RHODIUM GROUP

ENERGY & NATURAL RESOURCES

Taking Stock: Progress Toward Meeting US Climate Goals

The Paris Agreement, unanimously adopted by the nations of the world on December 12, 2015, marks a turning point in the global effort to combat climate change. Along with pledges from over 185 countries, the US committed to reduce its greenhouse gas (GHG) emissions 26-28% below 2005 levels by 2025, building on its existing goal of a 17% reduction below 2005 levels by 2020. This report quantifies the impact of all current and proposed federal policies on future GHG emissions to assess whether the US is on track to meet its climate targets. We find:

The US has successfully bent its emissions curve: We estimate that US carbon dioxide emissions from energy consumption in 2015 were 11% below 2005 levels. While slower than expected economic growth played a role in this decline, the majority was due to improved efficiency of cars, trucks, buildings and appliances and displacement of coal and oil with renewable energy and natural gas.

The 2020 target is within reach: Under current and proposed policies, the US is largely on track to meet its 2020 target. We project US GHG emissions that year will be 10% to 20% below 2005 levels, depending on the pace of economic growth, changes in technology costs and changes to US carbon sinks.

Meeting the Paris pledge will require additional action: Reducing emissions 26-28% below 2005 levels by 2025 will not be possible through current and planned policies alone. Even under the most effective policy implementation and optimistic technology and forest sink scenarios, we expect US emissions to be 23% below 2005 levels that year—leaving a 220-350 million metric ton gap. While the US still has nearly a decade to put additional policy in place, it will need to do so relatively quickly for the impact to be felt by the time the 2025 pledge comes due.

January 28, 2016

John Larsen
jwlarsen@rhg.com

Kate Larsen
kmlarsen@rhg.com

Whitney Herndon
wjherndon@rhg.com

Shashank Mohan
smohan@rhg.com

INTRODUCTION

Last month the nations of the world unanimously adopted the Paris Agreement in what many are lauding as an historic turning point in establishing a long-term, durable global framework to tackle greenhouse gas emissions (GHG). All countries agreed for the first time to establish GHG mitigation targets every five years and to pursue domestic measures to achieve those targets. To date, over 185 countries representing more than 98% of global emissions have put forward targets for the 2025 or 2030 timeframe.

This new era of international cooperation and action was made possible in no small part by the efforts of the Obama Administration to accelerate climate action at home and diplomatic engagement abroad. Since the breakdown of the Copenhagen talks in 2009 and the failure of Congress to adopt cap-and-trade legislation, the Obama Administration has taken a series of actions using existing executive authorities aimed at meeting the President's goal of achieving emission reductions in the range of 17% below 2005 levels by 2020. The President's Climate Action Plan, released in June 2013, lays out the Administration's roadmap for curbing GHG emissions from each key sector of the US economy in line with meeting the 2020 goal.

The Obama Administration's domestic climate policies have helped catalyze international action. In November 2014 President Obama and Chinese President Xi Jinping jointly announced their post-2020 GHG mitigation pledges, building on months of bilateral negotiations. The fact that the US had a credible plan for achieving its 2020 target and has made demonstrable progress towards that goal, increased American negotiating leverage in securing an ambitious post-2020 Chinese commitment. The US-China announcement helped spur a cascade of new pledges from developed and developing countries alike in the lead up to the Paris climate summit last year.

As the world now turns to implementing the Paris Agreement and countries begin to put the necessary measures in place to achieve their national commitments, continued American climate leadership is critical. The ability of the US to meet both its 2020 and 2025 targets will shape other countries' commitment to domestic climate action. And while nine years remain between now and when the US 2025 climate target comes due, there is a significant lag between policy development, adoption and impact. US policymakers need an objective assessment of how far current and proposed policies will go in reducing GHG emissions and where there are opportunities to close the remaining gap.

This report aims to provide such an assessment. We start by quantifying the impact of climate and energy policies enacted since 2009 on US GHG emissions today, in 2020 and in 2025. These "current policies"—including the Environmental Protection Agency's (EPA) Clean Power Plan (CPP)—span the largest emitting sectors of the US economy. We also consider the potential effect of policies or programs that have been proposed but not yet finalized, including pending standards for methane emissions from new oil and gas sources, revised heavy-duty vehicle efficiency standards, and efforts to phase down hydrofluorocarbons (HFCs) under the Montreal Protocol. Because these "proposed" policies are not yet final, there remains uncertainty about the timing and stringency of their implementation, which we account for.

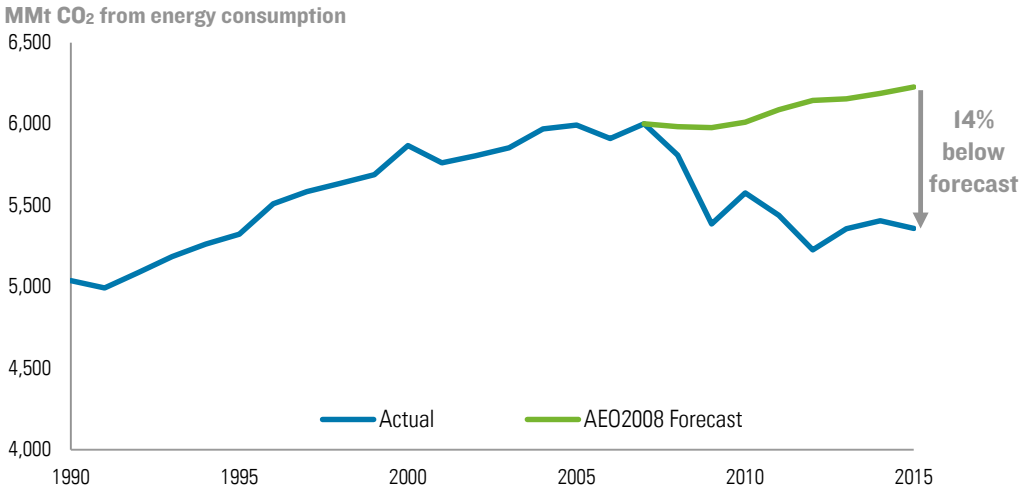
We explore the impact of these policies under a range of assumptions regarding future economic growth, changes in transportation demand (measured as vehicle miles traveled or VMT), and the rate of cost reduction for renewable energy and battery storage technologies. Finally we identify opportunities for additional emission reductions to close the gap between what current and proposed policies are likely to deliver and the 2025 Paris pledge.

PROGRESS TO DATE

The year before President Obama took office, the Energy Information Administration (EIA) projected in its Annual Energy Outlook (AEO) that carbon emissions from US energy consumption would continue to growth at their historical average of nearly 1% per year for the foreseeable future. US carbon emissions have instead declined significantly in absolute terms due to policy actions taken by the Obama Administration, slower than projected economic growth, and technological developments like the shale gas boom. Based on the most recent EIA data, we estimate that carbon dioxide (CO_2) emissions from energy consumption (which account for roughly 80% of total US GHG emissions) were 14% lower in 2015 than projected in EIA's 2008 AEO forecast (Figure 1).[1]

[1] Our 2015 values reflect actual data through at least the third quarter, coupled with our estimates for the remainder of the year.

