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ENVIRONMENTAL DEFENSE FUND
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March 2021

Recapturing U.S. Leadership on Climate

Setting an Ambitious and Credible Nationally Determined Contribution

To meet the scale of the climate crisis and recapture its role as a global climate leader, the United States should put forward a new ambitious and credible NDC with a target of reducing total net U.S. greenhouse gas emissions at least 50% below 2005 levels by 2030, charting an emissions path consistent with Paris Agreement temperature targets. This goal is within reach with a whole-of-government effort encompassing robust administrative action and new legislation in Congress, including investments in low-carbon technologies and infrastructure as well as policies that ensure reductions in emissions.

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Executive Summary

Climate change is a global challenge that demands a global solution. After four years of federal inaction and backtracking on climate, proactive reengagement by the United States in international climate diplomacy will be critical to advancing global efforts to meet the Paris Agreement goal of limiting global temperature rise to well below 2 degrees Celsius (2°C). President Biden's move to reenter the United States into the Paris Agreement on the first day of his administration was crucial—but was only the first step.

When it was adopted with the help of U.S. leadership in 2015, the Paris Agreement signaled a new frontier in the global fight against climate change, in which all of the world's countries committed to contribute in line with their national capabilities. In advance of Paris, the United States put forward a nationally determined contribution (NDC) with a target of reducing total net U.S. greenhouse gas (GHG) emissions 26-28% below 2005 levels by 2025. Then, in June 2017, less than six months after taking office, former President Trump announced his intention to withdraw the United States from the Paris Agreement, deeply damaging America's reputation. To regain U.S. credibility on the world stage, rebuild trust, and demonstrate the seriousness of the U.S. commitment to addressing climate change, the Biden administration must put forward a new NDC for 2030 that is both ambitious and credible, while taking immediate concrete steps to cut emissions in line with meeting that goal.

The new NDC must be ambitious enough to meet the pace and scale of the climate crisis and signal renewed commitment to meeting global temperature targets. That means setting a target that will put the United States on track to achieve net zero GHG emissions no later than 2050 and slow the rate of warming between now and then—goals that are consistent with what the science tells us is necessary globally to avert the worst impacts of climate change on people and the environment and one that has been embraced by the Biden-Harris administration. To be perceived as ambitious internationally, the new U.S. NDC must also be commensurate with those of similar economies such as the United Kingdom (UK) and European Union (EU), which have committed to net zero GHG emissions by 2050 and to reducing emissions by 68% and 55% respectively from 1990 levels by 2030.

At the same time, the new NDC must be credible—meaning that one or more technically and economically viable policy pathways can be identified to achieve it. Credibility is important in order to promote confidence in the Paris process; pledging a level of emissions reductions that is clearly out of reach would undermine the value of the NDC. At the same time, credibility also requires a willingness to act boldly and immediately to reduce emissions of multiple greenhouse gases with special emphasis on carbon dioxide (CO_2) and methane, the two most impactful, using every tool available, including existing law as well as new legislation. Credibility also requires that the NDC be developed in a transparent and inclusive process—with input from stakeholders across the United States, including the private sector and civil society.

To meet the need for ambition and credibility, the United States should put forward a new NDC with a target of reducing total net U.S. GHG emissions at least 50% below 2005 levels by 2030. As a component of the new NDC, the Administration should include an explicit commitment to reduce methane emissions in order to help slow the rate of warming over the coming couple of decades and limit peak warming. Given currently available mitigation technologies and approaches, a target of reducing methane emissions by 40% below 2005 levels by 2030 economy-wide is reasonable and would be broadly consistent with the "topline" goal of at least a 50% reduction in GHG emissions across the economy. Meeting these goals would put the United States on an emissions path consistent with achieving international temperature goals. Including an ambitious methane target will enable important reductions in near-term warming; delaying these reductions will result in more rapid near-term warming and a higher peak warming even if the overall temperature goals are met. These goals are within reach with an all-in, whole-of-government effort including swift action from the administration and new legislation in Congress to jumpstart the transformative change needed to bend the emissions curve down towards net zero GHG emissions no later than 2050.

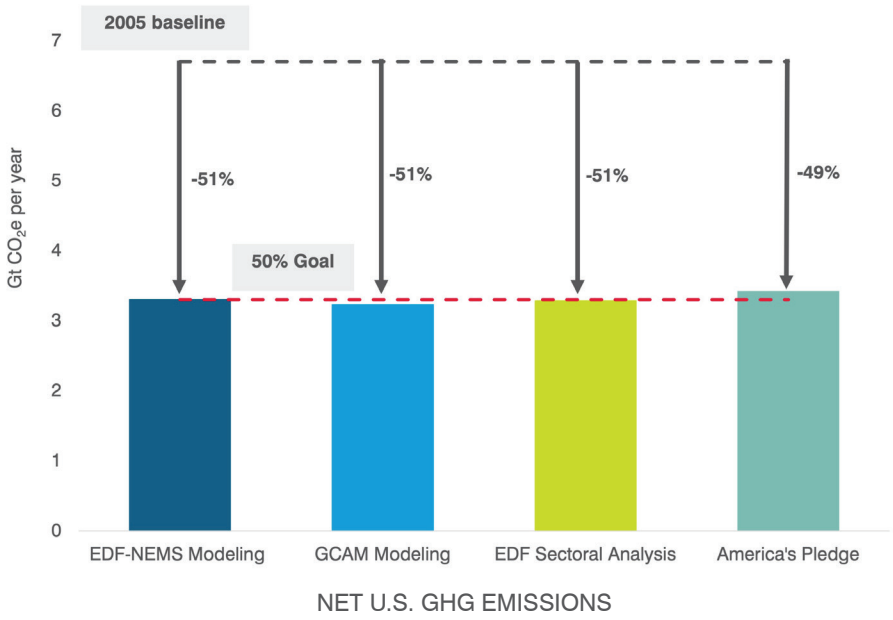
Independent analyses from different sources, using a range of modeling approaches and varied

assumptions, demonstrate the feasibility of reaching 50% GHG reductions by 2030 (see Figure below)—and there is strong evidence that even greater reductions are possible. Meeting this target will require the Biden administration and Congress to deploy all of the tools available. This includes adopting a suite of robust climate and clean air protections under existing law addressing the pollution emitted from the power and transportation sectors, as well as methane emissions from oil and gas; directing significant economic recovery dollars towards accelerated deployment of clean electricity and electric vehicles and supporting infrastructure and manufacturing; new legislation that limits pollution from the power sector, such as a clean electricity standard; increasing federal investment in innovation and demonstration of promising emerging technologies; and supporting state efforts to cut emissions. Crucially, in order to ensure we meet the new NDC, President Biden must work with Congress to enact new legislation that establishes enforceable declining limits on pollution across the economy. This will not only serve as a backstop mechanism to guarantee the United States hits both its near-term and long-term goals but will also supercharge and align efforts to cut pollution across all sectors and industries, moving us more quickly and affordably towards our net zero goal.

A 2030 NDC which is perceived domestically and internationally as both ambitious and credible will restore America's leadership on a global priority, extending our nation's reach and bolstering efforts to promote other American values abroad. It will also help revitalize international action on climate change, galvanizing increased ambition around the world, including from major emitters like China and India, where dramatic emissions reductions are necessary to meet global temperature goals.

The United States has much to gain from charting an ambitious path on climate over the coming decade. Well-designed climate policy can offer myriad benefits for American workers and consumers, including reducing near-term climate disruptions and the associated damages while creating millions of good jobs, avoiding hundreds of thousands of premature deaths from air pollution, promoting equity and reducing disparities in access to clean air and water, and positioning the United States to be a strong competitor in the growing global clean energy economy. Importantly, *how* we get to our new 2030 goal matters—to ensure we capture these benefits, policymakers must be intentional and thoughtful about policy design that works for Americans across the country.

A range of analyses demonstrate that the United States can cut GHG emissions at least 50% below 2005 level by 2030



Notes: Figure reports results from Environmental Defense Fund (EDF) using the RHG-NEMS model (EDF-NEMS Modeling); the University of Maryland Center for Global Sustainability using the GCAM-USA model (GCAM Modeling); EDF "bottom-up" analysis of sector-by-sector mitigation opportunities (EDF Sectoral Analysis); and America's Pledge using the ATHENA and GCAM-USA models. Emissions data include all GHGs and rely on AR4 100-year global warming potential (GWP) values. Reductions in 2030 are depicted according to the 2005 baseline used in each respective analysis. The 2005 baseline depicted by the gray dotted line relies on EPA's GHG Inventory baseline adjusted upward based on EDF's analysis of oil and gas methane emissions.

Introduction

On January 20th, hours after taking office, President Biden made good on his promise to reenter the Paris Agreement. The reentry took effect on February 19th, 2021. The landmark Paris Agreement is a legally binding international accord on climate change adopted by 196 countries in Paris on December 12th, 2015, and subsequently ratified by 190 countries.[1] The agreement significantly strengthens the global response to climate change in recognition of the fact that climate change is a global problem that requires a global solution. The major objective of the Paris Agreement is to limit global temperature increase to well below 2°C above pre-industrial levels, while pursuing efforts to limit the temperature increase to 1.5°C. The Paris Agreement requires each country to prepare, communicate, and maintain successive NDCs that it intends to achieve, as well as to report fully and transparently on its progress toward meeting those targets. The NDC submitted by the United States in advance of the Paris Agreement is no longer in effect due to the formal withdrawal of the United States from the Paris Agreement in November of 2020. Now that the Biden administration has rejoined the agreement, the United States will need to submit a new NDC.

This report makes the case that in order to be both ambitious and credible, the new NDC the United States puts forward should include a target of reducing total net U.S. GHG emissions at least 50% below 2005 levels by 2030. This would signal that the Unites States is aligned with the science and commitments of our international allies, help to rebuild our international credibility, recapture U.S. climate leadership, and position the country to be a strong competitor in the 21st century global clean energy economy.

The remainder of the introduction speaks to the importance of renewed U.S. climate leadership on the world stage, the urgent need for international action on climate, and the imperative of new commitments to ratchet up ambition under the Paris Agreement. The following section argues that the bar for ambition requires that the new U.S. NDC align with the science, be commensurate with commitments made by other advanced economies, and go beyond the straight-line emissions trajectory to cut more emissions in early years to achieve at least a 50% reduction in emissions by 2030 on the path to net zero by 2050. The final section presents a range of analyses demonstrating that this 2030 target is not only feasible, but that multiple policy pathways exist for meeting it, while illustrating that the credibility of the target will depend on a whole-of-government approach, including robust action under existing authority as well as new legislation from Congress.

The Importance of Renewed U.S. Leadership

Over the past four years, the world watched the Trump administration abandon U.S. international climate commitments, attack the suite of climate and clean air protections put in place under the Obama administration, deny foundational climate science, and ignore the impacts of climate change already affecting Americans across the country. Not only has the abdication of U.S. federal leadership—once a driving force for global climate action and ambition—damaged America's reputation on the world stage, it set back global efforts to confront the climate crisis, despite progress made by other countries and some U.S. state and local governments.

[1] The countries that have not yet ratified are Eritrea, Iran, Iraq, Libya, South Sudan, Turkey, and Yemen. See https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en.

