Expert support from:

Mobilizing Voluntary Carbon Markets to Drive Climate Action: What Does the Science Tell Us?

ACKNOWLEDGEMENTS
This paper was written and developed jointly by EDF and ENGIE Impact with support from the High Tide Foundation.
Contributing authors from EDF are: Kelley Kizzier, Ilissa Ocko, Steven Hamburg, Tianyi Sun, Alex Hanafi and Christa Ogata.
Contributing authors from ENGIE Impact are: Alexia Kelly, Kim Carnahan and Kristen Mertens.

April 2021

Introduction

This is the first in a series of papers that EDF and ENGIE Impact, with support from the High Tide Foundation, are developing to chart a path for voluntary carbon markets in the post-2020 world. This paper focuses on what the science tells us is central to developing effective strategies to address the impacts of global climate change. This paper presents a simple summary of the science of greenhouse gas (GHG) emissions and global climate change. It examines the actions and timeline needed to limit damages based on the best available scientific understanding. In order to achieve the temperature goals identified in the Paris Agreement, it seeks to answer:

- By how much do we need to reduce GHG emissions?
- By when do we need to reduce GHG emissions?

Key Messages

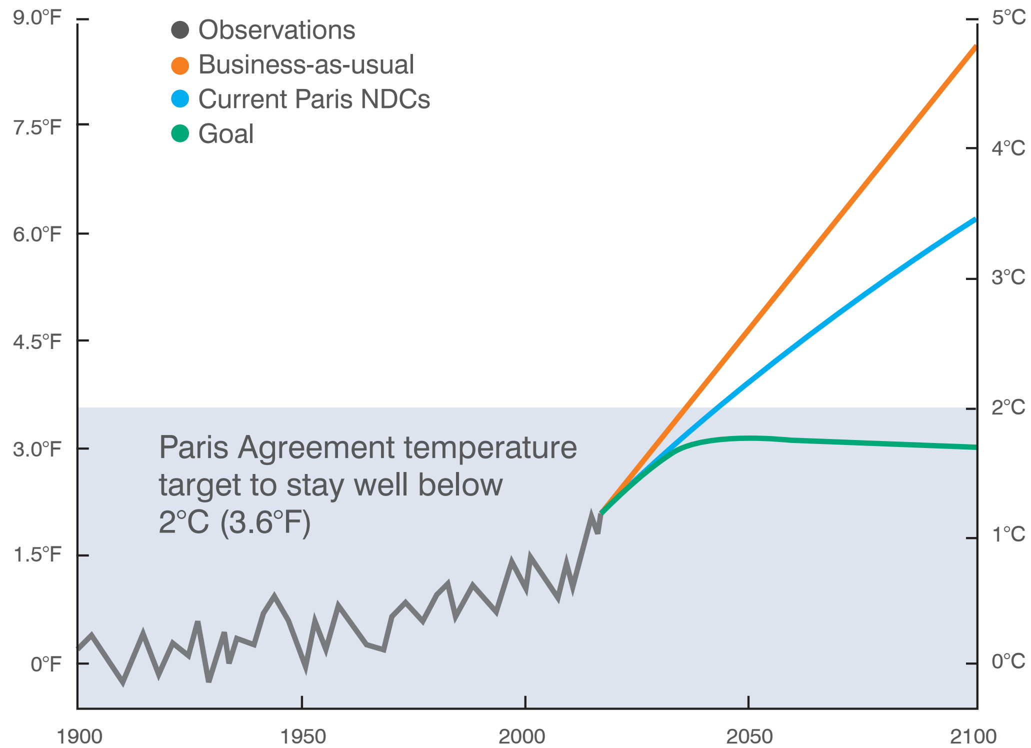
- There are two key factors that are important for limiting the severity of damage from climate change: how fast the planet warms and how high the warming gets. The effects on the environment caused by warming rate and maximum are both important.
- Warming rate is largely controlled by emissions of short-lived climate pollutants (e.g., methane), while maximum warming is largely controlled by long-lived climate pollutants (e.g., carbon dioxide).
- There are four levers needed to limit maximum warming and slow the rate of warming:

1. Budget long-lived pollutants (e.g., CO_2 emissions) to prevent build-up beyond a certain level;
2. Remove any remaining CO_2 emissions beyond the allowable level that cannot be reduced;
3. Protect current carbon stocks (i.e., forests, peatlands, etc.); and
4. Reduce the amount of short-lived climate pollutants now and maintain reductions in the future.