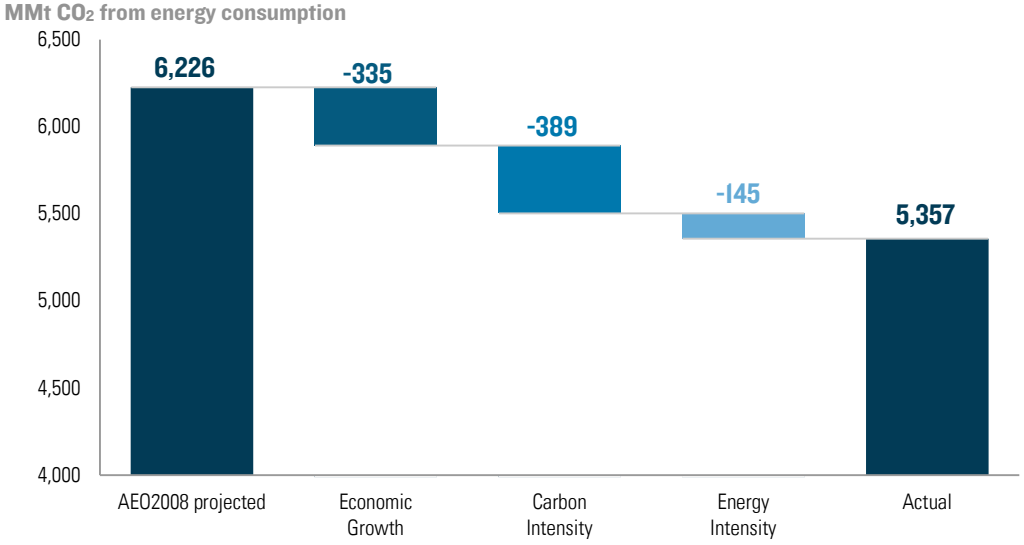
Figure 1: 2015 emissions 14% lower than projected in 2008



Source: EIA, Rhodium Group analysis.

The 870 million metric ton (MMt) drop in emissions between the AEO2008 forecast and what actually occurred in 2015 was due to a combination of slower than expected economic growth, a reduction in the carbon intensity of energy supply, and a reduction in the energy intensity of the economy. Slower than expected economic growth due to the financial crisis, Great Recession, and gradual recovery accounted for about 39% of the decline in actual 2015 emissions relative to AEO2008 projections based on a simple decomposition analysis (Figure 2). Reductions in the carbon intensity of energy—the amount of CO_2 emitted per unit of energy consumed—explains 45% of the decline. This is the result of an unprecedented increase in the availability and use of natural gas from shale resources coupled with expanded renewable power generation thanks to the federal Production Tax Credit (PTC) and Investment Tax Credit (ITC), state Renewable Portfolio Standards (RPS), other federal and state policies, and a decline in renewable technology costs. The remaining 16% comes from federal and state efficiency programs, fuel economy standards for light-duty vehicles (and high oil prices), building codes, technological improvements and shifts in the structure of the US economy.

Figure 2: Economic and policy factors contribute to lower than expected emissions in 2015



Source: EIA, Rhodium Group analysis.

EMISSIONS OUTLOOK UNDER CURRENT POLICY

While US emission reductions to date are impressive, the average annual pace of decline will need to accelerate to meet both the 2020 and 2025 targets. To assess how far the total package of federal policies currently on the books will go towards achieving those objectives, we use a combination of tools and approaches. Where our assumptions differ from US government forecasts, we use our own emissions projections to capture the most recent developments in US energy and climate policy. We supplement our estimates with the most recent, publicly available data from EPA and the US Second Biennial Report. Finally, we incorporate economic and technological uncertainty into our projection ranges. Our approach allows for consistent comparisons between our estimates and historical datasets as well as the latest US Biennial Report.

Energy CO_2 emissions outlook to 2025

In its most recent AEO, the EIA currently projects that energy CO_2 emissions will remain essentially flat out to 2025 and beyond. This reference case forecast contains all federal policies on the books as of the end of 2014 that affect CO_2 emissions. Significant new policies have been finalized or enacted since that time, most notably the CPP and the multi-year extension of the PTC and ITC.[2] Using RHG-NEMS, a modified version of the National Energy Modeling System used by EIA to produce the AEO, we've constructed a current policy scenario that starts with all of the economic, demographic, and technological assumptions contained in the AEO2015 reference case, and incorporates these and other policies that were finalized or enacted in 2015.

Along with state RPSs the PTC and the ITC have played a critical role in driving US renewable capacity additions. The PTC provides a 2.3 cent/kWh tax credit for ten years to any wind facility that breaks ground before the eligibility deadline. The ITC allows solar power projects to receive a tax credit equal to 30% of the total project cost. As part of a major year-end spending bill, Congress adopted an extension and phase down of the PTC for wind, and ITC for solar and an array of additional renewable energy technologies. This provides policy certainty to an industry that's experienced retroactive and last minute extensions of subsidies for over a decade, which has stymied renewable development. Both incentives have been extended at current levels for two years beyond their initial sunset dates and then phased down in a stepwise manner over four years. The PTC ultimately gets completely phased out by 2020 while the ITC flattens out at 10% of project costs in 2021.

EPA's CPP is the crown jewel of the Obama Administration's Climate Action Plan and establishes the first ever limits on CO_2 emissions from fossil-fuel fired power plants—the largest single source of CO_2 emissions across the US. Finalized in August 2015, the CPP sets binding guidelines and emission reductions targets that states must meet beginning in 2022. The CPP is more challenging to capture in our analysis than most policies because even though each state's target is known, states must still construct and implement compliance plans over the next several years. States have considerable flexibility in how they construct their plans, and whether and how they choose to coordinate implementation with other states. These choices will have important implications for overall emission reductions as we discuss further below.

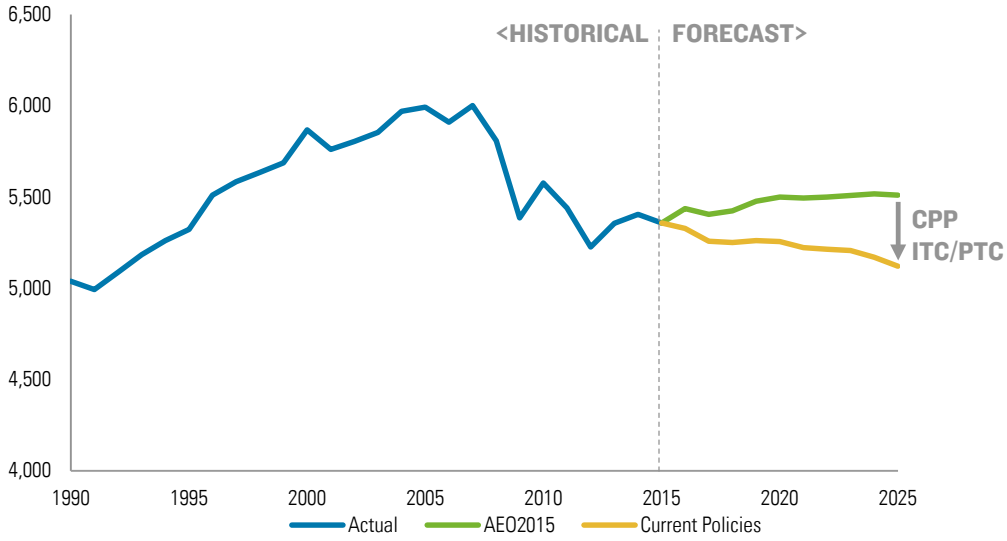
In this analysis we characterize the CPP as a single, national mass-based emissions standard setting a fixed ton limit on CO_2 from existing and new fossil steam and natural gas combined cycle (NGCC) generators. The limit follows the glide path for emission

[2] For a full review of additional policies incorporated into our current policies scenario please see the technical appendix accompanying this report.

reductions set by EPA and we assume allowances are freely traded across the country to facilitate efficient and least-cost compliance. This approach captures the most gradual and economically efficient CPP implementation pathway, making it appropriate for a national scale analysis such as ours, especially since, to date, few states have indicated to EPA their preferred implementation paths. For a detailed exploration of how different implementation choices can influence CPP emissions outcomes, see this research note we published with the Center for Strategic and International Studies.