Timeline of U.S. Participation in the Paris Agreement

December 2009	U.S. diplomacy at the 15th Conference of the Parties (COP15) of the UN Framework Convention on Climate Change (UNFCCC) helps secure the Copenhagen Accord, marking the first time that major developing countries including China agree to reduce their own emissions.
December 2011	At COP17 in Durban, South Africa, countries formally decide to develop a new climate agreement that includes commitments from "all Parties."
November 2014	The United States and China jointly announce their intended nationally determined contributions (INDCs) more than a year ahead of the Paris conference. The United States announces a target of reducing emissions by 26-28% below 2005 levels by 2025.
March 2015	The U.S. State Department formally submits the INDC to the UNFCCC.[2]
December 2015	The Paris Agreement is adopted in Paris by 196 Countries at COP21.
September 2016	President Obama deposits the United States instrument of acceptance with the United Nations Secretary General to join the Paris Agreement.
October 2016	With the deposit of the instruments of ratification of the EU countries, the Paris Agreement threshold of at least 55 countries accounting for at least an estimated 55% of global GHG emissions having deposited their instruments of ratification, acceptance, approval or accession is met, triggering the conditions for the agreement to enter into force.
November 2016	The United States presents its 'Mid Century Strategy for Deep Decarbonization' to the UNFCCC setting out economy-wide net GHG emissions reductions of 80% or more below 2005 levels by 2050.
November 2016	The Paris Agreement enters into force.
June 2017	President Trump announces his intent to withdraw from the Paris Agreement.
November 2019	The Trump administration files formal notice of withdrawal from the Paris Agreement, to take effect one year later. This was the earliest possible date for notice and effect according to Article 28 of the Paris Agreement.
November 2020	The United States formally withdraws from the Paris Agreement, effectively annulling the 2025 NDC.
January 2021	President Biden signs an executive order reentering the Paris Agreement.
February 2021	The reentry of the United States to the Paris Agreement takes effect.

[2] This was submitted to the UNFCCC as the United States' Intended Nationally Determined Contribution (INDC). The decisions that give effect to the Paris Agreement make clear that the INDC is considered to be the communicated NDC unless the Party decides otherwise. As a result, the INDC submitted by the United States effectively became the NDC when the United States deposited their instrument of acceptance.

In the face of federal inaction on climate, U.S. state and local governments stepped up. The "We Are Still In" movement—a joint declaration expressing support for the Paris Agreement and calling for a net zero trajectory for the United States—attracted nearly 4000 businesses, state and local elected officials, tribal and faith leaders, universities, and others. These commitments were foundational to building momentum towards climate progress, but there remains significant work to do to translate these commitments into concrete policies that can cut climate pollution and deliver results at the scale required to meet our climate goals. Despite the commitments of subnational actors to achieve state-level reductions consistent with the Paris Agreement goals, emissions projections pre-COVID showed that the United States was far from being on the path to reaching the original U.S. NDC commitment to reduce emissions 26-28% below 2005 levels by 2025. If the 25 states with climate commitments had put in place policies to limit pollution consistent with this target, the United States would have been a third of the way closer to hitting the target.[3] While this illustrates that states have the potential to deliver meaningful abatement with binding policies, it also underscores the imperative for strong federal policy frameworks alongside ambitious state and corporate action to deliver the necessary outcomes.[4]

Recapturing U.S. federal leadership in the wake of the last four years will not be easy, but it is critically important for leveraging the strong collective global response to climate needed to meet the goals set out in the Paris Agreement. The Paris Agreement is significant because it requires all of the world's countries to have national commitments to combat climate change, but without the major emitters, the impact of the agreement is diminished. The United States, the EU, and China represent over 40% of global GHG emissions, and the G20 countries collectively emit more than 80% of global GHG emissions. When the United States announced its intention to withdraw from the Paris Agreement, the balance of the agreement was thrown. With the United States back in, balance can be restored and the United States can bring its diplomatic weight to bear to press for global ambition.

The Urgent Need for International Action

A 2018 report from the Intergovernmental Panel on Climate Change (IPCC) shows that, to stabilize our climate and contain the risk of potentially catastrophic outcomes, global CO_2 emissions must decline to net zero—meaning the world is emitting no more than we remove from the atmosphere—around midcentury,[5] along with dramatic reductions of powerful non-CO_2 GHGs like methane. Further, reducing emissions of short-lived climate pollutants such as methane rapidly and soon will reduce the near-term rate of warming—with major reductions in climate-caused damage to society and ecosystems. For more on the science behind these targets, see the textbox on pg. 10.

The stakes for not meeting these targets are enormously high. Scientists warn that temperature rise above the 1.5 to 2°C range carries increasing risks of disastrous outcomes for human wellbeing, ranging from more frequent and severe risk of extreme heat, droughts, floods, wildfires, intense hurricanes, and infectious diseases to sea level rise and the deterioration of ecosystems that humans depend on for food, employment, and recreation. Every fraction of a degree of increased warming leads to greater likelihood of harm and increases the risk of triggering dangerous climatic tipping points and catastrophic outcomes, making it imperative that the United States and the rest of the global community move aggressively to limit global temperature rise to the slowest rate of increase and the lowest total amount of warming possible.

[3] EDF, "Turning Climate Commitments into Results: Progress on State-Led Climate Action", https://www.edf.org/sites/default/files/documents/FINAL_State%20Emission%20Gap%20Analysis.pdf.

[4] Kate Larsen et al., "Taking Stock 2020: The COVID-19 Edition" (Rhodium Group, July 9, 2020), https://rhg.com/wp-content/uploads/2020/07/Taking-Stock-2020-The-COVID-19-Edition.pdf.

[5] Specifically, net zero is defined as a state where anthropogenic emissions by sources are balanced by anthropogenic removals by sinks. (IPCC, "Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty," 2018.)

The Imperative to Ratchet Up Ambition

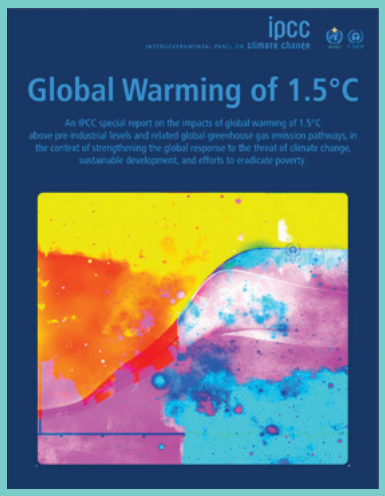
The initial set of NDCs put forward in Paris in 2015 put us on a path to a 3°C or greater increase in global temperatures, woefully shy of even the 2°C goal.[6] It was clear from the outset that much greater emission reduction efforts would be required. The Paris Agreement accounted for the need to continually increase ambition, requiring countries to come forward with new or updated NDCs every five years. The second round of NDCs was due in 2020 in advance of COP26. However, due to the pandemic, the COP was delayed and is now scheduled to be held in Glasgow in November of this year.

A growing number of countries have already committed to net zero or climate neutrality goals and many have already put forward new or updated NDCs consistent with a net zero pathway (see Appendix B). The EU has committed to climate neutrality by 2050 and is in the process of enshrining this commitment in law. The UK was one of the first countries to enact a net zero commitment in law and Japan, New Zealand, Norway, Costa Rica, Switzerland and others have also established net zero policies or laws as part of their long-term climate strategies. In September 2020, China's President Xi Jinping committed his country to achieving carbon neutrality by 2060 at the UN General Assembly.

After the climate inaction that defined the Trump administration, the United States must move decisively to overcome our credibility deficit with international partners. As the world turns toward the next round of international negotiations, the Biden administration has an opportunity to rebuild trust and demonstrate the seriousness of the United States' climate commitment.

[6] United Nations Environment Program, "Emissions Gap Report 2020" (Nairobi, 2020), http://www.unep.org/emissions-gap-report-2020.

The Science of Staying Below 2°C



Stabilizing the climate below 2°C will require preventing further build-up of GHG emissions in the atmosphere beyond a certain point. Given that long-lived climate pollutants—predominantly CO_2 and to a lesser extent nitrous oxide—can last for a century or longer in the atmosphere, we need to drastically reduce their emissions or balance via negative emissions as soon as possible, and ultimately achieve net zero emissions, where we are adding no more than we are simultaneously removing. It is important to note that greater reductions in emissions of short-lived climate pollutants than those required to maintain constant radiative warming (e.g., a 40% reduction for methane) would offset some net CO_2 emissions, requiring lower levels or even no negative emissions to offset the hard to eliminate sources of CO_2 emissions.[7] For short-lived climate pollutants that last from weeks to decades – such as methane, black carbon, and hydrofluorocarbons (HFCs)—we do not need to achieve net zero emissions, but we must reduce their rate of emissions to a level that maintains a stable impact on the climate. Even greater reductions are highly desirable since this is a powerful tool in reducing overall warming and equally important in slowing the rate of near-term warming and the concomitant increases in climate-caused damages to society and the environment.

In a special report published in 2018, the IPCC analyzed more than 100 emissions scenarios that were consistent with a 2°C target, and nearly 100 more that were consistent with a 1.5°C target. While several different pathways can achieve the same outcome, average characteristics of the pathways show net zero CO_2 emissions achieved around midcentury for 1.5°C pathways, and around 2070 for 2°C pathways. For 1.5°C in particular, this corresponds to on average around a 50% reduction in CO_2 emissions globally by 2030 (relative to 2010 levels). The overall amount of CO_2 emitted before net zero is achieved determines the amount of negative emissions needed afterwards: if we stay within a set "carbon budget," fewer negative emissions or fewer reductions in emissions of short-lived climate pollutants are required. Non-CO_2 emissions do not reach zero globally for any of these pathways, but are considerably reduced relative to present-day levels—such as around 40% reduction in methane and black carbon by midcentury. When the non-CO_2 scenarios are combined with the CO_2 scenarios (both positive and negative emissions for the latter)—which requires a metric such as global warming potential (GWP) to allow comparisons of the climate impacts of different greenhouse gases—it gives a sense that net zero GHG emissions occur around 2070 to be consistent with a 1.5°C target, and around 2100 or even later for 2°C.

[7] Rogelj, J., Meinshausen, M., Schaeffer, M., Knutti, R. & Riahi, K. Impact of short-lived non-CO_2 mitigation on carbon budgets for stabilizing global warming. Environ Res Lett 10, 075001 (2015).

Raising the Bar for Ambition

In order to signal to the world that the United States is serious about confronting the climate crisis, the next NDC must put the United States on the path to economy-wide net zero GHG emissions by 2050, consistent with meeting global temperature goals. Moreover, the United States has both the ability and the responsibility as an advanced economy and the world's second largest emitter to demonstrate leadership and move even more rapidly than the trajectory implied by a simple straight-line emissions trajectory to net zero. The Paris Agreement establishes that all NDCs will represent a progression beyond the previous NDC and a country's highest possible ambition.

To be consistent with this provision and commensurate with NDCs recently set forth by other advanced economies, the Biden administration should put forward an ambitious target of reducing total net U.S. GHG emissions at least 50% below 2005 levels by 2030. As a component of the new NDC, the administration should include an explicit commitment to reduce methane emissions in order to help slow the rate of warming over the coming decades and limit peak warming. Given currently available mitigation technologies and approaches, a target of reducing methane emissions by 40% below 2005 levels by 2030 economy-wide is reasonable and would be broadly consistent with the "topline" goal of at least a 50% reduction in GHG emissions across the economy (See Appendix C for more information on the methane target).

In setting the NDC, the United States should also demonstrate best practice, including by specifying a specific quantifiable value (i.e., 50%) for the target year of 2030, rather than a target range (e.g. 26-28%); precisely identifying target years and timeframes for implementation, noting that a multi-year budget approach to the target is more environmentally robust than a single year or point target; identifying all assumptions and methodologies underpinning the NDC, including the approach to accounting for land use and forests; specifying how the NDC will be implemented; describing how it is fair and ambitious; and specifying how it contributes to meeting the Paris Agreement temperature goals. The United States should also consider setting a multi-year budget, reflecting the fact that climate change is driven by the accumulation of GHGs in the atmosphere rather than emissions in any single year. (See text box on pg. 12).