What the Science Tells Us

To date, human activities are estimated to have already caused around 1°C of warming above pre-industrial levels.[1] Given various characteristics of the climate system (such as the longevity of carbon dioxide emissions in the atmosphere and the uptake of heat by the ocean), the level of warming that we have experienced to date is largely irreversible on human timescales and further warming is expected even with total elimination of all GHG emissions. If climate change continues at its current rate, the best available science suggests that we will reach 1.5°C of warming above pre-industrial levels between 2030 and 2052.[2] The international goal is to limit warming in the 21st century to well below 2°C with an aspiration to limit warming to 1.5°C.[3] This will require aggressive action in the coming decades. Each increment of warming yields more damage to our lives and livelihoods. In the absence of action, we are on pace to reach nearly 5°C of warming by end of century (see Figure 1). Current commitments by the end of the Paris Agreement are insufficient — even if extended — and more ambitious targets are needed.

Figure 1. Observed and projected global mean temperature increase relative to preindustrial levels (1850-1900).



[1] https://www.ipcc.ch/sr15/chapter/spm/
[2] https://www.ipcc.ch/sr15/chapter/spm/
[3] https://unfccc.int/sites/default/files/english_paris_agreement.pdf

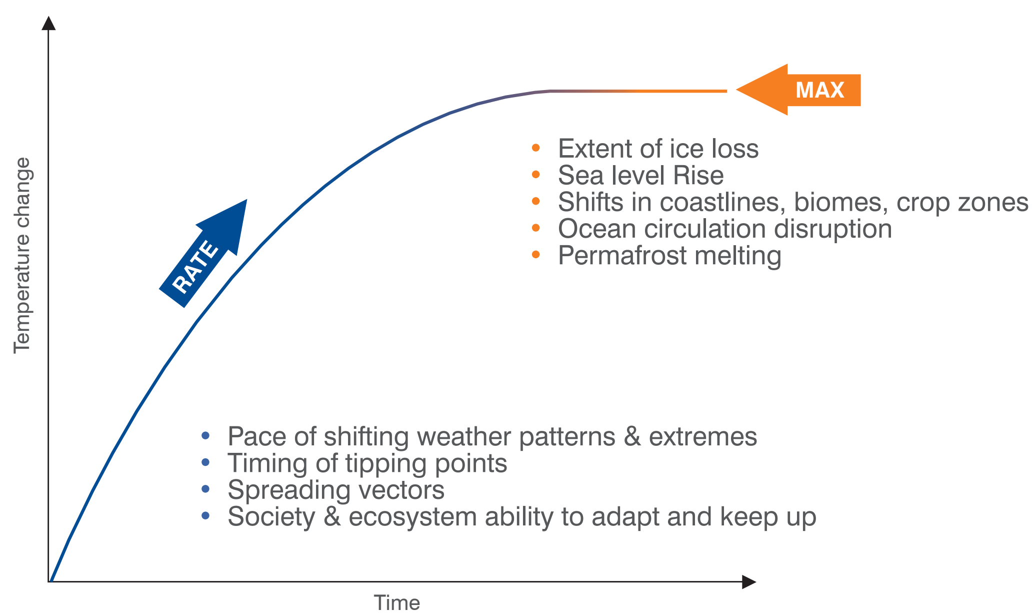
Understanding Global Warming Potential

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a non-CO_2 gas will trap in the climate system over a given period of time, relative to the emissions of 1 ton of CO_2 over the same period of time. The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years, although this downplays the strong near-term warming by short-lived climate pollutants. GWPs provide a common unit of measure, which allows the calculation of aggregated emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases.[4] While it is scientifically an imperfect measure that has drawn criticism over the years, it remains the standard metric used in climate-related policy. Best practice would require reporting emissions for two time horizons to convey climate implications of emissions in both the near- and long-term.[5]