Figure 3: Recent electric sector policies result put economy-wide emissions on the decline

Economy-wide CO_2 emissions (MMt) from energy consumption, 1990-2025



Source: EIA, Rhodium Group analysis.

The introduction of the final CPP and tax extenders move US CO_2 emissions from a relatively flat trajectory to gradually declining emissions from 2015 to 2025 (Figure 3).[3] Emissions begin to drop in 2016, reflecting the extension of the PTC and ITC. After 2022 the impact of the CPP is apparent, with total emissions declining by 7% below the AEO2015 reference case in 2025 and 15% below 2005 emissions. That would bring US CO_2 emissions to levels last seen in 1992.

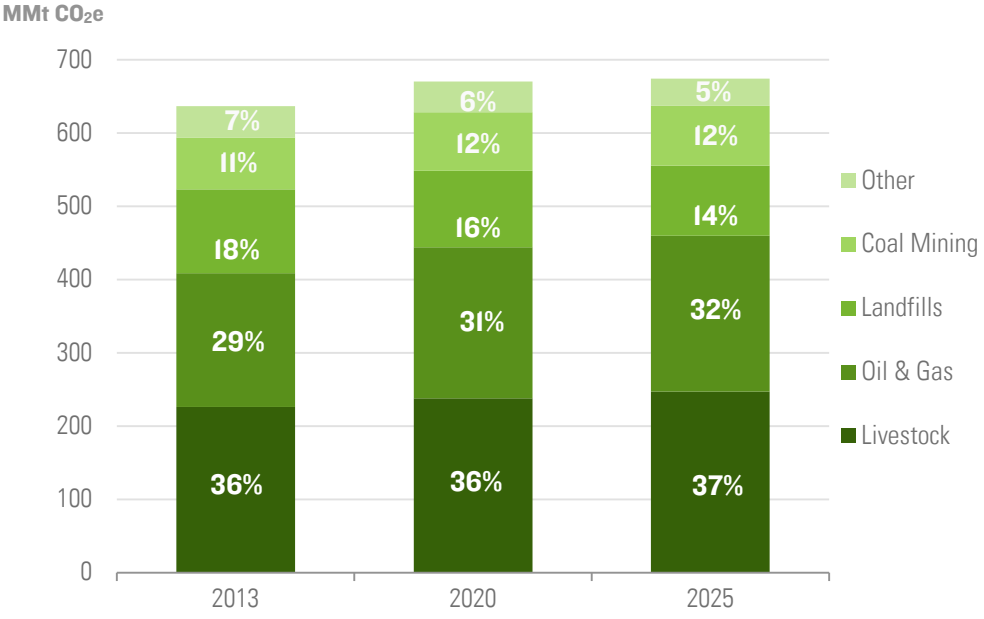
Emissions outlook for other gases and sectors

After CO_2, methane is the second largest contributor to US emissions, accountable for around 9.5% of total GHGs in 2013. Resulting primarily from leaks in natural gas systems, livestock, and waste decomposition in landfills, methane is an extremely potent GHG, over 25 times as climate-forcing as CO_2.[4] Methane emissions have decreased by over 10% since 2005, due in large part to an 11% drop in emissions associated with production of natural gas, the second largest source in the US. Despite this progress, EPA projects that absent further efforts, methane emissions will grow an additional 5.3% by 2020 and 5.9%

[3] With the exceptions of Figures 1, 2, and 3, we use EPA's GHG accounting conventions as opposed to EIA's. This allows us to present results under the same framework used by the UN Framework Convention on Climate Change (UNFCCC) to assess progress towards meeting US emission reduction commitments.
[4] Throughout this report we use 100-year Global Warming Potential (GWP) values from the IPCC's 4th Assessment Report (AR4) to compare CO_2 and non-CO_2 gases on an equivalent basis. EPA uses AR4 values for its GHG Inventory. Although the 5th Assessment Report provides more recent estimates, the UNFCCC guidelines require the use of AR4 values.

by 2025.[5] The bulk of the growth is expected to come from oil and natural gas activities (see Figure 4).

Figure 4: Methane emissions by sector under current policies



Source: EPA Second Biennial Report and Rhodium Group analysis.

Nitrous oxide (N_2O), a powerful gas nearly 300 times more potent than CO_2, contributed another 5% of total US GHG emissions in 2013. Nearly three-quarters of total N_2O emissions come from agricultural soil management, with the remainder primarily from fuel combustion in vehicles and other stationary sources. According to EPA estimates, N_2O emissions are expected to decline slightly (about 5%) by 2020 and then remain flat through 2025.[6]

The final group of non-CO_2 gases—fluorinated gases—includes HFCs, Perfluorocarbon (PFC), and Sulfur Hexafluoride (SF6), a group of gases hundreds to thousands of times more climate-forcing than CO_2. While they contribute a small portion of total US GHG emissions (around 3% in 2013), their potency and rapid growth make them an important area for attention. Emissions from HFCs, primarily used as a substitute for ozone-depleting substances in applications such as air condition and refrigeration, grew 24% between 2005 and 2013. EPA projects HFC emissions will rise nearly 30% from today's levels by 2020 and over 50% by 2025 absent additional abatement efforts.[7]

Forests and land use

A major wild card in assessing the potential for the US to meet its 2020 and 2025 targets is whether American forests and other lands are able to maintain their historically high rate of carbon sequestration. In 2013, over 13% of total US GHG emissions were offset as forests and other lands absorbed carbon from the atmosphere. Between 1990 and 2013, the carbon sink grew 14%, primarily as a result of growth in the existing forest stock and a slight expansion of total forested area. Recent studies suggest that as a result of

[5] We use EPA's non-CO_2 projections from the Second Biennial Report (2016), available here.
[6] Ibid.
[7] Ibid.

changing land-use patterns and the effects of climate change itself, over the long-term US forests may absorb carbon at a slower rate. There is significant uncertainty, however, about if and when such slowing may occur.

The President's Climate Action Plan includes conservation and sustainable management of US forests and lands as a central pillar in meeting US climate goals. In April 2015, USDA announced a plan to increase carbon storage in our forests and soils. The Building Blocks for Climate Smart Agriculture and Forestry Strategy uses authorities in the 2014 Farm Bill to provide incentives and assistance to farmers, ranchers, and forest land owners to improve conservation and stewardship of forest and land resources to maximize carbon sequestration.

Understanding how policy and other federal initiatives will influence the capacity of US forests and lands to sequester carbon over the coming decades is complicated by significant remaining uncertainties associated with market dynamics and other drivers of land-use change and forest use, the uncertain effects of future climate change on our lands and forests, and the complexity of understanding the carbon dynamics of America's diverse ecosystems. To reflect these uncertainties, the Administration, in its second Biennial Report, presented a range of projected emissions and removals from land use, land use change, and forestry (LULUCF) out to 2030. The difference between the low and high end of the sequestration range reflects the uncertainty in population and economic variables that impact forest product demand, land use change, and forest management practices. In the low sequestration scenario, forest area and forest carbon begin to decline after 2020. In the high sequestration scenario, forest area and carbon continue to grow until 2025, after which they decline. The result is an uncertainty band of 147 MMt CO_2 in 2020, growing to 429 MMt CO_2 by 2025.

The Administration believes the US is trending to the high sequestration path given the recently announced efforts by USDA to increase forest conservation and enhance the carbon sequestration potential of US forests and lands. In keeping with our approach of capturing the uncertainty associated with policy and other factors in our assessment, we maintain the full LULUCF range as laid out by the US Second Biennial Report in our projections of current and proposed policies out to 2025.