In the Weeds: Getting the Details Right on the Next NDC

There were significant transparency gaps in the initial NDCs that made it difficult to understand the resulting emissions levels or reductions, the gases and sectors covered, the data and accounting underpinning the headline targets, and the timelines associated with the NDCs. To address this problem, the Paris Agreement "rulebook," made up of a series of decisions agreed to at COP24 in 2018, sets out the information needed for clarity, transparency and understanding (CTU) of the NDCs. In updating NDCs, countries must provide the following information:

Quantifiable information on the reference point or base year: This includes information on the reference year or years and how the emissions are quantified in that year. For instance, many countries use 1990 as the reference year (e.g. the EU NDC is a 55% reduction below 1990). Some countries have different reference years for different gases (e.g. UK uses 1990 for CO_2, methane, and nitrous oxide, and 1995 for HFCs, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride). The United States, in its first NDC, used a 2005 reference year for all GHGs.

Timeframes or periods for implementation: This includes information on the implementation period (e.g. from January 1st, 2021 to December 31st, 2030) and whether the target is a single-year target (where the target is achieved in the target year) or multi-year target (which establishes a budget of emissions over the multi-year period). A single-year target, sometimes called a "point" target, only requires a country to achieve the reduction (e.g. 50%) in the target year (e.g. 2030). A multi-year target, on the other hand, establishes a 'budget' of emissions over the whole period. The budget can be based on average emissions over the period or based on a trajectory over the period. A point target offers little flexibility, raising the risk that external shocks, such as weather, drought or disease in the target year create challenges for NDC achievement. A multi-year approach offers more flexibility and so mitigates this risk as higher emissions in any given year can be offset by lower emissions in other years over the period.

Information on scope and coverage: This includes information on the sectors and gases covered by the NDC. The United States, as an advanced economy, should have an economy-wide NDC with an absolute emissions reduction target. Developing countries might not initially have economy-wide targets, but are encouraged to move towards economy-wide targets over time.

Planning processes: This includes information on the processes to prepare the NDC and information on implementation.

Information crucial to accounting: This includes information on the assumptions and methodological approaches to support the assessment of progress toward and achievement of the NDCs. Accounting information is critical for understanding progress towards NDCs, including when countries cooperate through carbon market mechanisms.

Information on fairness and ambition: This includes information about how the country considers that its nationally determined contribution is fair and ambitious in light of its national circumstances, reflecting on equity, and how the NDC represents a progression on the previous NDC.

Contribution to objectives: This includes information on how the NDC contributes to the temperature goals of the Paris Agreement and the objective of the UNFCCC.

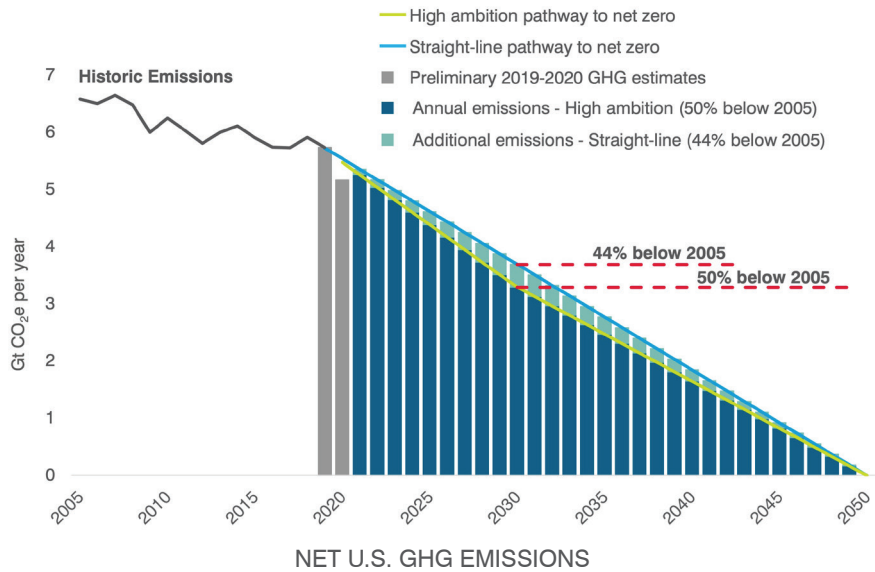
Setting a new NDC Consistent with a Path to Net Zero

A straight-line trajectory from 2018 GHG emissions levels—the most recent year for which historical emissions data has been finalized—to net zero by 2050 would imply an emissions reduction of roughly 44% by 2030 relative to 2005 (see Figure 1).[8] It is worth noting that emissions dropped significantly in 2020 due to the COVID-19 pandemic. Using preliminary projected net GHG emissions in 2020 from the Rhodium Group (RHG),[9] the 2030 target implied by the straight-line path to net zero is roughly 48% below 2005 levels. This drop in emissions has come at an enormous and tragic cost—making investments that can simultaneously accelerate clean energy deployment while creating good paying jobs, improving health, and promoting equity even more urgent.

Aiming for a "front-loaded" trajectory—one where we cut emissions more in early years than would be implied by the straight-line path—comes with significant climate benefits over all timescales. Early mitigation of short-lived climate pollutants, such as methane, can significantly slow down the rate of warming in the near-term, and with it, climate damages, while allowing for the same maximum warming to be reached even if CO_2 emissions persist to a limited degree past 2050. Similarly, early mitigation of long-lived climate pollutants, such as CO_2, reduces the increase in atmospheric concentrations, which is essential for limiting long-term warming and achieving eventual climate stabilization.

In addition, if we can reduce more emissions in earlier years, we will increase our chances of meeting domestic and international climate goals and allow greater flexibility down the road as we tackle more difficult-to-abate emissions from sectors such as heavy industry and aviation. Overall, aiming for more reductions than the straight-line path will unlock greater ambition at home and abroad and help position the United States to be a strong competitor in the 21st century global clean energy economy.

Figure 1: High Ambition and Straight-line Paths to Net Zero by 2050



Notes: Emissions data include all GHGs and rely on AR4 100-year GWP values. 2005-2018 emissions are from EPA's GHG Inventory. Progress toward net zero 2050 emissions begins in 2018 and does not adjust based on preliminary RHG 2019-20 GHG estimates.

[8] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018," 2020, https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf.

[9] Kate Larsen, Hannah Pitt, and Alfredo Rivera, "Preliminary US Greenhouse Gas Emissions Estimates for 2020," Research Note (Rhodium Group, January 12, 2021), https://rhg.com/research/preliminary-us-emissions-2020/.

A Fair and Ambitious NDC to Enable Greater Climate Ambition Abroad

When submitting its NDC, the Biden administration will be required to describe how the new U.S. contribution is fair and ambitious in light of its national circumstances and reflecting on equity. In order to be credible, the U.S. NDC will be expected to be comparable to those put forward by other advanced economies. To date, 72 countries representing more than 28% of global emissions have submitted new or updated NDCs. Most advanced economies have submitted NDCs with enhanced ambition consistent with climate neutrality by 2050. In December 2020, the EU enhanced its NDC target from a 40% reduction to a 55% reduction from 1990 levels by 2030. The UK submitted an NDC increasing its target from a 53% reduction[10] to a 68% reduction on 1990 levels by 2030 and Norway and Switzerland have both committed to at least 50% reductions by 2030. Each of these updated NDCs address the issue of fairness by confirming that the NDC puts the country or region strongly on the path recommended by the IPCC and consistent with achieving net zero emissions by 2050. If the U.S. NDC is not commensurate with this level of ambition, the United States will continue to face serious international credibility challenges.

A credible and ambitious NDC—one that targets at least a 50% reduction from 2005 levels by 2030—will provide the foundation for global U.S. leadership on climate, including in an array of critical forums like the G7 and the G20, the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the Climate and Clean Air Coalition (CCAC), the Artic Council, and beyond. Renewed international credibility will enable the Biden administration to champion critical opportunities to protect tropical forests and to reduce methane emissions—both crucial to avoiding the most dangerous impacts of climate change. Recapturing a strong standing on the world stage will also be important to extending our nation's reach and bolstering efforts to promote other American values abroad.

[10] This is an estimate of the UK's previous contribution to the EU's NDC of at least 40% by 2030 because the NDC put forward in 2020 is the first NDC put forward by the United Kingdom after Brexit.

Reaping the Benefits for American Economic Prosperity, Health, and Equity

The United States has much to gain from charting an ambitious path on climate over the coming decade. With continued growth in emissions, annual damages from climate change in the United States are projected to reach hundreds of billions of dollars.[11] In addition to the core economic and environmental benefits of tackling the climate crisis, well-targeted climate policy and clean energy investment can:

- **Create millions of good jobs for American workers:** Growing clean energy and low carbon industries are capable of expanding to support millions of jobs.[12] Ambitious U.S. action—including economic relief and recovery spending to support the development of a U.S. low-carbon manufacturing sector, infrastructure investment, and expanded federal investment in innovation—can help rebuild the post-COVID economy and expand access to high-quality employment across all 50 states, including in regions of the country that have experienced job losses due to declines in the manufacturing and extractive industries.
- **Save hundreds of thousands of lives:** Slashing U.S. climate pollution consistent with limiting warming to 2°C could prevent nearly 300,000 premature deaths by 2030 from reduced exposure to dangerous air pollution, and save an additional 35,000 lives a year thereafter, generating national economic benefits on the order of $250 billion per year.[13] New EDF analysis finds that eliminating tailpipe pollution from on-road vehicles alone could prevent over 150,000 premature deaths by 2050.[14]
- **Enable a more equitable future for all Americans:** Well-designed climate policy can be a critical tool for addressing historical disparities in access to clean air and water and generating economic opportunity in in a range of different types of communities facing a diversity of challenges. By prioritizing clean energy investments that simultaneously create jobs and deliver health benefits in frontline communities—including low-income communities, communities of color, and communities transitioning off of reliance on the fossil fuel economy—we can help build a more equitable economy for all Americans.
- **Position the United States to be a leader in the rapidly expanding global clean energy economy:** As the rest of the world moves to drive emissions down to net zero, the market for clean technologies is poised to grow rapidly. The global market for renewable energy alone is expected to reach a value of $1.5 trillion by 2025.[15] Aggressive federal investment in emerging clean technologies and industries can help position the United States to be a strong competitor in the global 21st century clean economy.

To ensure we capture these benefits, particularly with respect to promoting equity and supporting energy workers and communities in the transition to a clean economy, policymakers will need to be intentional and thoughtful about policy design that works for Americans across the country. There are many paths to getting to at least 50% reductions by 2030 and net zero by 2050—and importantly, *how* we get there matters. It is critical that American workers and consumers in every community across the country are accounted for and benefit from the policies put in place. Climate policy can and should be designed to expand access to economic opportunity, reduce exposure to health-harming pollutants, improve equity, and empower American workers in every community, while remaining affordable for all.

[11] USGCRP, "Fourth National Climate Assessment, Volume II: Impacts, Risks, and Adaptation in the United States" (Washington, D.C.: U.S. Global Change Research Program, 2018), doi: 10.7930/NCA4.2018.

[12] Saul Griffith and Sam Calisch, "Jobs, Jobs, Jobs, and More Jobs" (Rewiring America, n.d.).