The key factors that are important for limiting the damages from climate change are **maximum** temperature reached (e.g., the TOTAL intensity of warming such as 3° Celsius above pre-industrial levels) and **rate** of change of that temperature (e.g., how quickly the temperature rises over time). There are distinct impacts to society and ecosystems associated with both rate and maximum warming. Therefore, it is essential to address both warming aspects and find viable pathways as quickly as possible towards reducing both the rate of temperature change and the maximum increase in temperature above pre-industrial levels (see Figure 2).

The dominant factors that influence rate and maximum are: 1) short-lived climate pollutants, which drive the rate of warming, and 2) long-lived climate pollutants, which control the maximum temperature increase.[6,7] Short-lived climate pollutants have a powerful impact on global temperature but have a short atmospheric lifetime. Short-lived climate pollutants that cause warming (some cause cooling), such as CH4 and HFCs, control the rate of warming; thus, eliminating their emissions would have a near-immediate impact on slowing temperature rise. On the other hand, long-lived climate pollutants build up in the atmosphere over time and therefore control maximum temperature.

Figure 2. Environmental components associated with the rate of warming and the maximum of warming



[4] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials#:~:text=The%20Global%20Warming%20Potential%20(GWP,carbon%20dioxide%20(CO_2).

[5] Ocko et al., Science, 2017 https://science.sciencemag.org/content/356/6337/492.summary

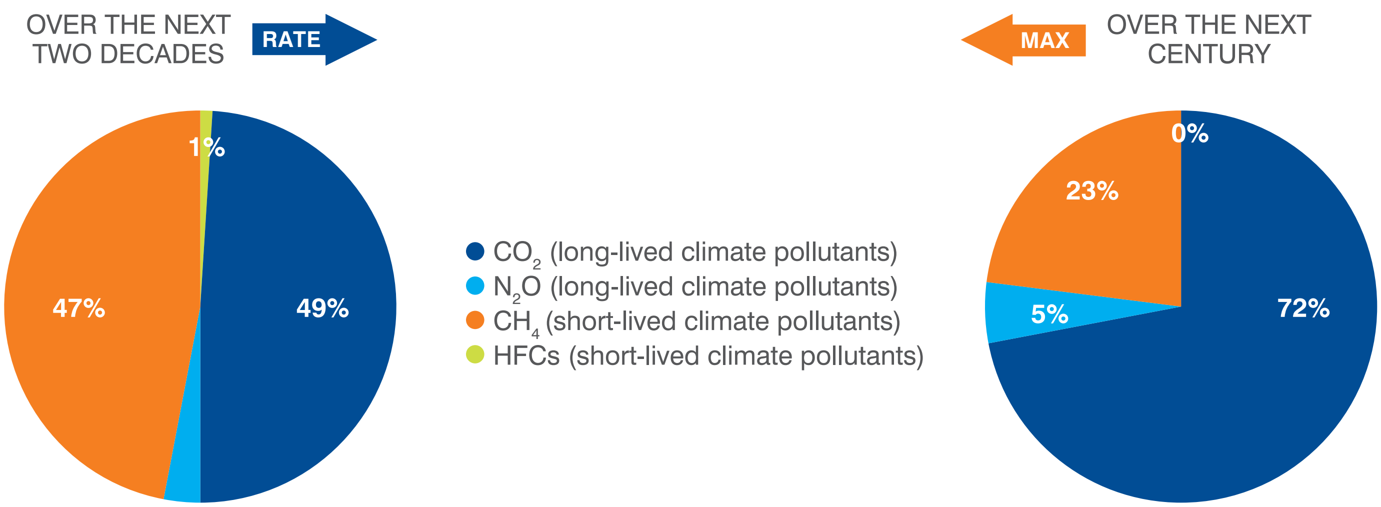
[6] Short-lived climate pollutants are primarily composed of those with short lifetimes in the atmosphere, such as methane (CH4), hydrofluorocarbon (HFC), ozone and aerosols, or their precursors.