Accounting for economic and technology uncertainty

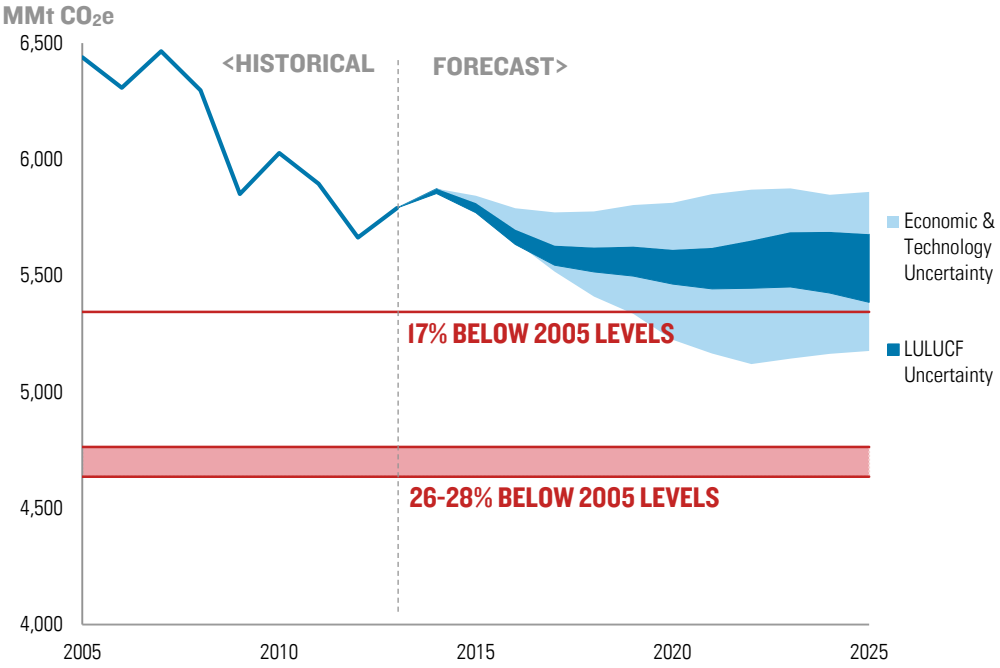
As indicated in Figure 1, future emissions are challenging to predict. There are developments outside of the policies we analyze that could push emissions above or below our core current policy scenario pathway. We consider three of the most significant in our analysis: economic growth, transportation demand, and renewable energy and energy storage technology costs.

Higher than expected economic growth can push GHG emissions higher, all-else-equal, by increasing energy consumption. The reverse is also true: lower economic growth leads to weaker energy demand and lower GHG emissions. Passenger vehicle transportation demand (measured in vehicle miles traveled or VMT) grew by 2.3% per year, on average, between 1970 and 2013. However, since the middle of the 2000s VMT has been largely flat even as the economy has recovered. It is unclear if the recent departure from long-term trends will persist into the future. Higher VMT increases GHG emissions from gasoline and diesel combustion; lower VMT leads to lower GHG emissions.

The cost and performance of new zero- and low-carbon technologies is a major source of uncertainty in projecting US GHG emissions. Utility-scale and distributed wind and solar power as well as battery technologies are so new, and recent cost reduction trends have

been so dramatic that it's difficult to project exactly what role these technologies may play in the future. The cheaper renewable technologies get, the more market share they can gain over fossil-fuel generation in the power sector. In the transportation sector reductions in battery costs can allow electricity to gain market share over gasoline, diesel, and biofuels. Accelerated deployment of these technologies due to lower than expected costs will lead to lower emissions, all-else-equal.

Figure 5: US net GHG emissions under current policy, 2005-2025



Source: EPA, US Second Biennial Report, Rhodium Group analysis.

Accounting for these areas of economic and technology uncertainty, we project a range of likely GHG emission outcomes (Figure 5). The upper bound of our range reflects our core current policy scenario assumptions but with greater economic and VMT growth, which increases energy demand and associated CO_2 emissions. We also assume the low carbon sequestration pathway for US forests and other lands, which reduces the extent to which those increased carbon emissions are offset. The lower bound of the range assumes a lower rate of VMT growth (whether due to market or policy forces), as well as more optimistic assumptions about declining renewable energy and battery storage costs and greater deployment of distributed generation. The combination of lower energy demand and cheaper, more abundant zero emitting generation pushes emissions considerably below our core scenario projections.[8] These assumptions are paired with greater carbon offsetting from US forests and other lands (using the high sequestration pathway).

Assessing the gap under current policy

Under our core scenario— current policies under AEO2015 economic and technology assumptions, and the most optimistic LULUCF outcome—we find that the US comes close, but does not meet the 2020 target, with emissions 15% below 2005 levels. In 2025 the US is pretty far from its goal with emissions 16% below 2005 levels (Figure 5). When

[8] For a review of all assumptions and methods used in this analysis please see the technical appendix that accompanies this report.

we account for economic and technology uncertainty, the range of possible emissions outcomes widens to 10% to 19% below 2005 levels in 2020 and 9% to 20% in 2025. While important progress has be made to date, current policies are not sufficient to meet US climate targets except under the most optimistic assumptions. Even then only the 2020 target may be achievable. In 2025 a considerable gap remains.

LOOKING AHEAD: POLICIES IN THE PIPELINE

Although there is nearly a decade remaining for new policies to be enacted and implemented, those put in place in the next few years will be critical for locking in emission reductions on the scale that is required to close the 2025 emissions gap. The Obama Administration, in its Climate Action Plan, laid out a wide range of proposed policies and programs, some of which have only been partially executed to date and several others remain to be fully fleshed out. In the following section we assess the state of all federal policies and programs still in proposal stage as of January 2016 and their potential contribution toward bringing US GHG emissions in line with our 2020 and 2025 goals.

Methane

In March 2014, the Obama Administration released its interagency Strategy to Reduce Methane Emissions, which laid out steps to reduce methane emissions from four key categories: agriculture, landfills, coal mines, and oil and natural gas. For two of these sectors—landfills and oil and gas—the Administration has proposed regulatory standards and/or quantifiable voluntary industry goals. We provide more details in the following sections, including estimates of their potential to achieve emission reductions in 2020 and 2025. For two other sectors—agriculture and coal mines—the Administration has indicated it plans to take action but has not released specific, quantifiable standards or proposals as of December 2015. Those potential policies are therefore excluded from our analysis of policies in the pipeline.[9]

Landfills

Around 18% of US methane emissions are the thousands of industrial and municipal landfills that process the nation's waste. Emissions from these sources have declined by nearly a third since 2005, primarily as a result of efforts to divert compostable waste, and federal requirements for collection and combustion of gas from the largest municipal landfills. In August 2015, EPA announced plans to expand control of Non-methane Organic Compounds (NMOCs)—hazardous pollutants co-emitted with methane—for new and existing municipal solid waste landfills, which are responsible for over 95% of total methane emissions from the sector. For existing landfills, EPA has proposed to lower the emissions threshold that would trigger installation of controls from 50 megagrams (Mg) of NMOCs to 34 Mg. The current threshold dates back to 1996 when landfills were much smaller than they are today. The methane reductions benefits from the proposed rule are estimated at 9 MMT CO_2e by 2020 and 10.9 MMT by 2025. A supplemental NSPS proposal would lower the emissions threshold at which new,

[9] As part of its methane strategy, the Administration announced that the Bureau of Land Management (BLM) would develop a program for capture of waste mine methane from coal production on public lands. A January 15 announcement by the Department of Interior indicated that BLM will move forward with this in concert with broader efforts to reform federal coal leases.