[13] Drew T. Shindell, Yunha Lee, and Greg Faluvegi, "Climate and Health Impacts of US Emissions Reductions Consistent with 2 °C," Nature Climate Change 6, no. 5 (May 2016): 503–7, https://doi.org/10.1038/nclimate2935.

[14] EDF has recently released an analysis of the benefits of eliminating tailpipe pollution from passenger vehicles by 2035 and will soon release an analysis of the benefits of eliminating this pollution from medium and heavy-duty trucks and buses swiftly in urban and community applications and for all such vehicles by 2040. These analyses build from the analysis included in this report in several important ways, including, for example, characterizing the health benefits of protective pollution standards. These analyses build from the analysis included in this report in several important ways, including, for example, characterizing the health benefits of protective pollution standards. The analyses find that protective pollution standards that achieve these light, medium- and heavy-duty vehicle goals will reduce a cumulative total of over 15 billion metric tons of climate pollution by 2050 and reduce health harming pollution that will prevent over 150,000 premature deaths through that timeframe.
See http://blogs.edf.org/climate411/files/2021/01/FINAL-National-White-Paper-Protective-Clean-Car-Standards-1.26.21.pdf for more information.

[15] Amit Narune and Eswara Prasad, "Renewable Energy Market by Type and End Use: Global Opportunity Analysis and Industry Forecast, 2018-2025" (Allied Market Research, May 2019), https://www.alliedmarketresearch.com/renewable-energy-market.

Regaining Credibility With Action

United States credibility on the world stage has been severely undermined by the Trump administration's decision to withdraw from the Paris Agreement and the accompanying assault on climate protections just when every country needed to be going all-in to reduce emissions. Moreover, this was not the first time the United States flip-flopped on international climate policy, having abandoned the Kyoto Protocol in 2001 when the Senate refused to ratify the agreement negotiated by the Clinton administration.

Overcoming the understandable skepticism of our international allies that the United States is both serious about addressing climate change and able to put in place the federal policies necessary to do so will require the Biden administration to put forward an achievable pledge and back it up with concrete action. In order to be credible, it must be clear to the rest of the world that one or more technologically and economically feasible pathways exist to achieve it, and—critically—that the White House and Congress have the political will to pursue it.

Credibility is important in order to promote confidence in the Paris process; pledging a level of emissions reductions that is clearly out of reach would undermine the value of the NDC. At the same time, credibility requires a willingness to act boldly and immediately to reduce emissions with every tool available, including existing law as well as new legislation. Credibility also requires that the NDC be developed in a transparent and inclusive process—with input from stakeholders across the United States, including the private sector and civil society.

A 2030 target of at least 50% below 2005 GHG emissions levels would put the United States on the path to net zero, demonstrate ambition, and—critically—is attainable with a strong whole-of-government approach. Illustrating that it is achievable is crucial to regaining the trust of the international community.

Reducing Emissions at Least 50% by 2030 is Achievable

The four analyses outlined in Table 1 demonstrate that reducing emissions at least 50% below 2005 levels by 2030 is possible (see Figure 2) with robust all-in action from both the administration and Congress. Each of these analyses relies on a different set of methodologies—including different models or accounting tools—assumptions, and policy pathways, which are described in further detail in Appendix A.

Although models are the best tools we have for projecting the future, they are not crystal balls and are only as good as the assumptions built into them. In some instances, models may underestimate achievable emissions reductions given inherent challenges with predicting technological change and innovation, which can lead to lower than projected abatement costs. However, in other instances, models may fail to capture on-the-ground realities that might make reductions more difficult to achieve than projected (e.g. coal retirements do not always occur despite uncompetitive economics). Relying on a range of models, rather than just one, provides greater confidence that the 50% goal is within reach, and confirms that there are multiple pathways to get there.[16]

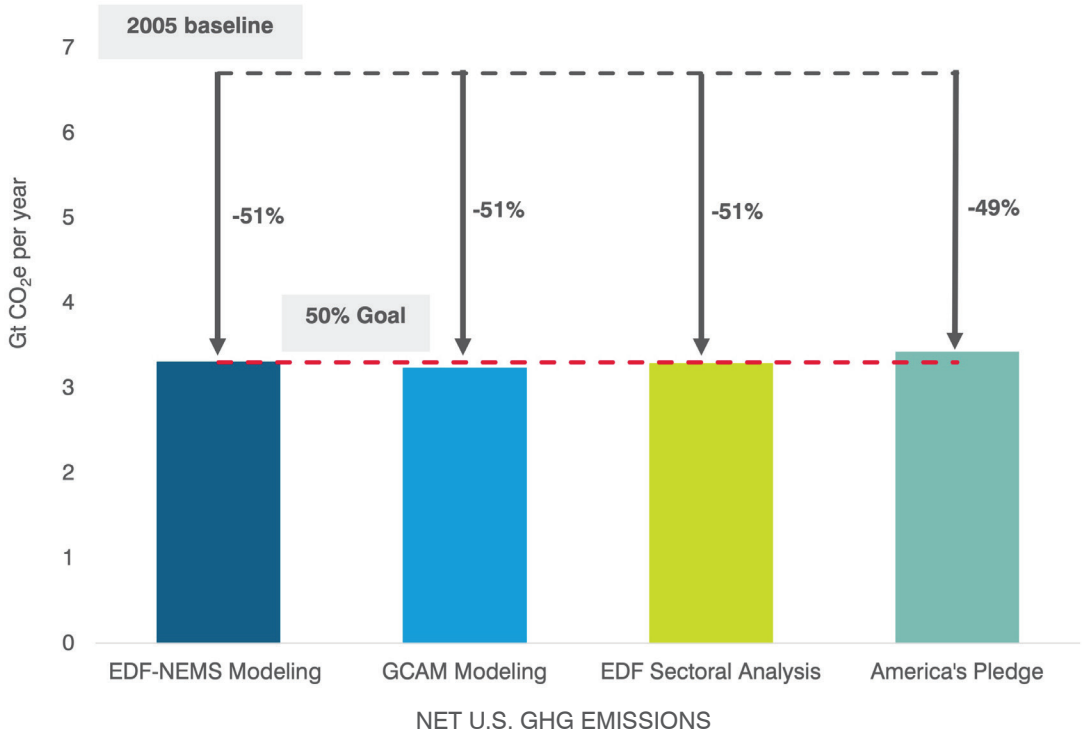
Moreover, there is strong evidence to suggest that reductions even greater than 50% by 2030 are possible given additional mitigation potential not fully captured in these analyses in sectors such as power and oil and gas methane. In addition, two of these analyses—EDF-NEMS and America's Pledge—do not capture the significant decrease in emissions that has occurred due to the economic recession stemming from the COVID pandemic, and would likely show greater emissions reductions if updated to reflect these and other recent trends.

[16] All analyses listed rely on the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4) 100-year global warming potential (GWP) values. This is consistent with the methodology used in EPA's 2020 Inventory of Greenhouse Gas Emissions and Sinks. However, the IPCC has updated GWP values in its Fifth Assessment Report (AR5), and therefore AR4 GWP values do not reflect the most up-to-date scientific research. Additionally, the 100-year GWP masks the near-term warming impact of short-lived climate forcers like methane, which is 84 times more potent than CO_2 on a 20-year timescale in terms of its warming effect on the atmosphere.

Table 1: Summary of Analyses

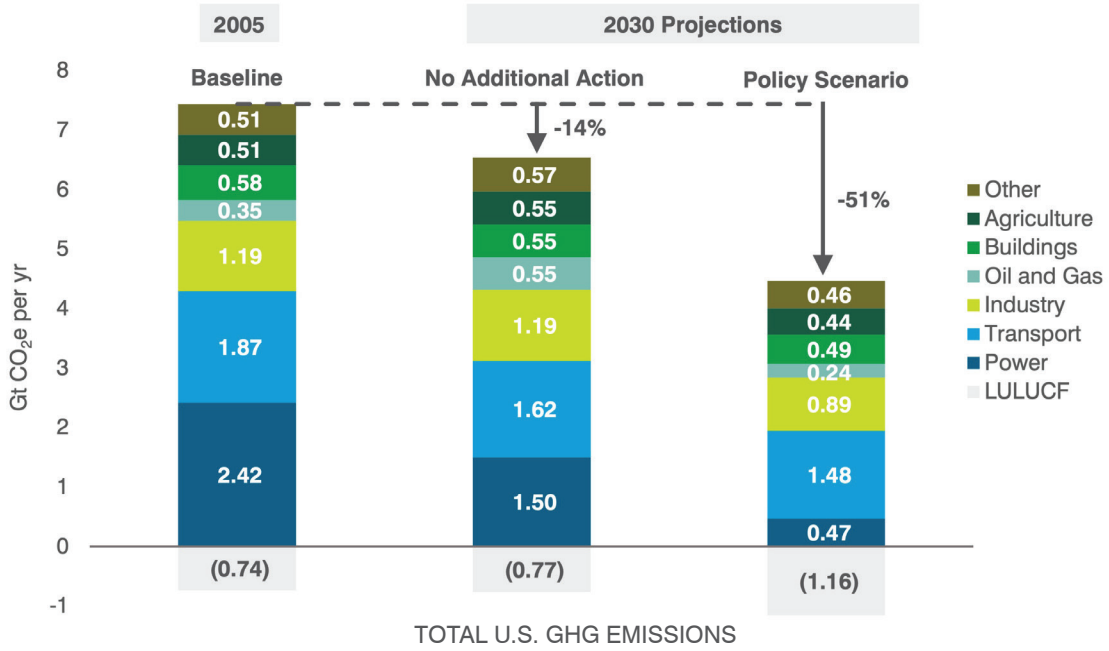
Analysis	Modeling Team	Model(s)	Summary of Policy Scenario	Projected 2030 Emissions Reduction (% below 2005 levels)
EDF-NEMS Modeling	Designed and directed by EDF and modeled by Rhodium Group	RHG-NEMS	A suite of sector-specific policies that reflect federal executive action, technology investments, complementary Congressional action, and an economy-wide limit and price on carbon.	51%
GCAM Modeling	University of Maryland Center for Global Sustainability	GCAM-USA	A suite of sector-specific policies that includes federal executive action and stimulus incentives.	51%
America's Pledge	University of Maryland Center for Global Sustainability and Rocky Mountain Institute	ATHENA, GCAM-USA	Expanded bottom-up action by states, cities, and businesses together with sector-specific federal executive and Congressional action.	49%
EDF Sectoral Analysis	EDF	Various	A suite of sector-specific policies, reflective of federal executive action under existing authority, new legislation, and additional incentives.	51%

Figure 2: A range of analyses demonstrate that the United States can cut GHG emissions at least 50% below 2005 level by 2030



Notes: Emissions data include all GHGs and rely on AR4 100-year GWP values. 2030 reductions are depicted according to the 2005 baseline used in each respective analysis. The 2005 baseline depicted by the gray dotted line relies on EPA's GHG Inventory baseline adjusted upward based on EDF's analysis of oil and gas methane emissions.

Figure 3: Achieving Net Zero Climate Pollution, EDF-NEMS Modeling Results



Notes: Emissions data include all GHGs and rely on AR4 100-year GWP values. All EDF-NEMS scenarios were designed and directed by EDF and modeled by Rhodium Group using RHG-NEMS, a version of the National Energy Modeling System maintained and operated by Rhodium.

