WORLD RESOURCES INSTITUTE

WORKING PAPER

Executive Summary

DELIVERING ON THE U.S. CLIMATE COMMITMENT: A 10-POINT PLAN TOWARD A LOW-CARBON FUTURE

KARL HAUSKER, KRISTIN MEEK, REBECCA GASPER, NATE ADEN, AND MICHAEL OBEITER

Mounting evidence indicates that combating climate change is compatible with strong economic growth, and that the benefits of a low-carbon economy can outweigh the costs.[1] Many of the key drivers of economic growth—including more efficient use of resources, infrastructure investments, and technological innovation—can also drive a transition to a lower carbon economy. This has been demonstrated across the United States, where numerous low-carbon investments are already saving money for businesses and consumers, creating new job opportunities in low-carbon technology sectors, and improving public health.[2]

Ambitious action is needed to avert the worsening impacts of climate change. In the absence of concerted, global efforts, greenhouse gas (GHG) emissions will continue to rise, posing huge economic, social, and environmental risks to the United States, as well as the global community. The year 2014 was the hottest on record, and the impacts of climate change are becoming more frequent and severe, with increasing costs to businesses, consumers, and public health.[3] The United States is already experiencing sea-level rise, higher frequency of flooding, heavier precipitation events, and more frequent heat waves and wildfires.[4]

As the largest economy and the second-largest emitter of GHGs, U.S. leadership is required for a global transition to a low-carbon economy. In this paper, we present pathways that illustrate how the United States could move toward a lower-carbon economy and meet its climate goals in the 2025–30 timeframe. The policies we examine to achieve these reductions can encourage and accelerate recent market trends, including more fuel-efficient vehicles

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues. Most working papers are eventually published in another form and their content may be revised.

Suggested Citation: Hausker, K., K. Meek, R. Gasper, N. Aden, and M. Obeiter. "Delivering on the U.S. Climate Commitment: A 10-Point Plan Toward a Low-Carbon Future." Working Paper Executive Summary. Washington, DC: World Resources Institute.

coming to market and falling prices of renewable energy technologies. This analysis estimates the impact of those pathways on total U.S. emissions, incorporating many of the policies we identified in our 2013 report—*Can The U.S. Get There From Here?*[5]—and our 2014 study entitled *Seeing Is Believing: Creating a New Climate Economy in the United States*.[6]

Our analysis shows that the United States can make deep cuts in GHG emissions while taking advantage of the economic opportunities available in a low-carbon future and providing global leadership on climate change. The Administration has taken steps in this direction with the President's Climate Action Plan, which includes necessary action in several key areas, including power plants, energy efficiency, transport, and others.[7] But to get on track to meet its 2020 emission reduction target (17 percent below 2005 levels)[8] or its 2025 target of 26–28 percent below 2005 levels, the United States will need to go beyond actions taken to date.

We find that the United States can meet, and even surpass, its announced target to reduce GHG emissions by 26–28 percent below 2005 levels in 2025 with a comprehensive approach using existing federal laws and state action. This would include expanding and strengthening some current and proposed policies and standards and taking new action across emission sources that are not yet addressed. Figure ES-1 presents emissions projections for three low-carbon pathways that could reduce U.S. emissions by 26–30 percent below 2005 levels by 2025 and 34–38 percent by 2030. We present a 10-point action plan that outlines specific steps federal agencies and state governments can take to achieve these reductions, recognizing that other pathways could reach those targets as well by applying different policy portfolios.

Looking beyond 2025, even deeper reductions will be necessary in the long term to avoid the worst impacts of climate change.[9] New federal legislation will likely be needed to drive these deeper reductions; for example, a carbon tax, cap-and-trade program, or national clean energy standard. We modeled two pathways that could reduce emissions 40–42 percent below 2005 levels by 2030 and 50–53 percent by 2040 with new legislation that establishes a price on carbon together with complementary policies across the economy. These pathways would maintain robust economic growth while pursuing a low-carbon transition, with cuts in spending on energy in the residential, commercial, and transport sectors.

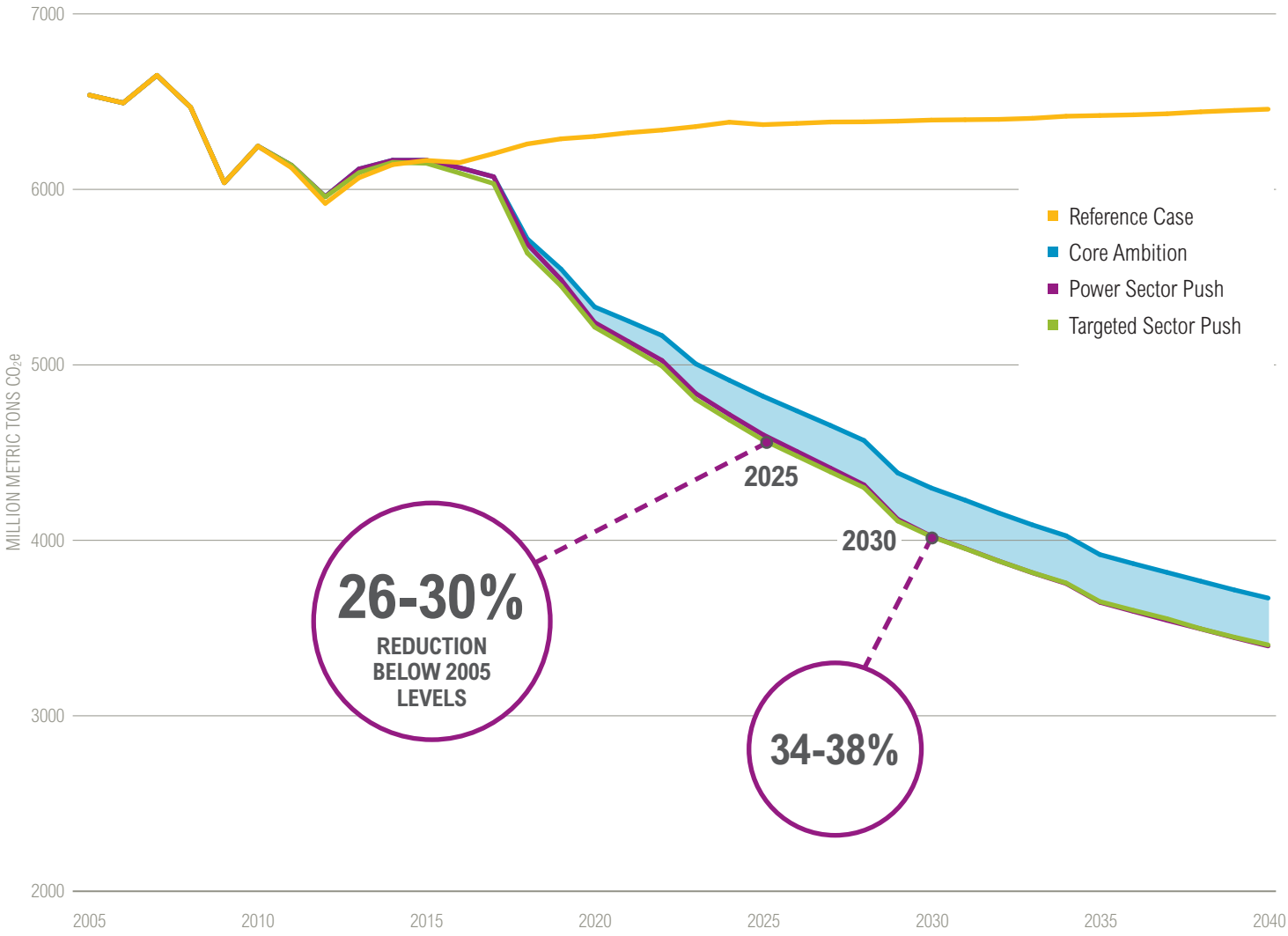
THE UNITED STATES' EMISSION TRENDS AND TRAJECTORY

U.S. GHG emissions have fallen by about 8 percent below 2005 levels in 2012 (the last year with historical data available at the time of this analysis), due to increased use of natural gas and renewable energy and improved energy efficiency across the economy, among other factors. Federal and state policies—including fuel economy standards for vehicles and federal appliance efficiency standards—together with technological innovation, have contributed to these trends. However, in recent years these reductions also were partly driven by reduced economic activity during the recession of 2008–10. In the absence of new policies and programs, emissions are expected to begin growing again as the economy continues to recover. Total GHG emissions are expected to grow slowly from current levels to 5 percent below 2005 levels by 2020 and 4 percent by 2025, far from the U.S. emission reduction targets for these years. Of course, future levels of GHG emissions could be higher or lower than these projected levels due to a variety of factors, including changes in fuel price trajectories and consumer behavior.