modified, or reconstructed landfills would be required to capture landfill gas to 34 Mg as well, reducing an additional 1.9 MMt CO_2e in 2020 and 1.3 MMt in 2025.[10]

Oil & natural gas

Oil and natural gas operations across the US produce nearly 30% of total US methane emissions, representing the largest single emissions source. Emissions from the sector, absent additional efforts beyond those in place in 2015, are expected to grow 13% by 2020 and 16% by 2025. In early 2015, the Administration announced an ambitious sector-wide goal of reducing emissions 40-45% below 2012 levels by 2025, which would nearly triple the rate of reduction achieved across the sector over the past five years. Meeting this goal will require significant reductions from across the oil and gas value chain—from production and process to transmission and distribution—including not only new sources, but also the existing stock of infrastructure which is estimated to contribute nearly 90% of total methane emissions from the sector in 2018.[11]

In its methane strategy the Administration announced it would consider all significant methane sources from oil and gas, decide whether to take a voluntary or regulatory approach, and complete any new regulations by the end of 2016. On January 22, the Bureau of Land Management proposed new standards to reduce flaring, venting, and methane leaks from oil and gas wells on federal and tribal lands. The roughly 100,000 onshore wells produce around 11% of the nation's natural gas and 5% of its oil. The US Department of the Interior estimates that between 2009 and 2014, 375 billion cubic feet of natural gas (the primary component of which is methane) was lost from venting, flaring and equipment leaks. BLM estimates that the proposed rules could reduce annual methane emissions from public lands by 4.1 to 4.2 MMt CO_2e starting in 2017.[12]

To address non-federal sources, EPA proposed New Source Performance Standards (NSPS) for methane emissions from new and modified oil and gas production sources, and natural gas processing and transmission sources. While the rules will reign in emissions growth from expansion of oil and gas operations, EPA estimates that these sources will account for only 2% of total methane emissions from the sector in 2020, and only 4 to 5% by 2025. If adopted as proposed, the rules should reduce emissions by 3.8 to 4.0 MMt CO_2e in 2020 and 7.7 to 9.0 MMt CO_2e in 2025.[13]

Under Section 111 of the Clean Air Act, once EPA proposes standards for *new and modified* sources, it is required to set standards for *existing* sources within that same source category, though it provides EPA discretion on the timing of such a rule. To date, the Administration has not indicated that it intends to regulate existing sources before its self-imposed 2016 deadline for new regulations to meet its methane goals. Instead, EPA will rely on its Natural Gas STAR program to encourage industry to voluntarily reduce methane emissions from existing sources. In July, EPA announced a new Methane Challenge Program which invites companies to establish voluntary methane reduction commitments and report on their progress. The program provides two options for participating companies. The first is to agree to adopt one or more best management practices company-wide. The second is to adopt a methane intensity target under the ONE Future framework, which aims to limit methane leakage across the natural gas

[10] EPA, "Regulatory Impact Analysis for the Proposed Revisions to the Emission Guidelines for Existing Sources and Supplemental Proposed New Source Performance Standards in the Municipal Solid Waste Sector," 2015, pages 3-12 and 7-19. Available here.
[11] ICF International, "Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries," 2014. Available here.
[12] BLM, "Waste Prevention, Production Subject to Royalties, and Resource Conservation (2016). Available here.
[13] EPA, "Regulatory Impact Analysis of the Proposed Emission Standards for New and Modified Sources in the Oil and Natural Gas Sector," 2015, pages 4-7. Available here.

value chain to 1% of total by 2025 production (EPA estimates current leakage at 1.3%), with an interim goal of 1.2% by 2020.

Because of the Methane Challenge program's voluntary nature, there is significant uncertainty about the level of industry participation, which types of commitments companies will take, and the degree to which those goals are achieved. This makes it difficult to quantify the potential emission reductions achievable through the proposed voluntary actions across existing oil and gas sources. To illustrate how such measures could contribute toward meeting the Administration's sector-wide goal, we estimate the maximum potential reductions achievable assuming universal industry participation and 100% effectiveness of those efforts to meet the ONE Future leakage goals.[14] While these expectations are optimistic, it provides a sense of what the upper bound of emission reductions might be. We estimate that universal industry participation and achievement of the voluntary goals could deliver as much as 4 MMt CO_2e in 2020 and 31 MMt CO_2e in 2025 over and above proposed BLM and NSPS standards.

Figure 6: 2020 methane emissions

$MtCO_2e$ from all methane sources

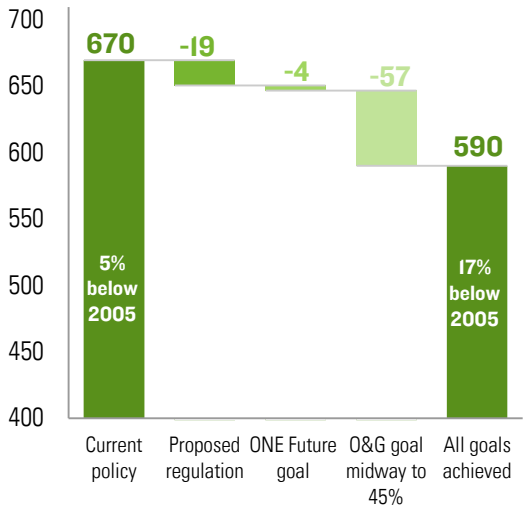
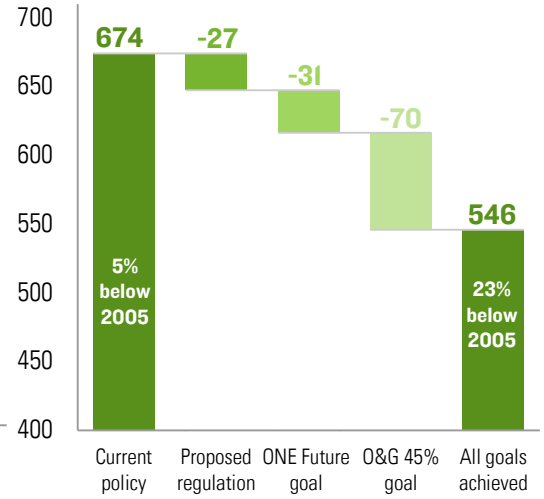


Figure 7: 2025 methane emissions

$MtCO_2e$ from all methane sources



Source: US Second Biennial Report, EPA, BLM, Rhodium Group analysis.

Figures 6 and 7 break down expected methane emissions in 2020 and 2025 under current policy, from standards currently in proposal stage (i.e. from landfills and the NSPS for oil and gas),[15] as well as expected reductions from proposed voluntary efforts and goals. To illustrate the potential of the Methane Challenge program, we include the upper bound of emission reductions possible through universal participation and achievement of the ONE Future goals. Even with such optimistic assumptions, the voluntary program falls far short of meeting the Administration's oil and gas sector goal, which requires additional reductions of 59 to 70 MMt CO_2e in 2025 to meet the 40-45% goal. Because natural gas production is expected to grow 25% above 2013 levels by 2025, meeting the Administration's goal would require nearly halving the leakage rate from across the entire natural gas sector—bringing it down from 1.3% today to around 0.65 to 0.7% in

[14] For simplicity of quantification, we assume all industry partners commit to participate in the ONE Future Coalition and achieve its stated goals. We acknowledge that some companies may opt for alternate approaches, which may achieve more or fewer reductions than meeting the ONE Futures goal.
[15] This assumes the high end of the emission reduction estimates are achieved.

2025.[16] Neither the proposed new source standards nor the voluntary efforts for existing sources in their current form come within this range.