EDF-NEMS Modeling

Designed and directed by EDF and modeled by Rhodium Group, this analysis shows that a combination of strong sector-specific policies through regulatory action and clean energy incentives in legislation—as well as a limit and price on carbon across the economy—can get the United States to at least 51% below 2005 levels in 2030. All scenarios were designed and directed by EDF and modeled by Rhodium Group using the RHG-NEMS model maintained and operated by the Rhodium Group.[17]

The bulk of the emission reductions—almost 60%—come from the power sector, which achieves an 80% reduction below 2005 emissions levels, followed by the transportation, LULUCF,[18] and industrial sectors (See Figure 3). The economy-wide limit and price on carbon helps drive greater emission reductions on a faster timeline by unlocking the fastest and cheapest reductions first, such as those in the power sector, while additional targeted policies help capture reductions outside the scope of the limit and price, such as methane from the oil and gas sector.

There is reason to believe even greater reductions are possible. Given currently available technologies and approaches, there is likely additional mitigation of methane emissions available from the oil and gas sector than is reflected in this analysis. If those reductions were accounted for, consistent with the economy-wide methane goal of 40% put forward in this report and outlined in Appendix C, overall economy-wide reductions would increase from 51% to roughly 52% below 2005 levels by 2030.[19] In addition, the EDF-NEMS modeling was conducted pre-COVID (2019-2020) and therefore does not account for the significant drop in emissions due to the economic recession associated with the pandemic. While the modeling itself does not speak to this issue, we believe that if this analysis were updated to reflect these recent trends, in combination with additional state and local climate action and continuing declining renewable energy and technology costs, further reductions below 2005 levels might be achievable by 2030.[20]

[17] All policy scenario specifications, interpretation of results and policy recommendations that follow are also EDF's and do not reflect the views of Rhodium Group or its staff.

[18] LULUCF includes emissions from land-use, land-use change, and forestry. The net negative emissions for this sector are largely driven by carbon sequestered in U.S. forests. The National Academy of Sciences has estimated above ground carbon storage potential from afforestation and forest management of 250 MMT CO_2 equivalent per year. EDF is actively working to update these estimates using new information and analytic processes to identify the management practices and geographies where carbon storage potential is greatest. (National Academies of Sciences, Engineering, and Medicine. 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Washington, DC: The National Academies Press. https://doi.org/10.17226/25259.)

[19] While this analysis assumed oil and gas methane emission reductions of 45% below 2012 levels by 2025, greater reductions of at least 65% below 2012 levels by 2025 are feasible with currently available technologies and approaches, consistent with the economy-wide methane goal of 40% in Appendix C.)

[20] In its most recent "Taking Stock" report, Rhodium Group examines a range of uncertainty in emission projections due to COVID-19's impact on the US economy. Under Rhodium Group's most optimistic or "V-shaped" economic recovery, emissions under a No Additional Action Reference scenario, which includes all existing federal and state policies "on the books" as of May 2020, are at 19% below 2005 levels in 2030. Under a more pessimistic or "W-shaped" economic recovery, emissions under a No Additional Action Reference scenario reach 23% below 2005 levels in 2030. (Larsen et al., "Taking Stock 2020: The COVID-19 Edition.")

GCAM Modeling

This analysis of opportunities for U.S. emissions reductions was conducted by the University of Maryland Center for Global Sustainability using the global integrated assessment model GCAM-USA. This analysis shows that a suite of sector-specific policies across all sectors and gases, including stimulus and investment incentives, executive actions, and more, can reduce emissions by 51% from 2005 levels by 2030.[21] The analysis shows that even in the absence of an economy-wide emissions limit and price on carbon, a well-coordinated package of sector-specific actions, in the form of ambitious executive and Congressional action, can get us to 51% below 2005 levels in 2030.

Similar to the EDF-NEMS analysis, the bulk of emission reductions come from the power sector, which achieves a 76% reduction below 2005 emissions levels, followed by the transportation sector.

Importantly, this analysis achieves relatively conservative methane emission reductions (16% economy-wide). If methane reductions were increased to align with the 40% economy-wide methane goal put forward in this report and outlined in Appendix C, economy-wide reductions for total net GHGs would increase from 51% to more than 53% below 2005 levels by 2030.

America's Pledge

Conducted by the University of Maryland Center for Global Sustainability and Rocky Mountain Institute using the ATHENA and GCAM-USA models, this analysis shows economy-wide net GHG emissions reaching 49% below 2005 levels in 2030 with a combination of new federal and subnational policies.[22] Similar to the GCAM Modeling analysis, the America's Pledge analysis shows that even without a limit and price on carbon, sector-specific action alone—in the form of expanded state, city, and business action together with ambitious federal executive and Congressional action—can get us in the range of 50% below 2005 levels in 2030.

Like EDF-NEMS, this analysis was conducted pre-COVID (in 2019) and therefore does not account for the significant drop in emissions due to the economic recession associated with the pandemic. If this analysis were updated to reflect these recent trends, in combination with additional state, city, and business commitments that have been subsequently announced, economy-wide net GHG emission reductions in 2030 would likely be greater.

[21] University of Maryland Center for Global Sustainability, "Charting an Ambitious U.S. NDC of 51% Reductions by 2030 (2021), https://cgs.umd.edu/research-impact/publications/working-paper-charting-ambitious-us-ndc.

[22] America's Pledge also examined the range of uncertainty using varying assumptions about socioeconomic change, technological change, fossil prices, and the size of the land use sink, and found that emission reductions in the "All-In" strategy could be as high as 52% below 2005 levels in 2030. (The America's Pledge Initiative on Climate Change, "Accelerating America's Pledge: Going All-In To Build a Prosperous, Low-Carbon Economy for the United States" (New York: Bloomberg Philanthropies, University of Maryland Center for Global Sustainability, Rocky Mountain Institute, World Resources Institute, 2019), https://assets.bbhub.io/dotorg/sites/28/2019/12/Accelerating-Americas-Pledge.pdf.

EDF Sectoral Analysis

This analysis was conducted by EDF using a combination of modeling and spreadsheet accounting, relying on internal EDF analysis and expertise for estimating the potential emission reductions from the power, transportation, oil and gas methane, and agricultural and forestry sectors under a suite of sector-specific policies.[23] This analysis shows that a suite of policies reflective of existing authority, new legislation and new incentives can drive economy-wide net GHG emissions down to at least 51% below 2005 levels in 2030.

This analysis assumes that federal executive action, new legislation, and stimulus incentives would achieve power sector emission reductions of 80% below 2005 in 2030. Additional analyses, such as a recent deep decarbonization study from Princeton University, indicate that this level of reductions from the power sector is within reach[24] and an EDF analysis performed by ICF using the Integrated Planning Model (IPM®) showed that even greater power sector emission reductions—90% below 2005 levels in 2030—are possible.[25] Using this higher level of ambition for the power sector, economy-wide net GHG emission reductions would increase from 51% to more than 54% below 2005 levels by 2030. Combining this with the additional methane mitigation from the oil and gas sector described in Appendix C, this reduction would increase further to more than 55%.

Key policies embedded in this analysis and critical to meeting the overarching 50% goal include:

1. **New legislation limiting emissions from the power sector, such as a clean electricity standard,** designed to reduce emissions by at least 80% below 2005 levels by 2030 on the path to zero emissions by 2035. Combined with multi-pollutant standards adopted under existing law, as well as long-term extension and expansion of clean energy tax credits, these policies are critical to ensure we decarbonize the power sector on a timeline that can enable swift and broad electrification of other sectors with clean power.
2. **Vehicle standards that ensure that by 2035, all cars, and by 2040, all freight trucks and buses sold in the United States are zero-emitting, while accelerating the transition to zero for all freight vehicles operating in communities and urban centers.** Combined with policies designed to lower barriers to adoption; accelerate stock turnover; increase equitable access to clean vehicles; support domestic manufacturing and supply chains, including production of batteries; build infrastructure in all communities; and invest in mass transit services, these policies can supercharge transformation of our vehicle fleets, cutting climate pollution while improving air quality in communities across the country.
3. **Methane standards for new and existing oil and gas operations and facilities, designed to reduce emissions from these facilities by at least 45% from 2012 levels by 2025.**[26] Congress should also provide funds to plug orphan wells—cutting emissions and creating jobs for transitioning oil and gas workers—and additional incentives for innovative technology to detect and repair methane leaks.
4. **Advances in climate-smart agriculture and forestry** to reduce net emissions through voluntary markets and incentives, including changes to farm programs to support climate-friendly practices and incentives to prevent forest conversion, help landowners improve the resilience and productivity of their existing forestland, increase the pace of reforestation, and use low carbon building materials, especially wood. The federal government should also greatly increase investment in reforestation and increasing the resilience of federal forestland.

[23] EDF analysis of transportation and oil and gas methane emission reductions was informed by the Optimization Model for reducing Emissions of Greenhouse Gases from Automobiles (OMEGA) for light-duty vehicles, ongoing M.J. Bradley & Associates analysis for EDF for medium- and heavy-duty vehicles, and EDF's internal oil and gas methane model.

[24] E. Larson et al., "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Interim Report" (Princeton, NJ: Princeton University, December 15, 2020), https://environmenthalfcentury.princeton.edu/.

[25] Based on power sector IPM modeling of clean energy standard scenarios developed by EDF and performed by ICF.

[26] There is evidence that much greater oil and gas methane emission reductions are achievable consistent with the methane targets included in Appendix C.

Additional Evidence that At Least 50% is Feasible

Beyond the four analyses described above, several additional analyses provide further evidence that at least 50% by 2030 is attainable. Resources for the Future (RFF) offers a publicly available tool: a "carbon pricing calculator" that projects the impact of a carbon price on economy-wide energy-related CO_2 emissions.[27] This tool demonstrates that a carbon price starting at $55-$67/ton CO_2 in 2022 rising 5% annually, or one that starts lower but rises more rapidly, can achieve roughly 49-52% gross reductions in energy CO_2 from 2005 levels by 2030. RFF modeling shows that similar reductions could be achieved by several bipartisan bills in the 116th Congress. Energy-related CO_2 represents the bulk of total GHG emissions, and reductions of this magnitude are aligned with energy CO_2 reductions achieved in the analyses of total net GHGs described above, further indicating that reductions in total net U.S. GHG emissions of at least 50% below 2005 levels by 2030 are within reach.

Three additional models included in the Stanford Energy Modeling Forum 32 study indicate reductions of this magnitude or higher are possible from economy-wide carbon pricing, even at the low end of the RFF pricing calculator range outlined above. The Dynamic Integrated Economy/Energy/Emissions Model (DIEM), the G-Cubed model, and Environment and Climate Change Canada's multi-sector, multi-region model (EC-MSMR)[28] all find that a $55/ton CO_2 price rising 5% annually could achieve reductions in the 50% to over 60% range by 2030.

The four analyses presented above, together with additional evidence from various carbon pricing modeling and deep decarbonization literature (see text box above), demonstrate that a reduction of 50% is achievable, and, moreover, there are good reasons to believe that even greater reductions are possible by updating the models to align with the latest trends (e.g. the recent economic recession and declining clean energy costs) as well as with improved understanding of abatement opportunities. Three recent deep decarbonization studies (the Princeton University study noted above, as well as two additional studies from the National Academies of Sciences and Evolved Energy Research), explore paths to net zero by 2050.[29] These studies highlight key abatement opportunities—such as natural and technological CO_2 removal and widespread electrification. Not all of these are fully captured in all of the models presented here, and incorporating some of these priorities into the modeling efforts described above could push some of these scenarios to greater than a 50% reduction by 2030. Other updates, such as incorporating updated declining costs of a transition to net zero would also push abatement further.[30]

While the different analyses share several commonalities—including a strong emphasis on the need for both executive branch regulation using existing authorities as well as robust investment and new legislation from Congress—the policies relied on to achieve these reductions vary. Some analyses—such as the EDF-NEMS and the RFF analyses—utilize an economy-wide carbon price to align incentives towards reducing emissions across most major emitting sectors, while others—such as the GCAM modeling—rely solely on sector-specific policies and incentives. The analyses further differ in their choice of sector-specific policies and the details of their implementation, demonstrating that there are multiple credible pathways to at least 50% by 2030.