The United States is currently taking a number of steps that will reduce GHG emissions, using authority under several existing laws, including the Clean Air Act, the Energy Policy Act, and the Energy Independence and Security Act. The Administration's current activities build off of its Climate Action Plan, released in 2013, which developed reduction strategies across many critical sectors and emission sources—including the power sector, transportation, hydrofluorocarbons (HFCs), natural gas systems, and others—that could be implemented using existing laws. Many state and local authorities also are taking action on climate change by increasing their use of renewable energy and energy efficiency, incentivizing clean vehicle technologies, and developing alternative fueling infrastructure, among other strategies. Some are finding that these actions can result in economic benefits.[10]

The United States set a goal to reduce GHG emissions 26–28 percent below 2005 levels by 2025 as part of a new international agreement to be finalized under the United Nations Framework Convention on Climate Change (UNFCCC) by the end of this year.[11] As part of the negotiations, each country will submit an Intended Nationally Determined Contribution (INDC), representing its emission reduction pledge. The U.S. INDC did not provide a detailed action plan for meeting the 2025 target, but it

Figure ES-1 | **Net U.S. Greenhouse Gas Emissions: Reference Case and Low-Carbon Pathways Using Existing Federal Authorities and Additional State Action**



Note: This figure depicts net GHG emissions under three low-carbon pathways we modeled in our analysis that could be pursued using existing federal laws and additional state action. Core Ambition reflects the U.S. Environmental Protection Agency's (EPA) proposed Clean Power Plan (CPP), in addition to emission abatement opportunities across other sectors of the economy. Power Sector Push builds on Core Ambition by assuming that states and utilities go beyond the CPP as proposed, or that EPA strengthens the proposal to take advantage of cost-effective energy efficiency resources and continued decreases in renewable energy costs. Targeted Sector Push assumes that the CPP is finalized as proposed, but pushes the envelope in a few key areas outside the power sector to achieve economy-wide reductions similar to Power Sector Push. Both of these pathways were designed to achieve very similar levels of emission reductions, illustrating alternative ways to go beyond a 26 percent reduction across the economy, either through increased action in the power sector or outside the power sector. The shaded area between the pathways indicates that reductions anywhere in this range are possible given mixtures of policies that blend these three pathways. See text for more details on these pathways and the Reference Case.

makes clear that the United States will rely on core aspects of the Climate Action Plan. The U.S. Climate Action Plan is poised to make significant contributions toward meeting these goals, particularly if finalized standards and strategies across all aspects of the plan are sufficiently ambitious. To date, however, actions taken to implement the plan are not enough to get the United States to its 2020 or 2025 climate goals. To meet these goals, the country will need to strengthen and expand some of the actions already taken or proposed, and take action on additional sectors not yet addressed.

PATHWAYS FOR THE UNITED STATES TO DELIVER ON ITS CLIMATE COMMITMENT

We developed three pathways, described below and summarized in Table ES-1, to determine the types of action required to meet the country's 2025 emission reduction target. These pathways include mitigation opportunities and policy tools that can be pursued using current federal authorities, as well as additional state action. All three pathways require ambitious action, which we define to reflect measures that (1) are technically achievable; (2) take advantage of and reinforce recent low-carbon technology and market trends; and (3) are necessary to capture the full scope of emission reduction opportunities in a given sector. Our pathways serve as illustrative examples of different combinations of policies and measures that the United States can take to achieve its targets.

1. **Our Core Ambition pathway would cut GHG emissions by 26 percent below 2005 levels in 2025 and 34 percent in 2030.** This pathway assumes that the U.S. Environmental Protection Agency's (EPA) Clean Power Plan is finalized as proposed and actions are taken to harness low-carbon opportunities across most other sectors of the economy.[a] These actions include new and strengthened federal appliance efficiency standards, improved GHG and fuel efficiency standards for passenger vehicles and medium- and heavy-duty trucks, new GHG standards for industry, emissions standards for new and existing natural gas systems, reduced HFC consumption, and others. Under this pathway, power sector carbon dioxide (CO_2) emissions fall 40 percent below 2005 levels by 2030 as a result of both the Clean Power Plan (as proposed) and additional reductions in electricity demand from federal standards for residential, commercial, and industrial equipment.[b]

   Roughly 70–75 percent of the potential abatement we identified in 2025 under this pathway is in sectors in which the Obama Administration has already begun to act. The United States can capture the remaining abatement potential by taking new action across emission sources not yet addressed and strengthening those already in place.

Because the power sector is the largest source of potential emissions abatement in the United States, the stringency of actions in this sector significantly affects how much additional action is needed across other sectors to achieve deeper economy-wide reductions. Our next two pathways examine two alternative ways to go beyond the Core Ambition pathway, either through greater action in the power sector or greater action outside the power sector:

2. **Our Power Sector Push pathway reduces GHG emissions by 30 percent below 2005 levels in 2025 and 38 percent in 2030.** This pathway assumes that EPA strengthens the proposed standards for existing power plants under its Clean Power Plan, and renewable energy technology costs continue their rapid decline. This allows states and utilities to deploy more renewable energy and energy efficiency, leading to CO_2 emission reductions in the power sector of 45 percent below 2005 levels by 2025 and 52 percent by 2030. The Power Sector Push Pathway also includes policies affecting residential, commercial, and industrial energy use; transportation; natural gas systems; and various industrial gases consistent with the Core Ambition pathway.

[a] In June 2014, EPA used its authority under the Clean Air Act to propose the Clean Power Plan, which establishes state-specific CO_2 emission standards for existing power plants and provides states with flexibility in how they can comply. States will develop implementation plans after the rule is finalized in the summer of 2015. EPA estimates that the plan will cut national power sector CO_2 emissions 30 percent by 2030. For more information, see: <http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule>.

[b] We assume that EPA sets separate standards for industry, and DOE establishes new and strengthened appliance and equipment standards (we do not assume implementation of any state appliance standards). We assume that CO_2 reductions resulting from these measures are additional to the CO_2 reductions resulting from EPA's proposed Clean Power Plan. Under this assumption, states would take credit only for efficiency measures that go beyond a baseline adjusted for these new federal measures. As the rule is implemented, it may be possible for states to receive credit for measures related to industrial efficiency and appliances regulated by federal standards, but EPA has not yet released guidance on these issues.

Table ES-1 | **Key Elements of the Pathways**

	CORE AMBITION	POWER SECTOR PUSH	TARGETED SECTOR PUSH
POWER SECTOR	■	●	■
OTHER ENERGY EMISSION SOURCES	▲	▲	●
NON-CO_2 EMISSION SOURCES	▲	▲	▲

■ Clean Power Plan as proposed combined with federal appliance and industrial efficiency standards (leading to power-sector emission reductions in the range of 36 percent below 2005 levels in 2025 and 40 percent in 2030).

● Low carbon trends are accelerated through the 2020s either in the power sector via greater deployment of renewables and energy efficiency (leading to power-sector emissions reductions in the range of 45 percent below 2005 levels in 2025 and 52 percent in 2030) or across four other key sectors (passenger vehicle CAFE standards, passenger vehicle travel demand, industrial energy efficiency, residential and commercial natural gas demand).