[7] Long-lived climate pollutants are defined as carbon dioxide (CO_2) and nitrous oxide, and some fluorinated gases.

The same set of GHGs contribute to warming rate and maximum warming, but the contribution varies depending on the lifetime of the gases in the atmosphere (see Figure 3). For example, when considering how this year's emissions of CO_2, CH_4 (methane), N_2O (nitrous oxide) and HFCs (hydrofluorocarbons) will impact warming in the near-term, such as over the next two decades, the contribution of CH_4 and CO_2 are similar, whereas N_2O and HFCs play smaller roles. However, when considering the long-term impacts, such as over 100 years, the contribution of the short-lived climate pollutants (CH_4 and HFCs) are diminished compared to their near-term impacts — methane's impact is reduced to half — while the contribution of the long-lived climate pollutants grows significantly, due to their long-lasting lifespan.

This means that climate change mitigation strategies must address both short-lived climate pollutants, such as methane and HFCs, while at the same time actions are needed to curb long-term climate pollutants such as CO_2 and N_2O. (Note that while current HFC emissions are small, they are projected to grow considerably in the absence of any action to reduce their emissions.)

Figure 3. Climate impact of today's emissions of short-lived pollutants and long-lived pollutants over the next two decades vs. the next hundred years.



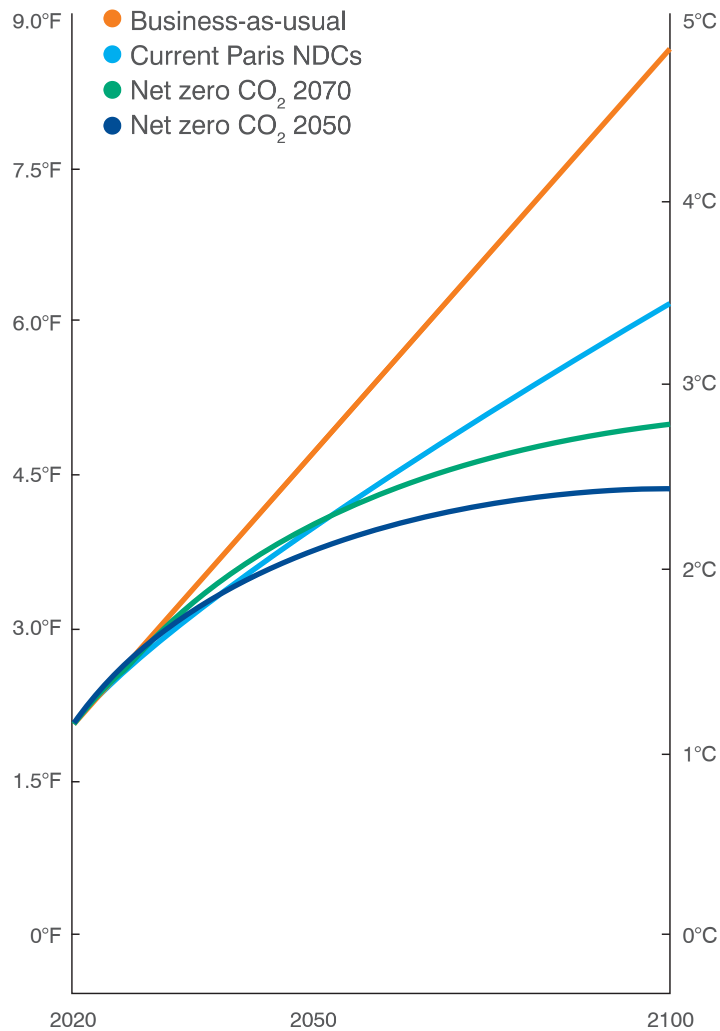
Four levers to limit maximum warming and slow the rate of warming