[27] RFF's carbon pricing toll can be found at: https://www.rff.org/publications/data-tools/carbon-pricing-calculator/

[28] See https://emf.stanford.edu/projects/emf-32-us-ghg-and-revenue-recycling-scenarios; Information on each of these models can be found in James R. Mcfarland et al., "Overview of the EMF 32 Study on U.S. Carbon Tax Scenarios," Climate Change Economics 09, no. 01 (February 2018): 1840002, https://doi.org/10.1142/S201000781840002X.

[29] National Academies of Sciences, Engineering, and Medicine, "Opportunities for Deep Decarbonization in the United States, 2021-2030," in Accelerating Decarbonization of the U.S. Energy System (Washington, D.C.: National Academies Press, 2021), https://doi.org/10.17226/25932. Larson et al., "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Interim Report." James H. Williams et al., "Carbon-Neutral Pathways for the United States," AGU Advances 2, no. 1 (2021): e2020AV000284, https://doi.org/10.1029/2020AV000284.

[30] According to the Evolved Energy Research study, recent technological progress has reduced the cost of achieving net zero emissions by 2050 to about $1 per person per day. Williams et al., "Carbon-Neutral Pathways for the United States."

A Whole-of-Government Approach is Needed

These analyses demonstrate that meeting the 50% goal demands rapid and dramatic transformation of our energy system, including accelerated and significant deployment of clean electricity generation and electric vehicles. Progress must also be made to drive down powerful methane pollution from oil and gas production, as well as emissions from industry and buildings. They also show that maintaining and expanding carbon sinks in the lands sector will be critically important to achieving both the 2030 goal as well as net zero.

The scope and scale of the necessary changes demand a swift and concerted whole-of-government effort to put in place policies to cut emissions from all major emitting sectors, incentivize and ramp up deployment of clean technologies, and orient investments towards low and zero carbon solutions. This includes a suite of strong climate and clean energy protections under existing law targeting major emitting sectors like power, transportation, and methane emissions from oil and gas. The Biden administration has already taken important steps to reverse the environmental rollbacks made by the Trump administration on each of these key sectors and replace them with stronger climate protections, but it will need to ramp up quickly in these early days to leverage all the tools at its disposal under existing law.

While the administration can make an enormous amount of progress on its own, these analyses make clear that executive action by itself will not be sufficient to meet the 50% by 2030 goal—or get us to net zero by 2050. To close the gap, we will need strong action from Congress – including legislation that centers strong climate and clean energy measures in the next round of economic recovery investments.

We also need continued leadership and action on climate by states, cities, and businesses. Over the past four years, subnational actors have stepped up, making strong commitments to concrete GHG emission reduction targets. It's time to deliver—and for state governors, in particular, to translate those commitments into reality. States have robust authority under existing environmental statutes to regulate GHG pollution, and the urgency to tackle these emissions head-on couldn't be greater. To ensure that we meet the 50% by 2030 goal or higher on the path to net zero, we need a whole-of-government approach that includes adopting comprehensive climate policies at both the federal and state level.

A Limit and a Price Would Accelerate Progress and Ensure We Hit Our Climate Goals

While these analyses show that there are multiple pathways to meet the 50% goal, including through different combinations of aggressive sector-by-sector policies, not all pathways are created equal. While it is possible to get to at least 50% with sector-specific action alone, an enforceable declining limit and a price on emissions economy-wide would get us there more quickly and affordably—supercharging action to cut pollution across major emitting sectors and providing a critical backstop to ensure we meet our goal. It would also raise significant revenue that could be directed towards critical priorities such as promoting equity, supporting energy workers and communities impacted by the transition to a clean economy, and investing in innovation and emerging clean technologies. For example, according to the RFF Calculator, a $55/ton carbon price rising at 5% annually would yield roughly $2.5 trillion over the next decade.

By tapping the fastest and cheapest reductions available first, and orienting incentives towards low and zero carbon solutions across all major emitting sectors, an economy-wide limit and price can help drive greater emissions reductions on a faster timeline, while simultaneously reducing the overall cost to American businesses, industries, and consumers. Designed well, such a mechanism can serve as a magnet that aligns efforts to cut pollution across the entire economy, making targeted sector-specific policies cheaper and easier to achieve, while driving investment in innovation and moving us more rapidly towards net zero.

To ensure that the benefits of these policies are spread across all communities, carbon pricing policies should be designed to promote equity, ensure affordability, invest in American workers, protect overburdened communities, and support those most directly affected by climate change and the transition to a cleaner economy.

Conclusion

An ambitious and credible 2030 U.S. NDC will be key to restoring U.S. leadership and building momentum on climate action in advance of COP26. High ambition is needed to align the United States with the goals of the international community and the best science around climate impacts, as well as to galvanize increased action at home and around the world. At the same time, the NDC must have a realistic pathway to success to be credible with our international allies. A target of reducing total net U.S. GHG emissions at least 50% from 2005 emissions levels by 2030 is necessary to meet both criteria.

In addition, given the urgency of reducing powerful pollutants like methane to immediately slow the rate of temperature rise and limit peak warming, the Biden administration should set specific reduction targets for short-lived climate pollutants, consistent with the overarching 50% goal, including a reduction in methane emissions of 40% from 2005 levels. Such a target could have a measurable and immediate impact on the rate of warming and expected temperature impacts in the near-term.

Achieving these targets will require immediate and robust federal action under existing law as well as new legislation. Congress took initial steps to bolster clean energy spending in the year-end stimulus package passed in December, but additional economic recovery investments focused on accelerating the transition to a clean economy, while creating jobs and building healthier and more equitable communities, is critical. A whole-of-government effort including strong legislation from Congress coupled with robust regulatory action by executive branch leadership, can get us to at least a 50% reduction by 2030. An enforceable declining limit on emissions and a price on carbon can supercharge action across the economy, allowing us to get there faster and more affordably, and ensure we hit our climate goals.

Appendix A

Analysis Methodology and Assumptions

This appendix provides further detail on the four analyses includes in Table 1 and the "Carbon Pricing Tool" developed by Resources for the Future (RFF), including information on the methods and models used, assumptions underpinning the "No Additional Action" reference scenarios (in which no new policies are implemented) and the "Policy Scenarios," and key insights.

EDF-NEMS Modeling

Methods: This analysis was designed and directed by EDF and modeled by Rhodium Group. All energy system modeling was done using RHG-NEMS, a version of the National Energy Modeling System (NEMS) maintained and operated by Rhodium Group. NEMS is used by the Energy Information Administration (EIA) to produce the Annual Energy Outlook. All non-energy emission reductions were estimated by EDF.[31] This modeling was conducted pre-COVID (2019-2020) and does not take into account the impacts of the pandemic and resulting decrease in emissions.

No Additional Action Scenario: The No Additional Action Reference scenario relied on Rhodium Group's Taking Stock 2019 Current Policy projections using central oil and natural gas prices and technology costs, updated to incorporate clean technology cost and performance estimates from the National Renewable Energy Laboratory's 2019 Annual Technology Baseline. Oil and gas methane emissions were adjusted to reflect higher methane leak rates than the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory based on EDF analysis.[32] This scenario incorporated all existing federal and state policies "on the books" as of June 2019 and reflects the Trump administration's federal rollbacks of light-duty vehicle standards and methane regulations.

Policy Scenario: The Policy scenario represents a suite of sector-specific policies and an economy-wide limit and price on energy CO_2. The sector-specific policies are reflective of existing authority action and/or sector-specific legislation or incentives. This includes policies such as next generation power sector carbon pollution standards and public health complementary regulations, next generation light-duty and medium/heavy-duty vehicle standards, and oil and gas methane standards for new and existing sources. It also includes policies such as buildings efficiency standards, industrial sector standards and/or incentives, agricultural and forestry policies that reduce nitrous oxide, methane, and CO_2 emissions and increase carbon removal, and U.S. ratification and implementation of the Kigali Amendment to the Montreal Protocol to phase out the consumption and production of hydrofluorocarbons.

Key insights: Under the No Additional Action Reference scenario, economy-wide net GHG emissions in 2030 were 14% below 2005 levels and under the Policy scenario were 51% below 2005 levels. This represents nearly 2.5 billion metric tons of GHG emission reductions—a roughly 43% reduction—compared to the No Additional Action Reference scenario in 2030.

The bulk of the 2030 Policy Scenario emission reductions relative to 2005 levels—almost 60% —come from the power sector which reaches approximately 80% below 2005 levels, followed by the transportation, LULUCF, and industrial sectors (See Figure 3). The economy-wide limit and price on carbon helps drive greater emission reductions on a faster timeline by unlocking the fastest and cheapest reductions first, such as those in the power sector, while additional targeted policies help capture reductions outside the scope of the limit and price, such as methane from the oil and gas sector.

The analysis also included a sensitivity which showed how innovation policies can yield similar emission reductions at lower cost and hence enable greater reductions at the same cost. In fact, at the time of this analysis, we assumed that sector-specific policies for light-duty vehicles would achieve 50% zero-emission vehicle sales by 2035.

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[31] All scenario specifications were developed by EDF and the interpretation of results and policy recommendations that follow are EDF's and do not reflect the views of Rhodium Group or its staff.

[32] Ramón A. Alvarez et al., "Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain," Science 361, no. 6398 (July 13, 2018): 186–88, https://doi.org/10.1126/science.aar7204.

Since then battery cost projections have continued to decline in addition to increased state and private sector action and commitments, and we now expect sector-specific policies such as next generation light-duty vehicle standards together with incentives could achieve 100% zero-emission light-duty vehicle sales by 2035.

GCAM Modeling

Methods: This new analysis was conducted by the University of Maryland Center for Global Sustainability to estimate the impacts of a suite of sector-specific policies that include executive authority action and stimulus incentives.[33] The assessment was carried out using GCAM-USA, a 50-state version of the Global Change Assessment Model (GCAM) —a global integrated assessment model.

No Additional Action Scenario: The No Additional Action Reference scenario reflects a counterfactual scenario where no additional policies are implemented beyond policies already in place.

Policy Scenario: The Policy scenario reflects emission reductions possible under a suite of sector-specific policies including executive action and incentives. This includes power sector regulations for coal and gas, light-duty as well as medium- and heavy-duty vehicle standards, oil and gas methane regulations, industrial and buildings efficiency standards in addition to renewable and 45Q tax credit extensions, nuclear incentives, vehicle incentives and programs such as cash for clunkers, and investment in forests and improved land management practices. In some cases, the specific policies were not explicitly modeled, and other tools were used as a proxy to model the impacts of those policies.

Key insights: Similar to the EDF-NEMS analysis described above, the bulk of emission reductions relative to 2005 levels come from the power sector followed by the transportation sector. The analysis shows that even without a limit and price on carbon, sector-specific action alone, in the form of ambitious executive and congressional action, can get us to 50% below 2005 levels in 2030.

America's Pledge

Methods: The America's Pledge analysis used an interactive two-step approach to assess the impacts from expanded actions by states, cities, and businesses together with complementary and ambitious federal action as part of an "All-In" U.S. climate strategy.[34] The first step used sector-specific, bottom-up models referred to as the Aggregation Tool for modeling Historic and Enhanced Non-federal Actions (ATHENA), and the second involved economy-wide analysis using GCAM-USA.