▲ Ambitious measures across all other emission sources analyzed in this study.

3. **Our Targeted Sector Push pathway also reduces GHG emissions by 30 percent below 2005 levels in 2025 and 38 percent in 2030.** This pathway limits the power sector to emission reductions consistent with the proposed Clean Power Plan, but achieves deeper economy-wide reductions by pushing the envelope in four key areas: passenger vehicle efficiency, travel demand, industrial energy use, and natural gas demand in buildings.

   The Targeted Sector Push pathway would require even more accelerated deployment of next generation vehicle technologies than has occurred in recent years, allowing current GHG and CAFE standards for light-duty vehicles (model years 2017–25) to be reached five years earlier than the Core Ambition pathway. In addition, this pathway reflects slower growth in personal travel demand, facilitated by supportive policies such as compact development patterns together with improved public transportation. In the industrial sector, both emissions standards and voluntary measures are scaled up to more fully capture efficiency opportunities and increased use of lower-carbon fuel sources. This pathway also captures greater natural gas savings in homes and commercial buildings through accelerated adoption of state efficiency savings targets. Outside these areas, the Targeted Sector Push Pathway includes policies affecting residential, commercial, and industrial energy use; transportation; natural gas systems; and various industrial gases consistent with the Core Ambition pathway.

While these pathways are based on existing federal authorities and action at the state level, implementation of policies that drive reductions at the upper end of the range (in particular those in our Targeted Sector Push pathway) would be enhanced by supportive congressional actions. These actions could include periodic transportation reauthorizations bills that help promote reduced travel demand (such as improvements to public transportation options), as well as new or reauthorized tax provisions promoting renewable energy and energy efficiency. At a minimum, we assume that Congress does not block executive branch actions using existing authorities.

Emission reduction opportunities

Figures ES-2 and ES-3 illustrate the emission reduction opportunities by sector. The power sector represents the largest opportunity for GHG emissions abatement across all our pathways, where cleaner generation combined with more efficient electricity use could reduce power-sector CO_2 emissions 45 percent below 2005 levels by 2025 and 52 percent by 2030. HFCs, industry,[12] vehicles and reduced transport demand, and natural gas systems also offer important abatement opportunities in the 2025–30 timeframe.

Figure ES-2 | **U.S. Emissions by Sector in Reference Case and Low-Carbon Pathways in 2025**

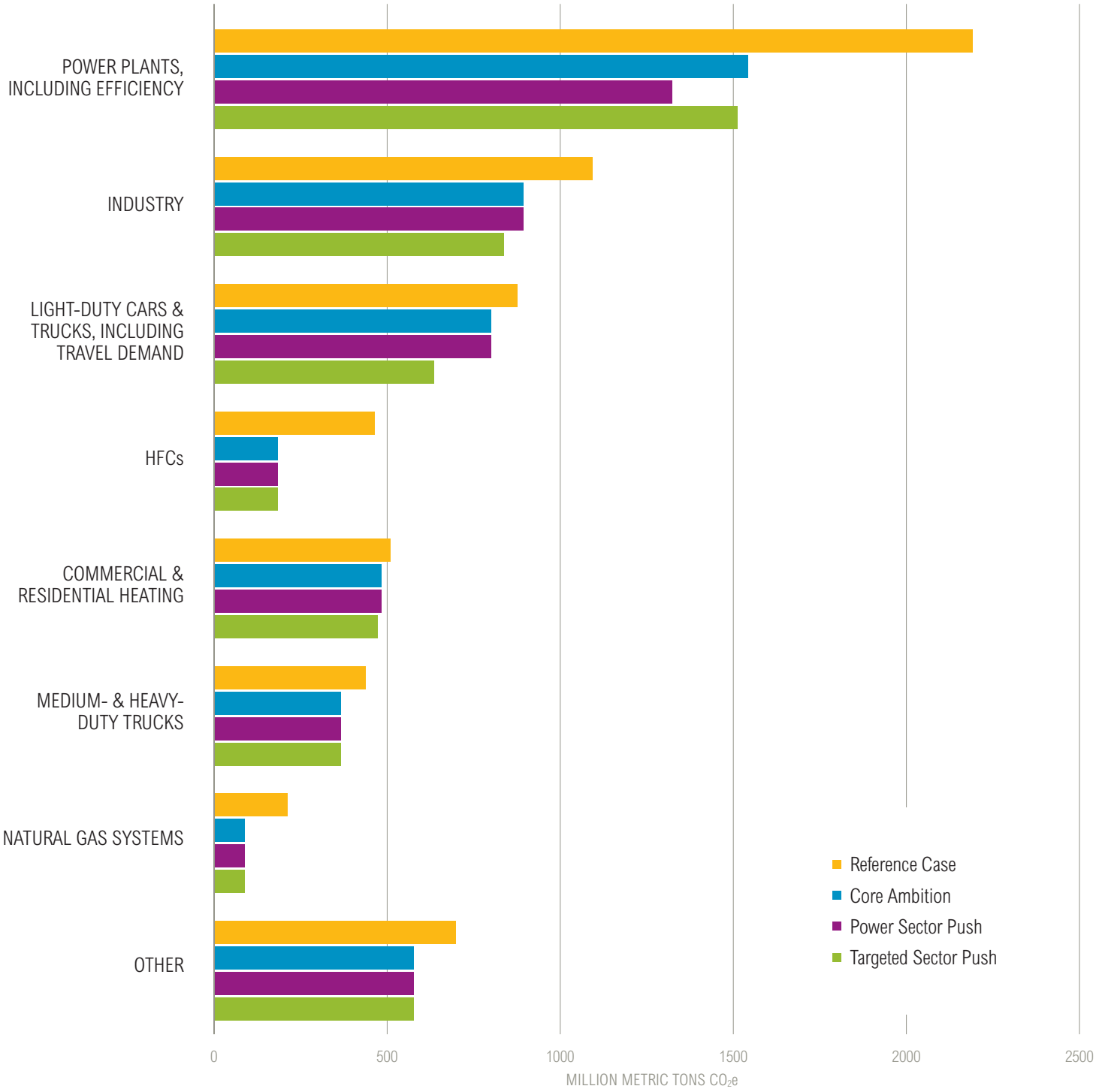
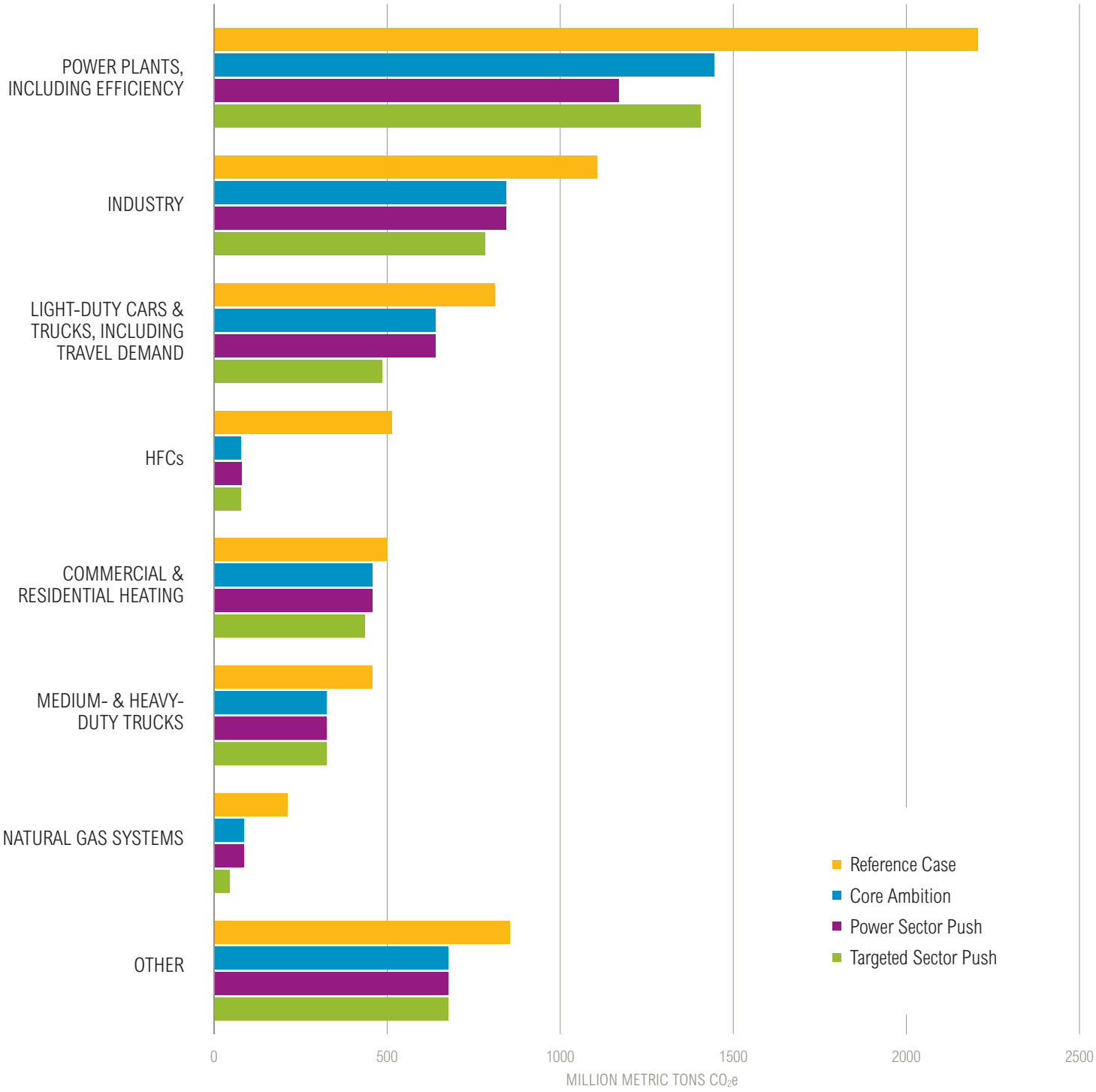