There are four primary levers to limit the maximum amount of warming and slow the rate of warming:

1. Set a budget for the amount of long-lived pollutants (e.g., CO_2) that we can emit in order to stay below temperature targets (the exact budget will depend on the temperature target and the probability of staying below that level of warming). This will prevent build-up of these gases in the atmosphere beyond a certain level.
2. Once the budget is reached, any residual long-lived climate pollutant emissions will need to be counterbalanced by permanent removal mechanisms such that there is no increase in their amount in the atmosphere (this is considered "net zero" emissions).
3. Protect current carbon stocks (i.e., forests) to avoid additional emissions of already stored CO_2. It takes a long time to reach the same level of stored carbon in a new, growing forest as an already existing forest.
4. Immediately and quickly begin reducing the emissions of short-lived climate pollutants to slow the rate of warming and sustain emissions reductions throughout the century to limit maximum warming.

Budgeting CO_2 emissions: Carbon dioxide emissions to date account for around half of today's warming, and future emissions are the dominant controller of maximum warming because they can last for hundreds of years in the atmosphere. Scientists have found that the level of global warming from CO_2 ultimately depends on the overall amount emitted from human activities; to stay below a certain level (such as 1.5 or 2°C), we have to cap emissions at a certain amount referred to as a "carbon budget." To stick within this set budget, global CO_2 emissions must be brought down drastically from current levels over the next several decades as we will far exceed this budget too quickly at current emission rates.

Figure 4. Projected global mean temperature increase under various CO2 emissions pathways.



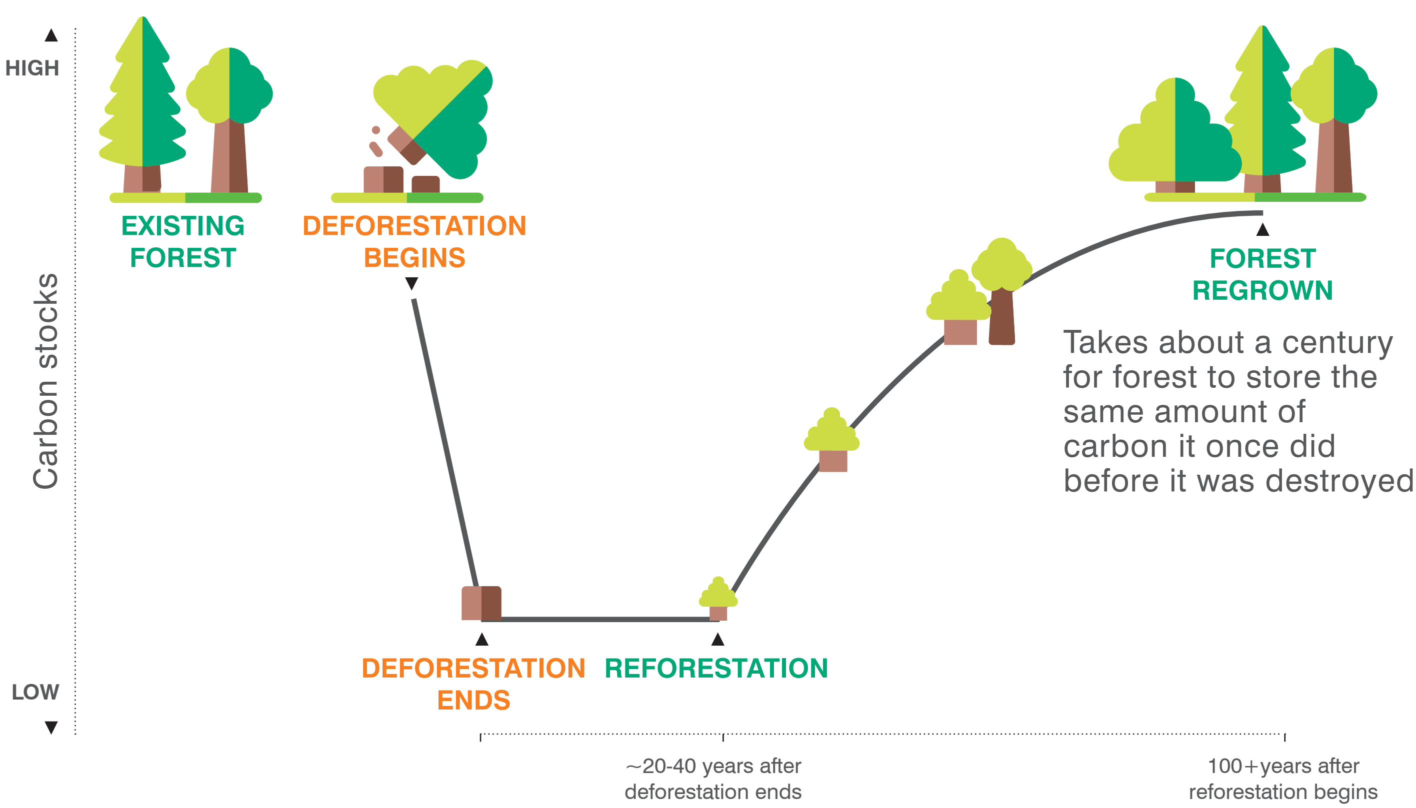
Source: Observations from NOAA. Projections from MAGICC model using JRC GECO (2018) scenarios and RCP 8.5 emissions.