No Additional Action Scenario: The No Additional Action Reference scenario reflects existing "on-the-books" policies as of 2019, including binding policies on the part of states, cities, and businesses, in addition to technological and economic trends.

Policy Scenario: The Policy scenario represents America's Pledge "All-In" climate strategy which includes bottom-up expansion of climate policies by states, cities, and businesses combined with sector-specific federal executive and congressional action.[35] These strategies rely on three main principles: (1) accelerating toward 100% clean electricity and other energy supplies; (2) decarbonizing energy end-uses in transportation, buildings, and industry, primarily through electrification and efficiency; and (3) enhancing the carbon storage potential of forests, farms, and coastal wetlands.

Key insights: The Policy scenario achieves almost 80% clean electricity generation in 2030, including close to 50% from renewable energy, and more than 60% light-duty zero emission vehicle sales in 2030, on a path to 100% shortly thereafter. While the power sector contributes the largest emission reductions in 2030, strategies in other sectors such as transportation lead to growing emission reductions in later years.

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[33] University of Maryland Center for Global Sustainability, "Charting an Ambitious U.S. NDC of 51% Reductions by 2030 (2021), https://cgs.umd.edu/research-impact/publications/working-paper-charting-ambitious-us-ndc.

[34] The America's Pledge Initiative on Climate Change, "Accelerating America's Pledge: Going All-In To Build a Prosperous, Low-Carbon Economy for the United States.""

[35] America's Pledge analysis was conducted pre-COVID. In 2020, America's Pledge assessed the impacts of recent trends due to COVID-19 and found increased confidence in the ability of bottom-up leaders to drive the ambitious 2030 emission reductions assumed in the analysis. Federal stimulus programs that include ambitious clean energy investments and policies also provide a critical opportunity to support climate ambition. (The America's Pledge Initiative on Climate Change, "Delivering on America's Pledge: Achieving Climate Progress in 2020" (New York: Bloomberg Philanthropies, University of Maryland Center for Global Sustainability, Rocky Mountain Institute, World Resources Institute, 2020), https://assets.bbhub.io/dotorg/sites/28/2020/09/Delivering-on-Americas-Pledge.pdf.)

EDF Sectoral Analysis

Methods: EDF did a combination of modeling and spreadsheet accounting to estimate the potential emission reductions possible under a suite of sector-specific policies, reflective of existing authority, new legislation and incentives, and relying on internal EDF analysis and expertise for the power, transportation, oil and gas methane, and agricultural sectors. [36]

No Additional Action Scenario: The No Additional Action Reference scenario we used was the midpoint of Rhodium Group's Taking Stock 2020 "V-shaped" and "W-shaped" economic recovery scenarios and reflects all existing federal and state policies "on the books" as of May 2020.[37]

Policy Scenario: The Policy scenario reflects:

- Next generation power sector carbon pollution standards and public health complementary regulations, in addition to new legislation limiting emissions from the power sector, such as a clean electricity standard and long-term extension and expansion of clean energy tax credits, achieving power sector reductions of at least 80% below 2005 in 2030
- Next generation vehicle standards and incentives achieving 100% zero emission vehicle sales by 2035 for light-duty vehicles and by 2040 for medium- and heavy-duty vehicles
- Oil and gas methane standards for new and existing sources in addition to state action achieving reductions of at least 45% below 2012 levels by 2025.[38]
- Climate-smart agriculture and forestry practices that reduce net emissions through voluntary markets and incentives, including changes to farm programs to support climate-friendly practices and incentives to prevent forest conversion, help landowners improve the resilience and productivity of their existing forestland, increase the pace of reforestation, and use low carbon building materials, especially wood; and increased investment in reforestation and federal forestland resilience.

In addition, rough estimates of emission reductions possible from buildings efficiency standards, industrial sector standards and incentives, and U.S. ratification and implementation of the Kigali Amendment to the Montreal Protocol were included.

Key insights: As in other analyses, the bulk of emission reductions relative to 2005 levels come from the power sector followed by transportation and LULUCF. Together, the power, transportation, and oil and gas methane sectors alone result in economy-wide net GHG emissions of 38% below 2005 levels in 2030, more than 75% of the way towards 50% below 2005 economy-wide net GHG emissions in 2030. The power sector contributes more than 55% of the emission reductions needed to reach 50% economy-wide reduction in 2030 and the transportation contributes roughly one-fifth of the emission reductions needed although this sector's share of reductions grow significantly after 2030. Oil and gas methane reductions have an outsized role in the near-term because methane is potent but short-lived. Therefore, methane's relative role in warming and mitigation compared to CO_2 is elevated when considering climate impacts over the next few decades as opposed to the following century.

[35] EDF analysis of transportation and oil and gas methane emission reductions was informed by the Optimization Model for reducing Emissions of Greenhouse Gases from Automobiles (OMEGA) for light-duty vehicles, ongoing M.J. Bradley & Associates analysis for EDF for medium- and heavy-duty vehicles, and EDF's internal oil and gas methane model.

[37] Oil and gas methane emissions were adjusted to reflect higher methane leak rates than EPA's Greenhouse Gas Inventory based on EDF analysis.

[37] While not included in this analysis, there is evidence that much greater oil and gas methane emission reductions are achievable in 2030 consistent with the methane targets included in Appendix C.

[38] There is evidence that much greater oil and gas methane emission reductions are achievable consistent with the methane targets included in Appendix C.

RFF Carbon Pricing Calculator

Methods: Resources for the Future (RFF) offers a publicly available tool that demonstrates the impact of a carbon price on economywide energy-related CO_2 emissions.[39] The calculator reports business-as-usual and price-reduced emissions as modeled in the Goulder-Hafstead Energy-Environment-Economy E3 CGE Model. The current version of the calculator reflects pre-COVID inputs and does not account for the impacts of the pandemic on emissions.

No Additional Action Scenario: The Business-as-usual emissions trajectory relies on reference case emissions and GDP from the Energy Information Administration's (EIA) from the 2019 Annual Energy Outlook (AEO). The Business-as-usual projections assume existing energy sector laws and regulations remain in place throughout the projection period.

Policy Scenario: Custom price scenarios require a user to specify an initial tax price per metric ton, an annual growth rate above inflation, and a revenue recycling option. The price is based on the carbon content of fossil fuels combusted within the United States and is limited to energy-related CO_2 emissions. In these results, we assume revenue is recycled in the form of a per household dividend. Although the RFF pricing calculator assumes that prices start in 2020, we adjust these price trajectories to start in 2022, hence why reported prices are not round numbers.

[39] See https://www.rff.org/publications/data-tools/carbon-pricing-calculator/.

Appendix B

Status of NDCs & Long-Term Targets by Country

This appendix provides further detail on the headline targets and current status of the NDCs submitted by G20 countries and advanced economies with updated NDCs, as well as information on the long-term targets in each of these countries, where available. Countries have used different terminology to describe their long-term targets, including carbon neutrality, net zero, and climate neutrality. The terms used by countries can also be different depending on the context in which they are used (e.g. different terms may be used in a long-term strategy as opposed to legislation). In some cases, a particular term is used to indicate the scope of coverage (e.g. only CO_2 vs all GHGs) and in other cases the reason for using a particular term is not clear.

COUNTRY	HEADLINE NDC TARGET	LONG-TERM TARGET	STATUS OF NDC UPDATE
Argentina	Cap net emissions at 359 $MtCO_2e$ in 2030	Carbon-neutral by 2050 (pledge)	NDC updated in 2020; target strengthened
Australia	Reduce GHG emissions 26-28% below 2005 levels by 2030		NDC updated in 2020; target unchanged
Brazil	Reduce GHG emissions37% below 2005 levels in 2025, and 43% below 2005 levels in 2030	Carbon neutral by 2060	NDC updated in 2020; target unchanged
Canada	Reduce GHG emissions 30% below 2005 levels by 2030	Net zero by 2050 (pledge)	NDC not updated; update expected
China	Peak CO_2 emissions before 2030	Carbon-neutral before 2060 (pledge)	New targets announced, but NDC not updated; update expected in 2021
Costa Rica	Cap net GHG emissions at 9.11 $MtCO_2e$ by 2030	Net zero by 2050 (in long term strategy)	NDC updated in 2020; target strengthened
EU	Reduce GHG emissions at least 55% below 1990 levels by 2030	Net zero by 2050 (EU law in co-decision)	NDC updated in 2020; target strengthened
India	Reduce GDO emissions intensity 33-35% below 2005 levels by 2030		NDC not updated
Indonesia	Reduce GHG emissions 29% (unconditional) and up to 41% (conditional) below BAU[40] scenario by 2030		NDC not updated; unchanged target
Japan	Reduce GHG emissions 25.4% below FY 2005 levels by 2030	Net zero by 2050 (pledge)	NDC updated in 2020; target unchanged;
Mexico	Reduce GHG emissions 22% below BAU scenario by 2030; reduce black carbon emissions 51% below BAU scenario by 2030		NDC updated in 2020; target unchanged

[40] BAU refers to "business as usual."

COUNTRY	HEADLINE TARGET	NET ZERO GOAL	STATUS OF NDC UPDATE
Norway	Reduce GHG emissions at least 50% (and towards 55%) below 1990 levels by 2030	Carbon-neutral by 2050 (Parliamentary decision)	NDC updated in 2020; target strengthened
Russia	Limit GHG emissions to 70-75% of 1990 levels by 2030		NDC updated in 2020
Saudi Arabia	"Actions and plans in pursuit of economic diversification that have co-benefits in the form of [GHG] emission avoidances…"		NDC not updated
South Africa	Emissions between 398 and 614 $MtCO_2$ by 2025 and 2030	Net zero by 2050 (Low Emission Development Strategy)	update expected in 2021
South Korea	Reduce GHG emissions 24.4% below 2017 levels by 2030	Carbon-neutral by 2050	NDC updated in 2020
Switzerland	Reduce GHGs emissions at least 50% below 1990 levels by 2030	Net zero by 2050 (Pledge of Federal Council)	NDC updated in 2020
Turkey	Reduce emissions up to 21% below BAU scenario by 2030		NDC not updated
United Kingdom	Reduce GHG emissions at least 68%, below 1990 levels by 2030	Net zero by 2050 (UK law)	NDC updated in 2020; target strengthened
United States	Reduce GHG emissions 26%-28% below 2005 levels in 2025	Net zero by 2050 (pledge)	NDC not updated; update expected in 2021

Appendix C

Economy-Wide Methane Target Analytics & Assumptions

This appendix provides further detail on the underlying analytics for achieving a methane reduction target of 40% below 2005 levels by 2030. The table below provides one potential breakdown of ambitious yet feasible methane emission reductions in 2030 from the five largest methane-emitting sectors—oil and gas, enteric fermentation, landfills, coal, and manure management —which are collectively responsible for more than 90% of current U.S. methane emissions.[41] This illustrative pathway should not be taken as the only way to reach the 40% target; the target can be reached in a number of ways depending on sectoral actions, and some sectors may overperform while others underperform. Information on the methods, sources, and assumptions can be found in the Table notes. We note that the level of reduction required for this target is also consistent with methane reduction commitments proposed and adopted by the state of California (SB 1383—"achieve a reduction in the statewide emissions of methane by 40 percent… below 2013 levels by 2030"[42]) and the U.S. Climate Alliance ("reduce [short-lived climate pollutant] emissions in the U.S. Climate Alliance as a whole by 40-50 percent below current levels by 2030"[43]); when calibrated to a 2005 baseline,[44] these two targets—if for methane only and nationwide—amount to a 38% and 34-45% reduction in methane, respectively. A reduction greater than 40% may also be possible with the further development of emerging technologies and strategies for hard-to-abate sectors such as enteric fermentation, as well as behavioral changes such as reduced waste.