Figure ES-3 | **U.S. Emissions by Sector in Reference Case and Low-Carbon Pathways in 2030**



Box ES-1 | **Modeling Our Pathways**

We modeled three pathways that examine abatement opportunities under existing federal authorities and state action using WRI's Greenhouse Gas Abatement Model (WRI-GAM), a bottom-up, sector-by-sector, Excel-based model that estimates emission reductions resulting from implementation of a variety of policy levers. We developed our own Reference Case based largely on U.S. government projections by the U.S. Energy Information Agency (EIA) and the U.S. Environmental Protection Agency (EPA). Unless otherwise noted, "Reference Case" here always refers to the one constructed for this analysis, and not to any official EIA or EPA projections or reference cases. The model then incorporates the effects of sector-based and end-use-based policies with impacts across six GHGs—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), and sulfur hexafluoride (SF_6)—projected out to the year 2040. While we do not include specific policies addressing land use and forestry, all three pathways (along with the Reference Case) assume the "high sequestration" projection from the latest U.S. report to the UNFCCC.[a] WRI-GAM is not an economic model, thus we could not capture the economic impacts of policies using this model. See See Chapter 2 of the full working paper and the Appendix for further description of our model, data sources, and methodology.

We used the version of the Energy Information Administration's (EIA) National Energy Modeling System (DUKE-NEMS) maintained by Duke University's Nicholas Institute for Environmental Policy Solutions—which collaborated with WRI in this study—to model our two pathways, which examine longer-term abatement opportunities through new legislation and the economic impacts of these pathways. This modeling effort is described in more detail in Chapter 3 of the full working paper and the Appendix.

[a] U.S. Department of State. 2014. "2014 U.S. Climate Action Report to the UN Framework Convention on Climate Change." Accessible at: <http://www.state.gov/e/oes/rls/rpts/car6/>.

TEN-POINT ACTION PLAN TO MEET THE 2025 REDUCTION TARGET

The United States should move forward with ambitious action across the economy to make significant emissions cuts in the 2025–30 time frame and meet its 2025 climate target. The Administration's implementation of the Climate Action Plan has provided a valuable start for achieving the necessary reductions. However, to meet the target, the country will need to strengthen measures already taken or proposed and take action in areas that have not yet been addressed. We have developed a ten-point plan, described in more detail below, of specific steps federal agencies (acting within existing authority) and states can take to achieve the necessary reductions.

Table ES-2 | **10-POINT ACTION PLAN**

1	Strengthen the Clean Power Plan both in the near term and over time to fully reflect cost-effective renewable energy and energy efficiency potential.
2	Scale up programs for residential and commercial energy efficiency.
3	Continue and expand programs to reduce hydrofluorocarbon (HFC) emissions.
4	Use emissions standards and voluntary programs to improve industrial energy efficiency.
5	Set methane emissions standards for new and existing natural gas and oil infrastructure.
6	Extend and strengthen GHG and fuel economy standards for passenger cars while reducing travel demand.
7	Extend and strengthen GHG and fuel efficiency standards for medium- and heavy-duty vehicles.
8	Accelerate air travel management and establish standards for new aircraft.
9	Reduce methane emissions from landfills, coal mines, and agriculture through standards or other measures.
10	Reduce emissions from other sources while increasing carbon sequestration from forests and other land types.

1. Strengthen the Clean Power Plan both in the near term and over time to fully reflect cost-effective renewable energy and energy efficiency potential

Accounting for up to 49 percent of total reductions in our pathways in 2025 and 44 percent in 2030, the power sector presents the greatest opportunity for low-cost (and even no-cost) emission reductions. While our analysis shows that the Clean Power Plan does not need to be strengthened in order to reduce economy-wide emissions by 26 percent below 2005 levels in 2025 (as long as ambitious action is taken across other emission sources), doing so would enable the United States to more easily achieve the upper range of its 2025 target and achieve deeper reductions beyond the 2025–30 time frame.

The sector has already begun to decarbonize, with power sector CO_2 emissions 15 percent below 2005 levels in 2013 due to a combination of fuel-switching away from coal and slower growth in demand.[13] Natural gas supplies and prices will likely remain favorable to further fuel-switching, and the costs of solar and wind power will likely continue their long-term downward trends.[14] Leading states are finding that renewable energy investments are driving energy bill savings, supporting new jobs, and providing other economic benefits.[15] The shift away from coal also reduces emissions of other pollutants, including sulfur dioxide, nitrogen oxides, particulate matter, and mercury, which results in numerous public health benefits. These health benefits often outweigh the estimated cost of the transition to a low-carbon power system, usually many times over.[16]

The proposed Clean Power Plan would reduce power plant CO_2 emissions by roughly 30 percent below 2005 levels by 2030, but our analysis suggests that the United States can achieve even deeper reductions from the power sector—roughly 52 percent below 2005 levels by 2030. Even though there is a short window of time before EPA finalizes the Clean Power Plan in the summer of 2015, the final rule should reflect, to the extent possible, each state's cost-effective renewable and energy efficiency potential. Studies have shown that a more rapid decarbonization of the power sector in the post-2020 time period is possible, as well as legally defensible, especially when considering the declining costs of wind and solar energy.[17,18] As technological innovation continues and renewable energy costs continue to decline going forward, EPA should revisit these targets periodically (as it is planning to do with its passenger vehicle standards) to ensure that each state's standard continues to reflect the full scope of opportunities in this sector.

2. Scale up programs for residential and commercial energy efficiency

Energy efficiency is often less expensive for electric utilities than building new sources of electricity generation (power plants)—and deployment of efficiency technologies can lead to direct financial savings for homes and businesses. Federal and state programs—including federal appliance standards, state energy efficiency savings targets, state building energy codes, and others—have increased the deployment of more efficient technologies, such as heating and cooling systems, refrigerators, light bulbs, and many others. These programs have helped decouple economic growth from growth in energy demand and saved billions of dollars for households and businesses.[19]

However, market barriers—including misaligned incentives between those who make investment decisions and those who receive the benefits (such as landlords and tenants), lack of information about the benefits of efficient products, and others—can prevent the adoption of the most efficient technologies. Much greater efficiency potential is available in residential and commercial buildings, as well as in the industrial sector (discussed in action number 4).