Achieving net zero CO_2 emissions: When we have emitted the full CO_2 budget, we must reach a point where no more CO_2 is emitted than can be simultaneously removed — this is considered net zero CO_2 emissions. Of various pathways considered by scientists to stay within a carbon budget consistent with the Paris Agreement temperature targets, net zero CO_2 emissions will need to be achieved sometime during this century, and likely around midcentury. The later the date when we reach net zero, the more CO_2 is emitted into the atmosphere, hence the warmer the Earth (see Figure 4). While removal mechanisms — both technological and nature-based — will become essential in balancing residual CO_2 emissions in the future, they cannot be heavily relied upon at this moment based on the maturity and cost of these interventions (this is why drastic emissions cuts are still needed). However, the more that we are eventually able to remove from the atmosphere relative to residual emissions, the lower the maximum rate of warming.

Protecting current carbon stocks: Protecting current carbon stocks is far more economical and effective than growing new forests. Once currently stored (or sequestered) carbon stocks are re-released into the atmosphere, it takes decades to store that carbon again through natural means. Therefore, the climate benefits from new forests will not be the same as the current benefits of existing forests for a long time (on the order of 100 years). Additionally, deforestation will both eliminate the carbon sink and emit CO_2 (see Figure 5).

Protection of current carbon stocks will play an important role in preventing additional CO_2 emissions. The "hysteresis mechanism" is vital when looking at existing stocks and systems. The concept of hysteresis, in an ecological context, is that once a system is changed, the effects cannot be undone with the expectation that you will be able to replicate or reflect its original state. In the case of forests, it will take 100 years or more to return to where it was. This is because in a reforestation process, the rate at which forest grows back is relatively slow. Until then, the environment and climate system will be entirely different and the world will be unable to transition back to where it was before. Therefore, the climate benefits of reforestation would be much smaller than avoiding the release of already stored carbon through avoided deforestation.