U.S. METHANE SECTORS *(top 5 responsible for >90% of 2018 emissions)*	**2005 Emissions[a] MMt[a]**	**Abatement Targets below 2005 by 2030 (%)**	**2030 Emissions (MMt)**
Oil & Gas[b]	11.5	66%	3.9
Enteric Fermentation[c]	6.8	6%	5.7
Landfills[d]	5.3	42%	3.1
Coal[e]	2.9	60%	1.2
Manure Management[f]	2.1	17%	1.3
Other *(e.g. Rice, Wastewater, Land Use, Transport, Power)*	2.5	0%	2.2
TOTAL (MMt/yr)	31	**40%**	18.5
TOTAL[g] (CO_2e100: GWP=28)	870		520

[41] Emissions in 2018 based on U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018. (2020) for all sectors but oil and gas. Oil and gas emissions from methodology described in note (a), with emissions from distribution mains in the GHGI replaced with the value estimated by Weller et al. 2020 (Weller Z. D., S. P. Hamburg, and J. C. von Fischer. (2020) A national estimate of methane leakage from pipeline mains in natural gas local distribution systems. Environmental Science & Technology, 54(14) 8958-8967. doi:10.1021/acs.est.0c00437).

[42] California Senate Bill No. 1383: SB-1383 Short-lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1383

[43] U.S. Climate Alliance, From SLCP Challenge to Action (2018) http://www.usclimatealliance.org/slcp-challenge-to-action

[44] Converting targets requires emissions data for the baseline year. We use EPA (U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018. (2020)) for all sectors but oil and gas. Oil and gas emissions come from EDF modeling as outlined in note (a).

Notes

[a] 2005 emissions levels are based on EPA's 2020 Greenhouse Gas Inventory (GHGI) for all sectors but oil and gas.[45] For oil and gas estimates, total site-level production emissions are estimated based on reported site-based measurements at 433 sites in six production areas (Barnett Shale, Fayetteville Shale, Marcellus Shale [Southwest PA/WV], Uintah County, Upper Green River Basin, and Weld County). Emission factors are correlated with yearly natural gas production and used to calculate a national emission total. Gathering station emissions were estimated from Enverus/DrillingInfo gas production and state-specific emission rates reported in Marchese et al., adjusted to better account for heavy-tail emissions.[46] Nationwide processing emissions are based on Marchese et al. and the plant count from the GHGI. Transmission & Storage emissions by source are taken from the GHGI, and an abnormal emissions category is added using the Zimmerle et al. estimate of 200 Mg/station/yr.[47] Nationwide distribution emissions by source are taken directly from the EPA GHGI for the relevant year, with one exception. For more details, please refer to Alvarez et al. 2018.[48] Using this methodology, oil and gas methane emissions are ~40% higher in 2005 than as estimated by EPA (8 MMt).

[b] Oil and gas methane reductions are based on analysis by the International Energy Agency (IEA).[49] Deployment of all technologically available emissions control measures (such as leak detection and repair, updating equipment, and deploying vapor recovery units), combined with reduced natural gas demand as part of the U.S. decarbonization goal, could reduce emissions by up to 75% below current levels, which amounts to a 66% reduction below 2005 levels. EDF analysis finds that U.S. methane oil and gas emissions could be reduced 45% below 2012 levels by 2025 (which equals 32% reduction below 2005 levels) by applying currently existing best-practice regulations to all localities. ICF International[50] and IEA[51] have also found this level of reduction cost effective. This reduction level could be increased up to 65% (57% cut relative to 2005) by deploying all the technological advances that exist with no exemptions. Alongside the 50% total GHG target's reliance on deep decarbonization of the energy sector which would reduce oil and gas demand, and an extended goal out to 2030 as opposed to 2025 which allows more development and ramp up time for abatement measures, a 75% reduction below current levels (72% relative to 2012 and 66% relative to 2005), is in the realm of the possible. Further, major oil and gas companies recently made bold commitments to reduce upstream leakage to 0.25% of production by 2025 with ambition to 0.2%[52] If all companies pursued and achieved these targets globally, EDF calculates it would lead to an 85% reduction in oil and gas emissions relative to projected levels in 2030.

[c] Using peer-reviewed evidence and system-level understanding of dairy and beef production in the United States, EDF estimates that it will be economically and practically feasible to reduce cattle enteric emissions by 10% by providing feed additives relative to current emissions (6% below 2005 levels). The most commonly researched additive (3-NOP) reduces enteric emissions by 32% in dairy (Feng & Kebreab 2020, Fig 2)[53] and 22% in beef (Dijkstra et al. meta-analysis,[54] quoted in Feng & Kebreab 2020), but beef cows (responsible for 75% of current U.S. enteric fermentation emissions based on EPA 2020 data) are on range or pasture during large parts of the year, and feed additives are not yet practical for grazing animals -- especially those widely dispersed on low producing rangeland. However, it could be possible to mix methane-reducing compounds into feed during winter months when these animals are fed hay or silage. We estimate a high-range estimate of 20% enteric emission reductions for the possibility that feed additives could be

[45] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018. (2020)
[46] Marchese A. J., T. L. Vaughn, D. J. Zimmerle, D. M. Martinez, L. L. Williams, A. L. Robinson, A L. Mitchell, R. Subramanian, D. S. Tkacik, J. R. Roscioli, and S. C. Herndon. (2015) Methane emissions from United States Natural Gas Gathering and Processing. Environmental Science & Technology, 49(17) 10718-10727. doi:10.1021/acs.est.5b02275
[47] Zimmerle D. J., L. L. Williams, T. L. Vaughn, C. Quinn, R. Subramanian, G. P. Duggan, B. Wilson, J. D. Opsomer, A. J. Marchese, D. M. Martinez, and A. L. Robinson. (2015) Environmental Science & Technology, 49(15) 9374-9383. doi:10.1021/acs.est.5b01669
[48] Alvarez R. A., D. Zavala-Araiza, D. R. Lyon, D. T. Allen, Z. R. Barkley, A. R. Brandt, K. J. Davis, et al. (2018) Assessment of methane emissions from the U.S. oil and gas supply chain. Science, 361 (6398) 186-188. doi:10.1126/science.aar7204
[49] International Energy Agency (IEA), "World Energy Outlook." (IEA, 2017).
[50] Alvarez ICF International, Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries (2014), https://www.edf.org/sites/default/files/methane_cost_curve_report.pdf
[51] International Energy Agency (IEA), "World Energy Outlook." (IEA, 2017).
[52] Oil and Gas Climate Initiative (OGCI), "A report from the Oil and Gas Climate Initiative." (OGCI, 2018).
[53] Feng X. and E. Kebreab. (2020) Net reduction in greenhouse gas emissions from feed additive use in California dairy cattle. PLoS ONE, 15(9). https://doi.org/10.1371/journal.pone.0234289
[54] Dijkstra J., A. Bannink, J. France, E. Kebreab, and S. van Gastelen. (2018) Antimethanogenic effects of 3-nitrooxypropanol depend on supplementation dose, dietary fiber content, and cattle type. Journal of Dairy Science 101(10) 9041-9047. https://doi.org/10.3168/jds.2018-14456.

provided to a larger portion of the cattle herd (Searchinger et al. 2019)[55] or that feed additives could be combined with genetic improvement (breeding), feed processing, and improved herd productivity for greater impact (Ahmed et al. 2020;[56] Herrero et al. 2016).[57]

[d] The EPA suggests that 12% of landfill emissions (below 2030 no action baseline) can be reduced at no net cost, with measures such as electricity generation with a reciprocating engine, gas turbine, combined heat and power, or microturbine and landfill gas recovery for direct use.[58] This number rises to around 20% for low-cost options (Hoglund-Isaksson et al. 2020).[59] Recent analyses also suggest that with limited improvement to technologies such as source separation with recycling and treatment with energy recovery, as well as no landfills of organic waste, emissions can be reduced by up to 80% below the 2030 baseline (Harmsen et al. 2020; Hoglund-Isaksson et al. 2020).

[e] The EPA (2013) suggests that 10% of emissions (below 2030 no action baseline) can be reduced at no cost, such as by deploying degasification for pipeline injection and power generation, and on-site use in coal drying. Both the EPA (2013) and more recent analyses (Harmsen et al. 2020;[60] Hoglund-Isaksson et al. 2020) suggest that 60% of coal-related emissions (below 2030 levels) can be reduced with existing technologies, including ventilation air methane (VAM) oxidation with improved ventilation, pre-mining degasification, and open flaring. However, an ambitious reduction in coal use will also substantially decline coal-related methane emissions.

[f] Based on recent syntheses, EDF estimates that it will be economically feasible (at less than \$100/t CO_2e) to reduce current livestock manure methane emission rates in the United States by 47%-50% (Pape et al. 2016;[61] Ahmed et al. 2020; Fargione et al. 2018).[62] The main intervention is to cover liquid manure storage pits and lagoons, thus enabling the capture of the methane produced in the anaerobic conditions. However, in consideration of the current trend to shift to more anaerobic storage (increasing baseline), we consider a lower end reduction potential of 30% below current levels (17% below 2005).

[g] For context, total U.S. GHG emissions in 2005 are ~7000 MMt CO_2e100/yr (EPA 2020 for all sectors by oil and gas; oil and gas estimates from EDF data and modeling – see (a)). A 50% reduction below 2005 levels in 2030 would then equal ~3500 MMt CO_2e100/yr.

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55 Searchinger, T.D., R. Waite, C. Hanson, and J. Ranganathan. (2019) Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050. World Resources Institute, Washington, DC. www.SustainableFoodFuture.org

56 Ahmed, J., E. Almeida, D. Aminetzah, N. Denis, K. Henderson, J. Katz, et al. (2020) Agriculture and climate change: Reducing emissions through improved farming practices. McKinsey & Company, New York, NY. https://www.mckinsey.com/industries/agriculture/our-insights/reducing-agriculture-emissions-through-improved-farming-practices

57 Herrero, M., Henderson, B., Havlík, P. et al. (2016) Greenhouse gas mitigation potentials in the livestock sector. Nature Climate Change, 6 452–461. https://doi.org/10.1038/nclimate2925

58 U.S. EPA. Global Mitigation of Non-CO_2 Greenhouse Gases: 2010-2030 (2013).

59 Höglund-Isaksson, L., A. Gómez-Sanabria, Z. Klimont, P. Rafaj, W. Schöpp, Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe–results from the GAINS model. Environmental Research Communications 2(2), p.025004 (2020).

60 M. Harmsen, D. P. van Vuuren, B. L. Bodirsky, J. Chateau, O. Durand-Lasserve, L. Drouet, O. Fricko, S. Fujimori, D. E. Gernaat, T. Hanaoka, J. Hilaire, The role of methane in future climate strategies: mitigation potentials and climate impacts. Climatic Change, 24, 1-7 (2020).

61 Pape, D., J. Lewandrowski, R. Steele, D. Man, M. Riley-Gilbert, K. Moffroid, et al. (2016) Managing Agricultural Land for Greenhouse Gas Mitigation within the United States. ICF International. Report prepared under USDA Contract No. AG-3144-D-14-0292. http://www.usda.gov/oce/climate_change/mitigation.htm

62 Fargione J. E., S. Bassett, T. Boucher, S. D. Bridgham, R. T. Conant, S. C. Cook-Patton, P. W. Ellis, et al. (2018) Natural climate solutions for the United States. Science Advances, 4(11). doi:10.1126/sciadv.aat1869