In order to harness this potential, EPA should strengthen the Clean Power Plan by taking into account all cost-effective energy efficiency potential when developing state-specific standards. This would encourage more widespread deployment of state efficiency programs, leading to greater demand reductions and savings for consumers. The U.S. Department of Energy (DOE) and EPA also should continue to scale up existing policies and programs, which are already delivering benefits many times greater than their costs. This includes continuing to strengthen existing appliance standards (for example, for residential boilers, commercial unit heaters); setting appliance standards for equipment not currently covered (for example, for computer equipment, commercial ventilation equipment, general service lamps); increasing funding for research, development, and deployment of efficient technologies and processes; expanding partnerships with businesses and industry (for example, DOE's Better Buildings Challenge); and expanding efficiency labeling programs (for example, ENERGY STAR). New and strengthened appliance standards and less energy-intensive manufacturing together with the Clean Power Plan could lead to total electricity demand reductions of 9–10 percent below projected levels in 2025 and 11–13 percent in 2030.

3. Continue and expand programs to reduce hydrofluorocarbon (HFC) emissions

Emissions of HFCs, which are used primarily for refrigeration, air conditioning, and the production of insulating foams, have been increasing due to the phaseout of ozone-depleting substances (chlorofluorocarbons and hydrochlorofluorocarbons) under the Montreal Protocol and Clean Air Act, which HFCs replace. Some HFCs have very high global warming potential (GWP), though alternatives with low GWPs are increasingly available. Several companies have begun to use these alternatives, with many saving money and energy while they reduce GHG emissions.[20] For example, Coca-Cola, Pepsi, Heineken, Red Bull, and Ben & Jerry's have all achieved 10–40 percent efficiency improvements by adopting low- or zero-GWP refrigerants in equipment such as vending machines.[21] However, some low-GWP replacements have relatively high upfront costs, require the replacement of old equipment, or require equipment redesign.[22] Thus, there is little reason to believe that the U.S. market will rapidly move to these alternatives without new rules or other incentives.

Reducing the use of HFCs represents the second largest abatement opportunity—at least 16 percent in 2025 and 18 percent in 2030. While the United States (with Canada and Mexico) has proposed an amendment to the Montreal Protocol for the past several years that would phase down the use of HFCs globally, it has yet to be passed. To help spur reductions of HFCs domestically pending such an agreement, EPA has started to implement measures that address high-GWP HFC use in personal vehicles and in pickups, vans, and combination tractors.[23] In February 2015, EPA finalized rules through the Significant New Alternatives Program (SNAP) program to approve low-GWP alternatives. Proposed rules to move some higher-GWP HFCs out of the market for various applications are anticipated to be finalized this year.[24]

Opportunities exist to make HFC reductions beyond those proposed by EPA to date. While a global phasedown, through the Montreal Protocol, would be much more effective than a few individual countries taking action alone, EPA can use the SNAP program to jump start the removal of high-GWP HFCs from the market when low-GWP alternatives become available.[25] However, it will be important for EPA to ensure that new alternatives are both safe and efficient. EPA should also extend the servicing and disposal of air conditioning and refrigeration equipment requirements for ozone-depleting substances to HFCs in order to increase HFC reclamation and recycling.[26]

4. Encourage industrial energy efficiency

Industry is a broad category that includes a wider range of economic activities than the residential, commercial, and transport sectors. The energy and emissions intensiveness of industrial activity varies among manufacturing, construction, agriculture, energy transformation, mining, and forestry subsectors.[27] Total U.S. industrial sector emissions peaked at 1.9 billion metric tons of CO_2 in 1979 and have intermittently declined since the late 1990s. In 2013, total U.S. industrial sector emissions amounted to 1.5 billion metric tons CO_2 (accounting for both direct emissions and indirect emissions attributable to electricity use).[28]

Within the industrial end use of energy, energy efficiency improvements (including technical improvements, material efficiency, and waste reduction) and fuel-switching are the primary levers for industrial sector emission reduction, while the growth of combined heat and power offers additional reductions. Industrial sector demand, as reflected in the value of shipments, is expected to grow by more than a third between 2015 and 2030.[29]

Industrial energy efficiency is inhibited by persistent barriers, including financing (such as intra-company competition for capital, corporate tax structures that allow companies to treat energy expenditures as tax offsets, split incentives, and energy price trends), regulation (monopolistic utility business models and cost-recovery mechanisms, exclusion of efficiency from energy resource planning), and informational barriers (ignorance of incentives and risks, unavailable energy use data, and lack of technical expertise). Barriers to energy efficiency improvement combine with industrial sector demand growth to create a range of challenges and opportunities that will influence the absolute level of industrial-sector GHG emissions in the United States. Achieving absolute industrial sector GHG emission reductions below 2012 levels will require additional investment and policy action as described in the Core Ambition, Targeted Sector Push, and Power Sector Push pathways.

Emissions mitigation in the industrial sector represents the third largest near-term abatement opportunity modeled in our assessment. Industrial end-use efficiency and fuel switching account for about 11 percent of abatement opportunities in 2025 and 2030, separate from the emission reduction related to electricity generation (from Clean Power Plan implementation) and natural gas production. To achieve these emission reductions, EPA should combine ambitious minimum performance

standards for equipment with voluntary benchmarking and labeling programs to encourage further industrial efficiency improvements.

5. Reduce methane emissions from natural gas systems

Leakage and venting of natural gas during its production, processing, transmission, and distribution represents a significant source of methane emissions and other air pollutants such as volatile organic compounds. But methane emissions also present an opportunity for cost-effective reductions by reducing the waste of this resource. Addressing these leaks means more natural gas is available to bring to market. These reduced methane emissions account for at least 7 percent of the abatement opportunity in 2025 and 5 percent in 2030. Market barriers can prevent drillers and other service providers from updating their equipment and practices to avoid methane losses. Additional policies are needed to spur necessary investments in emissions control technologies and practices.

EPA rulemakings have taken the first steps by indirectly reducing methane emissions in this sector, and forthcoming methane standards for new oil and gas infrastructure are an important step in the right direction, but much remains to be done. One recent study estimated that 40 percent of emissions from onshore gas development can be eliminated at an average cost of a penny per thousand cubic feet.[30] EPA should propose and finalize standards on both new and existing natural gas systems by 2017, and phase in implementation through 2020, to reduce methane leakage by 67 percent below Reference Case projections. This can be achieved using existing technologies, many of which pay for themselves in three years or less.

6. Extend and strengthen standards for passenger cars while reducing travel demand

Passenger vehicles account for at least 4 percent of total reductions in 2025 and 7 percent in 2030. To capture this potential, EPA and the U.S. Department of Transportation (DOT) should continue to extend and strengthen existing standards for passenger vehicles. Greenhouse gas and fuel economy standards for light-duty vehicles enacted in 2012 will approximately double the fuel economy of new vehicles by 2025, delivering net savings to many consumers (due to decreased fuel use) and decreasing American reliance on oil imports.[31] But further progress is possible, especially with advances in conventional vehicle technologies and battery and fuel cell technologies. The continuation or acceleration of the trends in alternative vehicle technology we are seeing today can help make large improvements in fuel economy possible in 2025 and beyond, resulting in even larger fuel savings for drivers. When current standards for light-duty vehicles end in 2025, EPA and DOT should seek a 63 mpg CAFE standard (126 grams per mile) by 2030. This would require car manufacturers to innovate and federal and state governments to expand alternative vehicle infrastructure across the country. As a result, American drivers would benefit from annual fuel savings at the pump. Additional policies will be needed at the federal and state level (such as tax credits, zero emission vehicle mandates, research and development) to support the adoption of alternative fuel vehicles and to install the infrastructure required to support these technologies. Putting these policies in place can help accelerate the technology learning curve and bring lower-cost alternative vehicles to market faster.