When we assume that all current and proposed federal policies and goals are achieved, total methane emissions from across the economy drop to 17% below 2005 levels by 2020 and 22% by 2025. According to EPA estimates, proposed regulations (including for new and existing landfills and new oil and gas sources) are expected to achieve reductions of around 19 MMt CO_2e in 2020 and 27 MMt CO_2e in 2025 (or about 2.6% and 3.8% below 2005 levels, respectively). An additional 4.4% below 2005 levels could be achieved in 2025 with universal industry-wide participation and achievement of voluntary goals by the natural gas sector (based on our assumption that all choose the ONE Future commitment). The bulk of the remainder relies on additional, yet to be specified actions to reduce emissions from existing oil and gas sources.

HFCs

Another key aim of the President's Climate Action Plan is cutting emissions of one of the most potent and fastest growing GHGs, HFCs. To stem their growth, the Administration is using its existing authority to limit the use of the most harmful HFCs in certain applications and expand the list of available alternatives through EPA's Significant New Alternatives Policy Program (SNAP). Last July, EPA released a final rule restricting the use of certain HFCs in various end-uses in the aerosols, refrigeration, air conditioning, and foam blowing sectors where lower-GHG substitutes are available. Despite this, emissions are expected to increase more than 29% from 2013 levels by 2020 and 53% by 2025 absent additional abatement efforts that go beyond those adopted by 2015.

Last October, EPA released a proposed rule that, once finalized in 2016, would extend refrigerant management requirements to HFCs, reducing emissions associated with servicing by 7.5 MMt CO_2e each year. EPA also announced plans to initiate a rulemaking in the first half of 2016 that will continue to expand the list of climate-friendly alternatives and prohibit high-GWP substances where safer options are available.

The ability of the US alone to drive change across the industry is limited, however. The most effective approach for expanding alternatives and driving down costs would be for a global approach. After seven years of effort, the Parties to the Montreal Protocol finally agreed last November to work over the course of 2016 to amend the agreement to phase down the production and consumption of HFCs. If negotiations are successful initial requirements may kick in as early as 2019, as outlined in the 2015 North American proposal submitted by the US, Canada, and Mexico. Under the proposal, HFC consumption and production for the US and other developed countries would be capped at 90% of current levels starting in 2019, ratcheted down to 65% by 2024, with an almost total phase down by 2036. EPA estimates that the subsequent drop in US emissions associated with reduced HFC production and consumption (including reductions already achieved through final and proposed EPA regulations) would total around 63 MMT CO_2e in 2020 (or a 30% reduction from projected levels) and 113 MMT CO_2e in 2025 (or 45% below projected levels).[17]

Figures 8 and 9 break down the relative contribution of current and proposed federal efforts toward expected emission reductions in 2020 and 2025. Taking into account current policy and standards in the formal proposal stage, HFC emissions are expected

[16] To calculate the natural gas leakage rate required to meet the Administration's 45% goal, we distribute the required reductions to the oil and natural gas sectors based on their expected share of emissions in 2025 (i.e., 95.9% of methane reductions will come from natural gas, and 4.1% from oil). We calculate the leakage rate once those reductions are achieved using EIA estimates of natural gas production and consumption in 2025.
[17] Second Biennial Report of the United States of America (2016). Available here.

to reach 55% above 2005 levels in 2020 and about 85% above 2005 levels by 2025. The significant reductions anticipated from adoption of a Montreal Protocol Amendment will stem the rise of emissions to only 13% above 2005 levels in 2020 and 4% by 2025.

Figure 8: 2020 HFC emissions and reductions

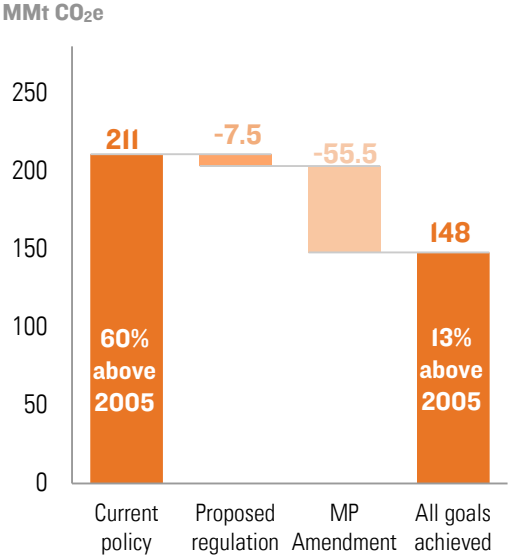
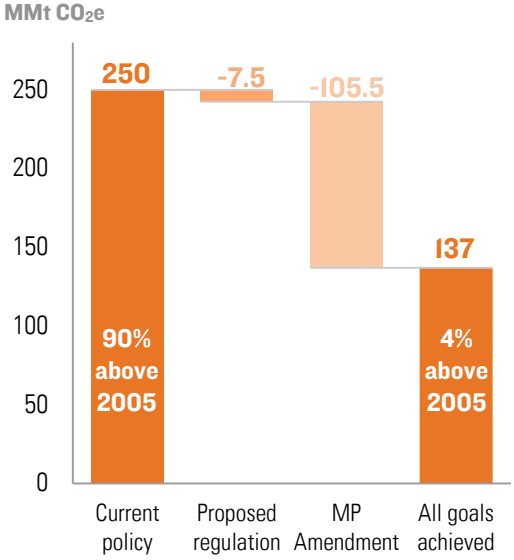


Figure 9: 2025 HFC emissions and reductions



Source: US Second Biennial Report, EPA, Rhodium Group analysis.

Transportation

The primary regulatory tool for tackling GHGs from transportation (which account for over a quarter total US emissions) has been the GHG emission and fuel economy standards developed by EPA and National Highway Traffic and Safety Administration (NHTSA). In 2012, the agencies finalized Phase 2 standards for light-duty vehicles for model years 2017-2025, expected to achieve fleet-wide fuel economy of over 54 miles per gallon by 2025. As part of the Phase 2 rulemaking, EPA committed to conduct a midterm evaluation of whether standards for model years 2022-2025 should be revised based on new developments in technology and fuel prices, among other trends. EPA plans to issue a proposed determination in 2017, with a final determination expected in April 2018.

With new efforts to ramp up GHG standards for light-duty vehicles on hold until 2018, the upcoming decision on Phase 2 standards for medium- and heavy-duty vehicles—including big rig trucks, delivery and utility trucks, buses, garbage trucks, and the largest pickup trucks and vans—is the most significant new regulation in the pipeline for the 2025 timeframe. The proposed standards—released in July 2015 and expected to be finalized in summer 2016—will apply to model years 2021-2027, and once fully phased in are expected to lower CO_2 emissions and fuel consumption from new big rig tractors by as much as 24%, according to EPA estimates. Based on integrated modeling of the proposed HDV rule with the full range of current and proposed policies, we estimate that by 2025, the full suite of HDV standards will achieve additional reductions of 20 to 26 MMt CO_2 from the current policy case.

