf by implementing portable or stationary flares.
- Intermittent Pneumatic Devices - opportunity to reduce emissions by 12.3 Bcf by replacing intermittent bleed devices with lower-emitting devices.

- **Price Sensitivity** – The Canada, U.S., and Mexico cost curve reports assumed a price of $4 per McF of gas. That number was chosen as a reasonable assumption given that the analyses go to 2018 and 2020 and the U.S. EIA's long-term price projections are $3.79/Mcf in 2015, $3.80/Mcf in 2016, $3.91/Mcf in 2017, and $5.02/Mcf in 2020[17]. However, current gas prices are closer to $2 per McF of gas. Recognizing this historically low price environment, this memo has also calculated what the costs/reductions across North America would be at $2/Mcf gas.
  - That analysis finds that, even in this lower price environment, North America can still achieve a 42% reduction of its oil and gas methane emissions for 1 cent/Mcf gas produced, with a cost of reduction of approximately $2.32/Mcf methane reduced or $4.79/ton CO_2e . Additionally, even with this lower gas price there are still cost-savings. The value of the gas that can be recovered at today's low gas price equals approximately $491.5 million USD per year.

  If and when gas prices recover to more recent historical levels ($4/Mcf), the savings will increase and the cost-effectiveness of these actions will increase as outlined in this report.

Co-Benefits Exist – Reducing methane emissions will also reduce - at no extra cost - conventional pollutants that can harm public health and the environment. The methane reductions projected here would also result in a reduction in volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) associated with methane emissions from the oil and gas industry.

[17] EIA. Annual Energy Outlook, Table 13. April 14, 2015. Natural gas spot price at Henry Hub. Prices converted from MMbtu to Mcf using a factor of 1.028. Data available at http://www.eia.gov/forecasts/aeo/tables_ref.cfm