Transportation policies can reduce travel demand, thus lowering fuel use and emissions from vehicles. Passenger vehicle travel demand is already growing more slowly now than in the past decades, due in part to social and demographic trends. It is uncertain whether these trends will continue or whether travel demand growth will rebound due to continued recovery from the recession, population growth, changes in oil prices (such as the rapid declines that occurred in late 2014), or other factors.

State and local policies should aim to reinforce recent trends, for instance, through compact development patterns coupled with improved public transportation and safe options for walking and biking. DOT, EPA, DOE, the U.S. Department of Housing and Urban Development, and other federal agencies can encourage and support these efforts in a number of ways, including increased funding for public transit infrastructure, implementation of performance criteria for funding that incentivizes compact development and related strategies, research and development, tax policies that promote infill development (such as renewal of the Federal Brownfield Tax Incentive), and technical assistance.[32]

7. Extend and strengthen fuel efficiency standards for medium- and heavy-duty vehicles

The heavy-duty truck sector accounts for at least 4 percent of abatement potential in 2025 and 6 percent in 2030. Current medium- and heavy-duty vehicle GHG

and fuel consumption standards are estimated to result in $49 billion in net benefits to society (from fuel savings, CO_2 reductions, reduced air pollution, improved energy security due to decreases in the impacts of oil price shocks, and other benefits) over the lifetime of model year 2014–18 vehicles.[33] EPA and DOT have another big opportunity coming up when new standards are proposed for the post-2018 time frame sometime in 2015. EPA and DOT should set strong standards to reduce fuel consumption rates an average of 40 percent below 2010 levels by 2025.[34] This level of fuel savings can be achieved using technologies that are currently available—such as tractor and trailer aerodynamic enhancements, hybridization and electric drive, and weight reduction, among others—that are estimated to have an average payback period of less than two years.[35]

8. Accelerate air travel management improvements and establish standards for new aircraft

Improving the existing aircraft fleet operations and making new aircraft more efficient represents at least 2 percent of the abatement opportunities we identified in 2025 and 2030. To achieve these reductions, the Federal Aviation Administration should continue to reduce GHG emissions from aircraft by expanding initiatives—under its Next Generation Air Transport Systems program—that enhance the way air travel is managed across the country. In anticipation of international adoption of aircraft CO_2 emissions standard in 2016, EPA should stay on track to release an advanced notice of proposed rulemaking in 2015 and finalize its findings in 2016, and should aim to set standards that improve the fuel efficiency of new aircraft in the range of 2-3 percent annually.

9. Reduce methane emissions from landfills, coal mines, and agriculture

Taking action on additional methane sources represents at least 3 percent of the abatement opportunity in 2025 and 2 percent in 2030. EPA should finalize its proposed methane emissions standards for new landfills, and set standards or develop other programs that reduce methane emissions from existing landfills. The EPA should also take additional action, either using its authority under the Clean Air Act to set emissions standards, or through other measures, to reduce methane emissions from coal mines. Opportunities exist to reduce methane emissions from agricultural sources,[36] however, quantifying these sources was beyond the scope of this analysis.

10. Reduce emissions from other sources while increasing the U.S. carbon sink

Other emission sources, like off-highway vehicles, nitric and adipic acid manufacturing, and PFC and SF_6 emission sources, represent 4 percent of the abatement opportunity in 2025 and 5 percent in 2030. Federal agencies—including EPA and DOE—should establish emission or efficiency standards, expand existing voluntary programs, and/or establish new programs or other measures to address these sources. The United States should also develop a plan to maintain and even increase the nation's carbon sinks, especially given the uncertainty of current sequestration projections and the latest data suggesting that U.S. forests are likely to sequester carbon at a slower rate over the long term.[37]

DRIVING DEEPER REDUCTIONS BEYOND 2025 IN PARALLEL WITH ROBUST ECONOMIC GROWTH

Deeper GHG emission reductions will be needed beyond 2025 to avoid the worst impacts of climate change. A transition to a low-carbon economy in the 2030–40 time frame will likely require new legislation to overcome market barriers and provide the long-term, consistent policy signals that provide confidence for investors in new technologies and infrastructure.

We find that climate legislation—together with targeted complementary policies across the economy—can reduce U.S. GHG emissions 40–42 percent below 2005 levels in 2030 and 50–53 percent in 2040. Reductions of this magnitude would require greater action from the power sector than is likely possible using existing laws—more than double the reductions under the Clean Power Plan as proposed by 2030. We explored two policy pathways that could achieve these reductions, either through a carbon price that solely affects the power sector or a carbon price on all energy-related CO_2 emissions.[38] New legislation could establish a carbon price through a tax mechanism or a cap-and-trade program while a flexible national clean energy standard could effectively put a price on carbon in the power sector. These pathways also would require implementation of standards and other measures identified in our 10-point plan to drive deeper reductions across the economy.

A low-carbon transition of this magnitude does not require sacrificing the health of our economy. The legislative pathways we explored include actions that cover

a range of costs—from negative costs with net savings accruing to consumers, to positive costs. Our results show that a long-term low-carbon transition could be pursued in parallel with robust economic growth, with relatively small shifts from the expected economic trajectory in the Reference Case scenario.

Economic modeling of our legislative low-carbon pathways indicates:

- **Little long-term impact on gross domestic product (GDP).** While GDP grows marginally slower through 2022 under our legislative pathways, it picks up and eventually grows slightly faster compared to the Reference Case starting in 2023. By 2030, GDP is on average 0.7 percent lower than Reference Case levels and by 2040, it's only 0.3 percent lower. These differences are fairly minor when one considers the size of the U.S. economy. In 2030, for example, GDP losses are equivalent to about three days of economic output that year ($170 billion less in GDP compared to a total economy of over $24 trillion). In addition, the United States would likely experience positive economic impacts related to public health benefits associated with accompanying reductions in conventional air pollutants, as well as longer-term climate-related benefits.

- **Little near-term impact, and no long-term impact, on employment.** Total employment is projected to show a similar pattern as impacts on GDP. Employment in some sectors would be expected to grow (for example, renewable energy) while others would decline (coal production). Overall, our legislative pathways result in slightly higher unemployment rates in the near term compared to the Reference Case, but nearly equivalent rates by 2030 (roughly 5 percent). The legislative pathways have slightly lower unemployment rates in the longer term (2030 to 2040). Of course, it will be important to manage the transition for future job seekers in declining sectors.

- **Lower energy bills in the residential, commercial, and transport sectors.** Significant demand reductions from energy efficiency policies more than offset higher electricity rates and higher fuel prices, resulting in lower energy spending compared to Reference Case levels. While electricity expenditures increased 6–15 percent by 2030 in the industrial sector under both of our legislative pathways, total energy spending in industry decreased by 15 percent in 2030 under the pathway that included targeted efficiency standards in addition to a price on carbon in the electricity sector.

Our results, in combination with recent trends and other analyses, suggest that the United States has an opportunity to capture multiple economic benefits by pursuing a long-term transition to a low-carbon economy. Well-designed policies can reduce GHG emissions while stimulating technological innovation, saving American consumers money, and improving public health. Three long-term recommendations can facilitate the transition to a low-carbon future:

1. Congress should implement new legislation to drive a deep decarbonization across all sectors.

2. Federal, state, and local authorities should continue to implement supportive policies across key emission sources.

3. The federal government should increase investment in research, development, and deployment of clean energy technology.