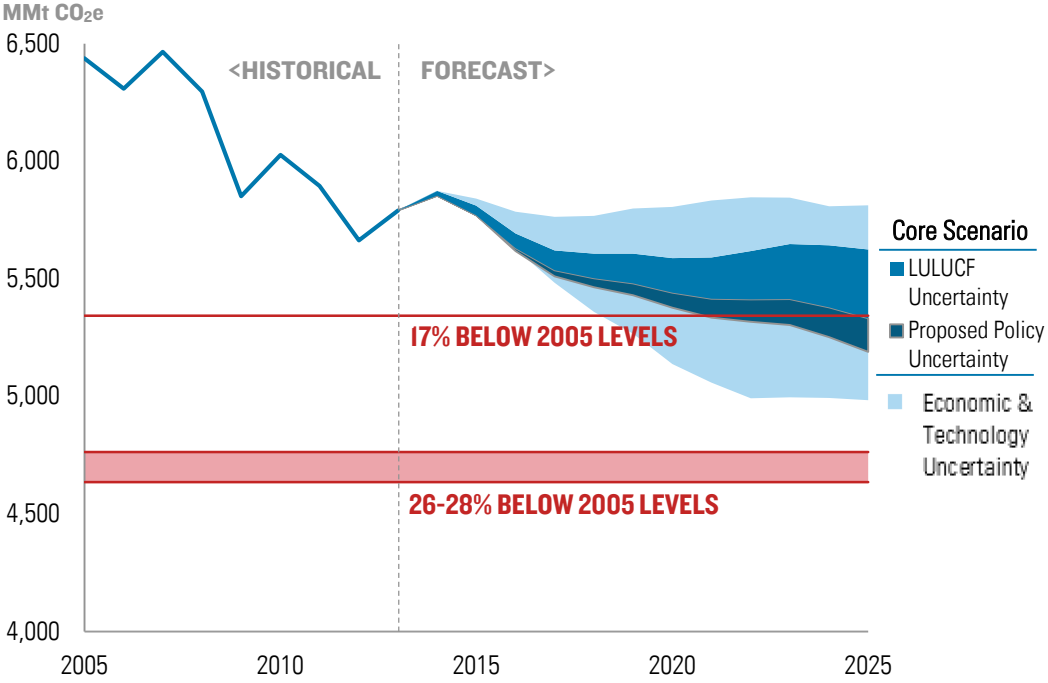
EMISSIONS UNDER CURRENT & PROPOSED POLICIES

Proposed policies can make a meaningful contribution to emission reductions above and beyond what we expect current policy to deliver, though most of the additional benefits

come after 2020. As we discussed in the previous sections, there are three sources of uncertainty reflected in our range of potential GHG emission pathways: LULUCF uncertainty; proposed policy uncertainty; and economic and technology cost uncertainty. We maintain the same range of LULUCF uncertainty throughout the analysis, which adds up to nearly 300 MMt in 2025, making up just under 5% of the 26-28% reductions required below 2005 levels.

Proposed policy uncertainty reflects the high and low range of emission estimates from the suite of proposed polices outlined in the section above. At the high end of the range, we assume that proposed regulations (for methane, HFCs, and HDVs) are finalized as proposed, but that none of the voluntary or aspirational goals are achieved. At the low end of the range, we include proposed regulations as well as achievement of the ONE Future 1% leakage goal for the entire natural gas industry (as a proxy for the effect of the Methane Challenge program) as well as adoption of an amendment to the Montreal Protocol for HFCs. In 2025, the proposed policy uncertainty spans around 140 MMt, or just over 2% below 2005 levels (see Figure 10). Much of this difference is made up of reductions achievable by adoption of the Montreal Protocol amendment to phase down HFCs, highlighting its importance for near-term efforts by the Obama Administration.

Figure 10: US net GHG emissions under current and proposed policy, 2005-2025



Source: EPA, US Second Biennial Report, Rhodium Group analysis.

Under our core scenario (using AEO2015 economic and technology assumptions) the US will be within striking distance of the 2020 goal (16.5% below 2005 levels) if we achieve an optimistic LULUCF outcome and the highest potential emission reductions from current and proposed policies. Under this scenario, and absent new policy from 2016 forward, emissions would be 19% below 2005 levels in 2025. When we account for economic and technology uncertainty, the range of possible future emissions widens to 10% to 20% below 2005 levels in 2020 and 10% to 23% in 2025 (Table 1). That's 220 to 1,040 MMT short of the low end (26%) of the 2025 target.

Table 1: GHG reductions given policy, LULUCF, and economic & technology uncertainty
Change from 2005 levels

	2020	2025
Current Policies	-10% to -19%	-9% to -20%
Current & Proposed Policies	-10% to -20%	- 10% to -23%

Source: Rhodium Group analysis.

OPPORTUNITIES FOR ACHIEVING ADDITIONAL REDUCTIONS

Where should additional policy action focus to close this emissions gap? Figure 11 shows projected GHG emissions under our core current and proposed policies scenario in 2025 (assuming the high end of proposed policy reductions are achieved).[18] Carbon dioxide continues to make up the overwhelming majority of GHG emissions, more than four times all other gases combined. Even after significant new steps to reign in emissions from the transportation and electric power sectors between 2008 and 2015, they remain the leading contributors of GHGs over the next decade. Closing the gap between currently projected emissions and the 2025 US target will likely require additional action in these sectors. Industrial CO_2 emissions—the third largest emitting sector behind electric power and transportation—increase 18% from current levels by 2025. To date this sector has not received much policy focus, but could provide opportunities for additional reductions.

Methane emissions drop only 3% from current levels despite proposed emission standards for new and modified oil and gas sources and industry-wide achievement of the voluntary ONE Future 1% leakage goal for natural gas. This points to the need for a new strategy for this potent gas. Even with significant voluntary efforts from the natural gas sector, emission reductions fall far short of the Administration's 40-45% reduction goal from 2012 levels by 2025.

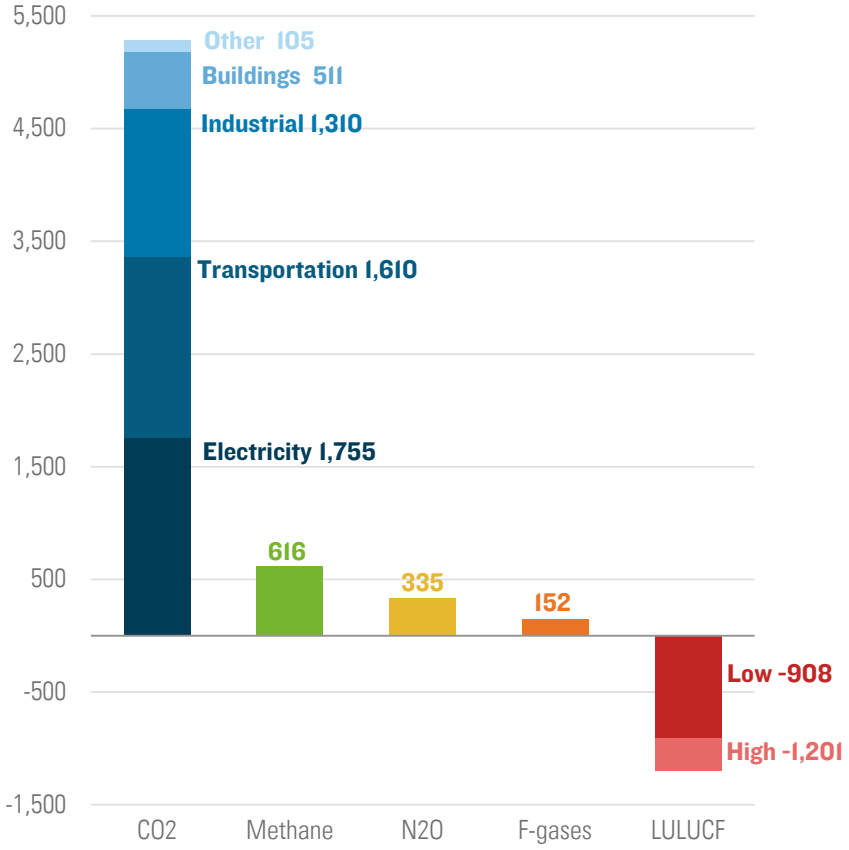
Finally, the importance of the forest sink can't be overstated. In the high sequestration scenario, American forest land sequesters almost as much carbon as is emitted by the industrial sector. Enhancing the forest sink to increase the chances of achieving or surpassing the high sequestration scenario could make an important contribution to meeting America's climate targets. On the other hand, failure to maintain and enhance sequestration will put more of the emission reduction burden on emitting sectors.