Figure 5. Changes in carbon stocks over time due to deforestation and reforestation



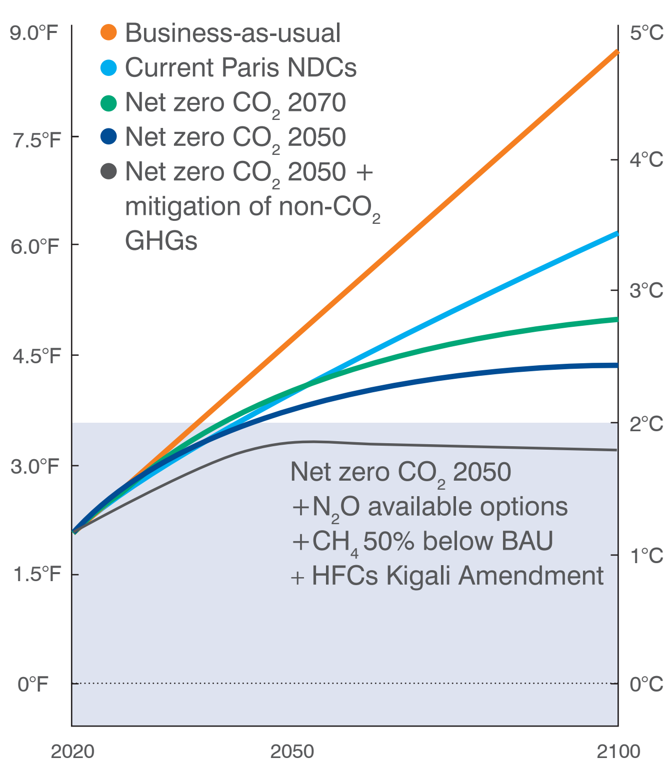
Reducing emissions of short-lived climate pollutants (SLCPs): With projected emissions of SLCPs based on no further climate action, we will not achieve long-term temperature goals without slashing SLCP emissions rates by midcentury at the latest (see Figure 6). The IPCC suggests at least a 35% cut in methane and black carbon (a component of particulate matter that is a powerful SLCP) emissions below 2010 levels by midcentury.[8] Overall, a holistic approach of reducing both short- and long-live climate pollutants is critical to keep warming below 2°C.

Further, if emissions of SLCPs are reduced immediately, we can slow the rate of warming over the next few decades — thus avoiding additional damages before midcentury. While the long-term climate benefit of reducing the same amount of methane emissions benefits today versus later is similar, the timing of methane reduction will have a substantial impact on warming before mid-century. This is because methane accounts for around a quarter of warming today but is short-lived in the atmosphere, and thus has near-immediate benefits when emissions are reduced. Methane can also be relatively easy and inexpensive to abate from certain sectors, and thus offers an important mitigation opportunity.

In summary, all individual GHGs need to be considered and addressed to limit global warming. While it is important to reach net zero CO_2 emissions to stay within a set carbon dioxide budget, it is also important to reduce emissions of short-lived climate pollutants. The exact timing of net zero CO_2 will be determined by the overall carbon budget and how fast we can reduce emissions, and the timing of short-lived climate pollutant emissions reductions will greatly impact how much we can slow the rate of warming and limit damages in the near-term.

The science is clear that both short- and long-lived climate pollutant emissions reductions are necessary to address climate change. In order to address all individual GHGs effectively and on timeframes that are meaningful, various approaches will be needed and will include a combination of market-based and non-market-based approaches under separate frameworks and regulatory systems. While not a panacea, and certainly not without their challenges, well-designed carbon markets can accelerate and advance additional emission reductions and avoided emissions in a range of critical sectors and should be considered in climate mitigation strategies moving forward. The next installment of this paper explores the growing demand in the voluntary carbon markets and factors that may impact the market going forward.

Figure 6. Reducing emissions of short-lived climate pollutants



Source: Observations from NOAA. Projections from MAGICC model using JRC

[8] IPCC Special Report on Global Warming 1.5° 2018