ENDNOTES

1. The Global Commission on Climate Change. 2014. "Better Growth, Better Climate." Accessible at: <http://newclimateeconomy.report/>.
2. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/publication/new-climate-economy>.
3. National Oceanic and Atmospheric Administration, National Climatic Data Center. 2014. "Global Analysis- Annual 2014." Accessible at: <http://www.ncdc.noaa.gov/sotc/global/>.
4. U.S. Global Change Research Program. 2014. "2014 National Climate Assessment." Accessible at: <http://nca2014.globalchange.gov/>.
5. Nicholas Bianco, Franz Litz, Kristin Meek, and Rebecca Gasper. 2013. "Can The U.S. Get There From Here? Using Existing Federal Laws and State Actions to Reduce Greenhouse Gas Emissions." Washington, DC: World Resources Institute. Accessible at: <http://pdf.wri.org/can_us_get_there_from_here.pdf>.
6. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/publication/new-climate-economy>.
7. Executive Office of the President. 2013. "The President's Climate Action Plan." Accessible at: <https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf>.
8. John Larsen, Kate Larsen, and Whitney Ketchum. 2014. "Is the US on Track? EPA's Clean Power Plan and the US 2020 Climate Goal." New York: Rhodium Group. Accessible at: <http://rhg.com/notes/is-the-us-on-track-epas-clean-power-plan-and-the-us-2020-climate-goal>. Nicholas Bianco, Franz Litz, Kristin Meek, and Rebecca Gasper. 2013. "Can The U.S. Get There From Here? Using Existing Federal Laws and State Actions to Reduce Greenhouse Gas Emissions." Washington, DC: World Resources Institute. Accessible at: <http://pdf.wri.org/can_us_get_there_from_here.pdf>.
9. The Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (2007) indicates that industrialized countries need to collectively reduce emissions between 25 and 40 percent below 1990 levels by 2020 and 80 to 95 percent below 1990 levels by 2050 to keep atmospheric concentrations of greenhouse gases from exceeding 450 parts per million of CO_2e and to keep global average temperatures from increasing more than 2 degrees Celsius above preindustrial levels. For more information, see: https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm.
10. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/publication/new-climate-economy>.
11. U.S. Department of State. 2015. "Submission of the U.S. Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change." Accessible at: <http://unfccc.int/files/focus/indc_portal/application/pdf/u_s_cover_note_indc_and_accompanying_information.pdf>.
12. Industry is a broad category that includes a wider range of economic activities than residential, commercial, and transport sectors. The energy and emissions intensiveness of industrial activity varies among manufacturing, construction, agriculture, energy transformation, mining, and forestry subsectors.
13. U.S. Energy Information Administration. Monthly Energy Review. Accessible at: <http://www.eia.gov/totalenergy/data/monthly/>.
14. U.S. Department of Energy. 2014. "Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections." Sunshot. Accessible at: <http://www.nrel.gov/docs/fy14osti/62558.pdf>. R. Wiser and M. Bolinger. 2014. "2013 Wind Technologies Market Report." Berkeley, CA: Lawrence Berkeley National Laboratory. Accessible at: <http://emp.lbl.gov/sites/all/files/2013_Wind_Technologies_Market_Report_Final3.pdf>.
15. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper (p. 14). Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/publication/new-climate-economy>.
16. For example, EPA found that the Clean Power Plan, as proposed, would generate monetized health benefits of $15-$40 billion (2011$, net present value (NPV) basis), which far exceed the estimate of compliance costs of roughly $4-$8 billion. In their modeling of an approximately 60 percent reduction in CO_2 emissions from the power sector below 2005 levels in 2030, the Union of Concerned Scientists projected that on an annualized basis, benefits from reduced SO_2 and NO_x emissions alone would total $56 billion in 2025, growing to $69 billion in 2030 (equal to five and ten times the annual compliance cost to the power sector). U.S.EPA. 2014. "Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants." Accessible at: <http://www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf>. Union of Concerned Scientists. 2014. "Climate Game Changer." Accessible at: <www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf>.
17. Natural Resources Defense Council. "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units." Docket No. EPA-HQ-OAR-2013-0602. Accessible at: http://docs.nrdc.org/air/files/air_14120101b.pdf.
18. M. M. Hand, S. Baldwin, E. DeMeo, J. M. Reilly, T. Mai, D. Arent, G. Porro, M. Meshek, and D. Sandor, eds. Renewable Electricity Futures Study. Four vols. NREL/TP-6A20-52409. Golden, CO: National Renewable Energy Laboratory. Accessible at: <http://www.nrel.gov/analysis/re_futures/>. Natural Resources Defense Council. 2014."Cleaner and Cheaper: Using the Clean Air Act to Sharply Reduce Carbon Pollution from Existing Power Plants, Delivering Health, Environmental, and Economic Benefits." Accessible at: <http://www.nrdc.org/air/pollution-standards/files/pollution-standards-IB-update.pdf>. Union of Concerned Scientists. 2014. Climate Game Changer. Accessible at: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf.
19. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper (Chapter 2). Washington, DC: World Resources Institute. Accessible at: http://www.wri.org/publication/new-climate-economy>.
20. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/publication/new-climate-economy>.
21. N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden. 2014. "Seeing is Believing: Creating a New Climate Economy in the United States." Working Paper (p. 103). Washington, DC: World Resources Institute. Accessible at: http://www.wri.org/publication/new-climate-economy. Coca-Cola. Accessible at: http://www.coca-colacompany.

com/innovation/coca-cola-installs-1-millionth-hfc-free-cooler-globally-preventing-525mm-metrics-tons-of-co2. PepsiCo. Accessible at: http://www.pepsico.com/Media/PressRelease/PepsiCo-Debuts-Energy-Efficient-HFC-Free-Cooler-at-Super-Bowl02022010.html. Red Bull. Accessible at: http://energydrink.redbull.com/coolers. Heineken. Accessible at: http://sustainabilityreport.heineken.com/The-big-picture/What-we-said-and-what-weve-done/index.htm. Hydrocarbons 21. Accessible at: http://www.hydrocarbons21.com/news/viewprintable/4760>. Ben & Jerry's. Accessible at: <http://www.atmo.org/presentations/files/124_3_Asch_Ben_n_Jerry.pdf>.