While the adoption of new policies will be required to meet the 2020 and 2025 targets, there are a number of actions that could be taken within the framework of current federal policy that would help to drive emissions beyond the lower end of our projection range. Cataloging all potential opportunities for additional emission reductions as well as potential options for congressional action are beyond the scope of this analysis. Below we present the key categories of executive and state action that could help put the US within reach of its climate goals: 1) supporting positive economic and technology trends; 2) implementation of existing rules; 3) strengthening existing and proposed rules; 4) action to reduce emissions from sources and sectors not yet addressed; and 5) continued support for state and local efforts.

[18] The "other" category in Figure 11 largely consists of CO_2 emissions from US territories, petroleum systems, and natural gas systems as well as other non-industrial uses of process CO_2. The "industrial" category includes both CO_2 from fossil fuel combustion and industrial processes.

Figure II: Remaining GHG emissions under current and proposed policies in 2025

MMt CO_2e, assumes high end of proposed policy reductions achieved



Source: EIA, Rhodium Group analysis.

Support lower technology cost and VMT trends

Our core scenario maintains the AEO2015 assumptions about economic and technology trends. When we modify those assumptions to reflect more positive trends in VMT reduction, declining costs for renewable energy and battery storage technologies, and greater deployment of distributed generation, we find an additional 4% below 2005 levels can be achieved in 2025. These outcomes are not entirely divorced from federal and state policy. Programs that support research and development (R&D), provide incentives for expansion of distributed generation, and that encourage ride-sharing or greater use of public transit can all help push emissions toward the lower end of our emissions range.

Implementation of existing rules

So far in this report we have assumed that federal policies finalized in 2015 have locked in a fixed value of emission reductions out to 2025. It is very likely, however, that upcoming decisions at the federal and state level on implementation of those rules could push emissions higher or lower than what we show in this analysis. The most important example is the CPP. Under the CPP, EPA set state-specific emission reduction goals in the final rule, leaving it up to the states to construct and implement plans to meet those goals. Two key issues states will grapple with are whether or not to cover new fossil power plants in addition to existing plants as required under the CPP and what to do with any

surplus credits if they overachieve their goals.[19] As we've noted previously, the CPP doesn't require states to cover new fossil sources, but leaving them out of an implementation plan could result in higher overall emissions if zero-emitting baseload generators, namely nuclear plants, retire and new fossil generation takes their place. In a separate analysis we found that under a worst-case scenario, CO_2 emissions could increase by as much as 155 MMt above what the CPP would otherwise achieve.

Due in part to federal and state policies to promote renewable energy and energy efficiency as well as persistently low natural gas prices, many states will meet or exceed their mass-based CPP emission targets without additional action. Under the CPP these surplus or "hot air" tons can be traded to generators in states with binding goals. Alternately, states could choose to withhold them or even retire them from the market. If no hot air is retired, the CPP will achieve emission reductions in line with our current policy case. We estimate that if all states with hot air retire their credits rather than selling them, as much as 53 MMt of additional emission reductions could be achieved, on average, between 2022 and 2025. We estimate that as many as 12 states may confront this decision over the next few years. While it's unlikely that all states with hot air will choose to retire these tons, the opportunity for additional emission reductions under the framework of the CPP is real and should be explored further.

Strengthen existing and proposed rules

There are a number of regulations in place that the Administration has the discretion to revisit and potentially strengthen, and in some instances the Administration has indicated it plans to do so. For example, under the National Program for GHG and fuel economy standards, popularly known as Corporate Average Fuel Economy (CAFE) standards, EPA and NHTSA finalized rules in 2012 that require the average fuel economy of new vehicles to ramp up to 54.5 miles per gallon in 2025. As part of the rulemaking, EPA and NHTSA promised to review the standards in 2017 to determine whether the improvement pathway for model years 2022 and beyond should be revised. CAFE targets the second largest CO_2 emitting sector, transportation, of which passenger vehicles contribute over 60% of total emissions. If the review process produced stronger standards than in the current CAFE pathway, the action would help the US make modest additional progress in meeting the 2025 target. If the review were to weaken the current standard, it would set back emission reduction efforts considerably.

In addition, there are a number of rules and programs currently in the proposal stage that could be finalized at more stringent levels or expanded in scope from what was originally proposed. The two most important examples are the heavy-duty vehicle standards to be finalized this summer, and standards for methane emissions from oil and gas sources. In its proposed HDV standards, EPA offered a more ambitious alternative that would accelerate the schedule for efficiency improvements, bringing proposed FY2027 standards forward three years, achieving full implementation in 2024. This may provide some modest additional reductions by 2025 (estimated at around 10 MMt CO_2).[20] Even more substantial additional reductions could be achieved by expanding the scope of proposed rules to include methane emissions from existing oil and gas sources. Neither the proposed NSPS nor the voluntary Methane Challenge, even if they meet their most ambitious expectations, will be capable of delivering the scale of reductions necessary to meet the Administration's 40-45% reduction goal. Additional efforts must be considered if the US is to come within reach of this goal.

[19] For a complete discussion of the emission implications of state CPP implementation choices please refer to this RHG-CSIS research note.
[20] EPA HDV Regulatory Impact Analysis (2015), available here.

Move forward expeditiously with announced federal actions

The President's 2013 Climate Action Plan laid out a comprehensive plan for meeting US targets using existing executive authorities. While the majority of the policies it enumerates have been completed, several have yet to be formally proposed. There are clear indications that the Administration is moving many of these forward. In June 2015, EPA took the first step toward regulating GHG emissions from commercial aircraft. To open the way for future standards, EPA first had to find that GHG emissions contribute to air pollution that causes climate change and endangers public health and welfare under section 213(a) of the Clean Air Act. In a parallel move, EPA also issued an advance notice of proposed rulemaking (ANPR) for US adoption of international CO_2 emission standards likely to be adopted by the International Civil Aviation Organization (ICAO) in February 2016. Further efforts to improve the efficiency of existing and new aircraft will be an important contribution to tackling emissions from the transport sector.

The Administration has also signaled that they expect new policies from the Bureau of Land Management (BLM) in the coming year. To address emissions from coal on public lands, BLM announced in 2014 it was accepting comments on a program for capture of waste methane from coal mining on lands leased by the Federal Government. It now appears this will be folded in to the recently announced comprehensive review of the federal coal program to better reflect impacts on the environment, including GHG emissions.

Continue to encourage state and local efforts

Federal efforts aren't the only ones that matter when it comes to meeting our national climate goals. Cities and states have been at the leading edge of climate and clean energy action over the past several decades. Local governments have a great deal of authority over emission sources that are less directly influenced by federal policy, including buildings, land use planning, transportation, and waste management. States will be making important decisions about implementation of federal standards, such as the CPP, and considering how complementary measures, like state renewable energy and energy efficiency goals, can help go above and beyond what the CPP requires. Many US states and cities have committed to ambitious climate goals of their own. Last year, ten US states and five cities signed the Under2 MOU, committing to achieve 85-90% reductions below 1990 levels by 2050.

Conclusion

As a renewed global leader in climate action, the US has adopted ambitious GHG reduction goals. While current and proposed policies will get us close, meeting the goals will require an all-of-the-above GHG reduction strategy going forward. In order to take effect in the next five to ten years, new policies and programs must be adopted expeditiously to allow time for implementation lags, especially for new sources that require several years to turnover. This makes it critical that policymakers now engage in a broad exploration and frank discussion of what additional steps can help deliver on America's climate goals.

DISCLOSURE APPENDIX