22. Michael Parr, federal government affairs manager, DuPont, personal communication, July 24, 2014.
23. U.S. Environmental Protection Agency. 2011. "EPA and NHTSA Adopt First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles." Accessible at: <http://www.epa.gov/otaq/climate/documents/420f11031.pdf>.
24. U.S. Environmental Protection Agency. 2014. "Protection of Stratospheric Ozone: Change of Listing Status for Certain Substitutes under the Significant New Alternatives Policy Program." 40 CFR, Part 82. Accessible at: <http://www.epa.gov/ozone/downloads/SAN_5750_SNAP_Status_Change_Rule_NPRM_signature_version-signed_7-9-2014.pdf>.
25. U.S. Environmental Protection Agency. 2014. "Text of North American HFC phase-down amendment proposal." Accessible at: <http://www.epa.gov/ozone/downloads/HFC_Amendment_2014_Text.pdf>.
26. Specifically, EPA should also extend the servicing and disposal of air conditioning and refrigeration equipment requirements for HCFCs and CFCs (under section 608 of the Clean Air Act) to HFCs, as well as increase initiatives for HFC reclamation and recycling to ensure that fewer virgin HFC compounds are used until they are able to be phased down. Alliance for Responsible Atmospheric Policy. 2014. "Petition to Extend the Requirements of 40 C.F.R. Part 82, Subpart F to HFCs." Accessible at: <http://www2.epa.gov/sites/production/files/2014-05/documents/alliance-petition-31jan2014-v2-2.pdf>.
27. Total national energy use and GHG emissions are commonly classified into four end-use sectors: residential, commercial, industrial, and transportation. From an end-use perspective, industry includes energy transformation activities such as electricity generation, petroleum refining, and natural gas production. This assessment also includes overlapping analysis of these energy transformation activities as key areas for reducing U.S. GHG emissions.
28. U.S. Energy Information Administration. "Table 12.4 Carbon Dioxide Emissions From Energy Consumption: Industrial Sector." Electricity Power Monthly. Accessible at: <http://www.eia.gov/totalenergy/data/monthly/>.
29. U.S. Energy Information Administration. "AEO 2014 Reference Case." Accessible at: <http://www.eia.gov/forecasts/aeo/>.
30. ICF International. 2014. "Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries." Accessible at: <http://www.edf.org/sites/default/files/methane_cost_curve_report.pdf>. For reference, the daily spot price for natural gas in 2014 ranged from $2.81 to $8.35 per thousand cubic feet, with an average price of $4.48. See: <http://www.eia.gov/dnav/ng/hist/rngwhhdD.htm>.
31. U.S. Environmental Protection Agency. 2012. "Regulatory Impact Analysis: Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards." Accessible at: <http://www.epa.gov/otaq/climate/documents/420r12016.pdf>.
32. For a review of existing and potential new opportunities for federal action in these areas, see: <http://www.nrel.gov/docs/fy13osti/55634.pdf>.
33. U.S. Environmental Protection Agency and Department of Transportation. 2011. "EPA and NHTSA Adopt First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy Duty Vehicles." Accessible at: http://www.epa.gov/otaq/climate/documents/420f11031.pdf. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration. 2011."Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: Regulatory Impact Analysis." Accessible at: <http://www.epa.gov/otaq/climate/documents/420r11901.pdf>.
34. American Council for an Energy Efficient Economy, Environmental Defense Fund, Natural Resources Defense Council, Sierra Club, and Union of Concerned Scientists. 2014. "Big Fuel Savings Available in New Trucks." Accessible at: <http://aceee.org/files/pdf/fact-sheet/truck-savings-0614.pdf>.
35. ACEEE et. al. (2014) found that many technologies could be used to achieve the highest level of reductions, including tractor aerodynamic enhancements and integration with the trailer, hybridization and electric drive, engine downsizing, dual-stage turbocharging, trailer aerodynamic enhancements, low rolling resistance tires, weight reduction, idle reduction, among other technologies that would improve engine, transmission and driveline, and vehicle and trailer performance. They also found that "a new truck that includes an advanced engine and transmission, new axle design, and improved aerodynamics to the tractor and trailer could save average tractor-trailer owners and drivers about $30,000 per year in fuel. In 2025, these new efficiency technologies would increase truck purchase costs by about $32,000, which is recovered by fuel savings in just 13 months." See: American Council for an Energy Efficient Economy, Environmental Defense Fund, Natural Resources Defense Council, Sierra Club, and Union of Concerned Scientists. 2014. "Big Fuel Savings Available in New Trucks." Accessible at: <http://aceee.org/files/pdf/fact-sheet/truck-savings-0614.pdf>.
36. Doug Boucher and Kalifi Ferretti-Gallon. 2015. "Halfway There? What the Land Sector Can Contribute to Closing the Emissions Gap." Union of Concerned Scientists. Accessible at: <http://www.ucsusa.org/sites/default/files/attach/2015/01/ucs-halfway-there-2015-full-report.pdf>.
37. U.S. Department of State. 2014. "2014 U.S. Climate Action Report to the UN Framework Convention on Climate Change." Accessible at: <http://www.state.gov/e/oes/rls/rpts/car6/>.
38. See the body of the report for more details on these pathways and detailed recommendations for a long-term transition to a low-carbon economy.

ABOUT THE AUTHORS

Karl Hausker is a Senior Fellow in WRI's Global Climate Program. He leads analysis and modeling of domestic climate mitigation scenarios, and he contributes to work on the New Climate Economy, the social cost of carbon, and energy access. He has worked for 28 years in the fields of climate change, energy, and environment in a career that has spanned legislative and executive branches, research institutions, NGOs, and consulting. He has led climate policy analysis and modeling projects for USAID, USEPA, the Regional Greenhouse Gas Initiative, the Western Climate Initiative, and the California Air Resources Board. Much of his work has focused on the energy and transportation sectors, and on low carbon, climate resilient development strategies.

Contact: khausker@wri.org

Kristin Meek is an Associate in the Global Climate Program at the World Resources Institute. She supports WRI's efforts with the U.S. states and U.S. federal agencies as they work together and in parallel to develop programs to reduce greenhouse gas emissions. Prior to joining WRI, Kristin worked with SAIC's climate change services team, where she focused on a wide range of GHG management projects for federal government agencies, local governments, and private sector entities.

Contact: kmeek@wri.org

Rebecca Gasper is a Research Analyst in WRI's Global Climate Program. She supports WRI's efforts with the U.S. states and U.S. federal agencies as they work together and in parallel to develop programs to reduce greenhouse gas emissions. Before joining WRI, Rebecca worked at the Center for Integrative Research (CIER) at the University of Maryland. She worked primarily on climate change mitigation and adaptation at the regional and international levels. She also has experience supporting state efforts to develop water quality markets.

Contact: rgasper@wri.org

Nate Aden is a Research Fellow with WRI's Global Climate Program. As a member of the U.S. Climate Initiative, Nate researches industry energy use in the U.S. Midwest. In addition to analyzing data on industry energy use, Nate is working with regional stakeholders to realize efficiency, competitiveness, and emissions mitigation improvements. Prior to joining WRI, Nate conducted energy efficiency research with the Lawrence Berkeley National Laboratory in California. Over five years with LBL, Nate's projects were focused on energy efficiency policy, assessment of Chinese urban form energy use and emissions, Chinese energy data compilation, transport electrification and renewable electricity scenario analysis, the coal mining sector, and the steel sector.

Contact: naden@wri.org

Michael Obeiter is a Senior Associate in WRI's Global Climate Program. As a member of the U.S. Climate Initiative, he works to advance climate and clean energy policies at the national level. His work focuses on methane emissions from natural gas, power plant standards, and carbon taxes. Prior to joining WRI, Michael was the analyst for energy and environment for the Senate Budget Committee.

Contact: mobeiter@wri.org

ACKNOWLEDGMENTS

We would like to thank Sarah Forbes for her contributions, Etan Gumerman of the Nicholas Institute for Environmental Policy Solutions for his modeling expertise and review of the publication, and Marilyn Brown and team of the Georgia Institute of Technology for their contributions. We would also like to thank the following individuals for their valuable guidance and reviews: Samuel Adams, Paul Allen, Juan-Carlos Altamirano, Manish Bapna, Maria Belenky, Nicholas Bianco, Erin Boyd, Nicholas Chase, Rachel Cleetus, John Coequyt, Tom Damassa, Christina DeConcini, Hanna Fekete, Rhys Gerholdt, Sonia Hamal, Noah Kaufman, Kevin Kennedy, Whitney Ketchum, John Larsen, Kate Larsen, Alden Meyer, Jennifer Morgan, Helen Mountford, Gabe Pacyniak, Michael Parr, Matthew Ritter, Josh Ryor, Rodney Sobin, Bob Sussman, Laura Valeri, Brent Wanner, and David Waskow. We would also like to thank Bob Livernash for copy editing, and Nick Price, Carni Klirs, and Hyacinth Billings for publication layout and design. Funding for this project was generously provided by an Anonymous Donor, the William and Flora Hewlett Foundation, the Robertson Foundation, the Ruth McCormick Tankersley Charitable Trust, the Tilia Fund, the ClimateWorks Foundation, the International Policies and Politics Initiative, and other WRI donors. While our reviewers were very generous with their time and input, this working paper reflects the views of the authors alone.

ABOUT WRI

WRI is a global research organization that works closely with leaders to turn big ideas into action to sustain a healthy environment—the foundation of economic opportunity and human well-being.

ABOUT OCN

The Open Climate Network (OCN) brings together independent research institutes and stakeholder groups to monitor countries' progress on climate change. We seek to accelerate the transition to a low-emission, climate-resilient future by providing consistent, credible information that enhances accountability both between and within countries.

This paper is part of an OCN initiative to inform the post-2020 GHG mitigation goals in Intended Nationally Determined Contributions under the United Nations Framework Convention on Climate Change. The OCN Secretariat, based at the World Resources Institute, is managing this multi-country effort. For more information, see www.openclimatenetwork.org or contact openclimate@wri.org.

PRODUCED IN PARTNERSHIP WITH

OCN
OPEN CLIMATE NETWORK