FULFILLING AMERICA'S PLEDGE

How States, Cities, and Businesses Are Leading the United States to a Low-Carbon Future

Bloomberg Philanthropies

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Climate leadership by states, cities, businesses, and other real economy actors can drive down overall U.S. emissions at an accelerating rate between now and 2030.

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About America's Pledge

When President Donald Trump announced his intention to withdraw the United States from the Paris Agreement in June 2017, the response from across the country was swift and significant. An unprecedented coalition of U.S. states, cities, businesses, universities, and other organizations spoke out in continued support for America's climate pledge to the world.

Coalitions backing the Paris Agreement, including the notable "We Are Still In" network, have since doubled in size, with over 3,000 signatories. States, cities, and businesses all over the United States are continuing to lead by adopting greenhouse gas (GHG) emissions reduction targets and other policies to deliver emissions reductions.

In July 2017, former New York City Mayor and United Nations Secretary-General's Special Envoy for Climate Action Michael R. Bloomberg and California Governor Edmund G. Brown, Jr., launched an initiative, known as America's Pledge, to analyze, catalyze, and showcase climate action leadership by U.S. governors, mayors, business leaders, and others. Five months later, at the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change (COP-23), Michael Bloomberg and Governor Brown published a comprehensive survey of U.S. climate action led by such real economy actors. This first report estimated that real economy actors representing more than half the U.S. economy—whose economic activity is equivalent to that of the third-largest country in the world—were actively engaged in fulfilling the Paris Agreement and had demonstrated their potential to drive decarbonization swiftly and effectively.

This report, *Fulfilling America's Pledge,* builds on our 2017 report and provides the most comprehensive assessment to date of how U.S. states, cities, businesses, and others (often referenced within this report as "real economy actors") are embracing new economic opportunities and technologies to implement climate targets and deliver emissions reductions within their own jurisdictions and operations under their own authority. This report includes an assessment of the impact of their existing commitments on the overall U.S. emissions trajectory, and provides a concise roadmap of 10 broad opportunities for action that together can lay the groundwork for even deeper emissions reductions from the real economy. This report also provides an internationally applicable toolkit to help policymakers and other stakeholders understand how real economy actors can drive more ambitious climate outcomes and serve as implementing partners in the context of other national governments' nationally determined contributions under the Paris Agreement.

Acknowledgments

The America's Pledge report is the product of a collaborative effort between the leadership of the America's Pledge initiative and a core report team that carried out analysis and writing. America's Pledge is co-chaired by Michael R. Bloomberg and Edmund G. Brown, Jr. Mr. Bloomberg is Special Envoy for Climate Action to the United Nations Secretary General and former mayor of New York City. Mr. Brown is Governor of California. Mary Nichols, Chair of the California Air Resources Board, and Carl Pope, former Executive Director of the Sierra Club, are vice chairs of the America's Pledge initiative.

This report was co-led by Rocky Mountain Institute (RMI) and the Center for Global Sustainability at the University of Maryland (UMD), with significant contributions from the World Resources Institute, Environmental Defense Fund, American Council for an Energy-Efficient Economy (ACEEE), CDP, and The Cadmus Group. Nate Hultman (UMD) and Koben Calhoun (RMI) served as the report's lead authors, with guidance and coordination from Paul Bodnar (RMI). Writing, modeling, and analysis team members from contributing organizations include:

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Executive Summary

KEY POINTS IN THIS REPORT

1. Implementing the vision of the Paris Agreement calls for broad, rapid, and significant engagement across all parts of society in order to reap the benefits of a low-carbon, climate-resilient future fueled by clean jobs and economic growth. In the United States, cities, states, and businesses, and other real economy actors have embraced this future—helping drive better outcomes for their own citizens and business operations. Although their efforts are driven in part by necessity, in light of the lack of national-level leadership on climate change, these real economy actors have embraced action for the benefit of their own constituents and stakeholders while helping bend the emissions curve downward.

2. Today, we are almost halfway to the original U.S. target under the Paris Agreement of 26-28 percent below 2005 levels by 2025. Across the country, real economy actors have established policies and commitments which, as they are implemented, will drive continued substantial progress towards the Paris pledge.

3. Current federal and real economy commitments, combined with market forces, will drive U.S. emissions to 17 percent below 2005 levels by 2025, roughly two-thirds of the way to the original U.S. target.

4. This report presents a roadmap for 10 *Climate Action Strategies* that are high-impact, near-term, and readily available for implementation by cities, states, businesses, and other actors. This analysis estimates that fully implementing these measures could drive emissions down further, to 21 percent below 2005 levels by 2025.

5. But "readily available" cannot be our limit. Broader engagement and mobilization of motivated cities, states, and businesses can both serve their immediate short-term priorities and enable continued American leadership on climate. It is vital for real economy actors to identify and drive climate reforms that benefit their constituents and stakeholders.

6. Broader engagement of this real economy coalition, within realistic legal and political limits, has the potential to reduce emissions by more than 24 percent below 2005 levels by 2025. This would be within striking distance of the Paris pledge, making the 26 percent threshold achievable shortly thereafter.

7. As we move onward from the Paris pledge, this momentum in turn sets the stage for more rapid decarbonization in the 2025-2030 period. This analysis demonstrates that essential deep decarbonization (80 percent or more by 2050) can be led by the bottom-up efforts of real economy actors—but only with deep collaboration and engagement.

In 2015, the world came together in Paris to forge the first truly global climate agreement: a robust, long-term framework designed to reduce GHG pollution in order to hold global temperature increases to well below 2 degrees Celsius and prevent "dangerous anthropogenic interference with the climate system."[1]

The Paris Agreement entered into force in record time, and with one notable exception, the United States, national leaders in all countries of the world have continued to support the Paris Agreement's goals and approach. The reasons are clear: the risks of climate change to human health and ecosystems are too great, and the benefits of embracing clean energy innovations for well-being, jobs, and economic growth are many. Such action demands full partnership and deep collaboration between national governments and the full range of stakeholders and entities that they represent on the international stage: states, cities, businesses, universities, and communities. It is these *real economy actors* whose decisions shape greenhouse gas (GHG) emissions, drive innovation, and determine the speed of the global energy transition. And nowhere is this kind of decentralized climate leadership currently more important than in the United States.

This report refers to the many U.S. entities taking action on climate change outside the federal government as **real economy actors.**

This term covers a diverse set of such actors, including cities, states, businesses, investors, counties, regional associations, faith institutions, and universities. The term 'real economy actor' is derived from economic governance literature.[3]

Though the meaning can shift in different contexts, it is utilized in this report to differentiate their actions from the current actions of the federal government. In other reports and in the context of the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC), such groups are sometimes called "non-state actors," "sub-national actors," or "non-Party stakeholders."

Photo by Dennis Schroeder / NREL

Three scenarios in this report build out this ladder of ambition:

- First, the *Current Measures* scenario estimates the extent to which existing state, city, and business commitments and policies are likely to reduce emissions;

- Second, an extensive consultation and analysis process identified a discrete set of 10 high-impact, near-term, and readily available opportunities, and estimated their potential to reduce emissions via the *Climate Action Strategies* scenario; and

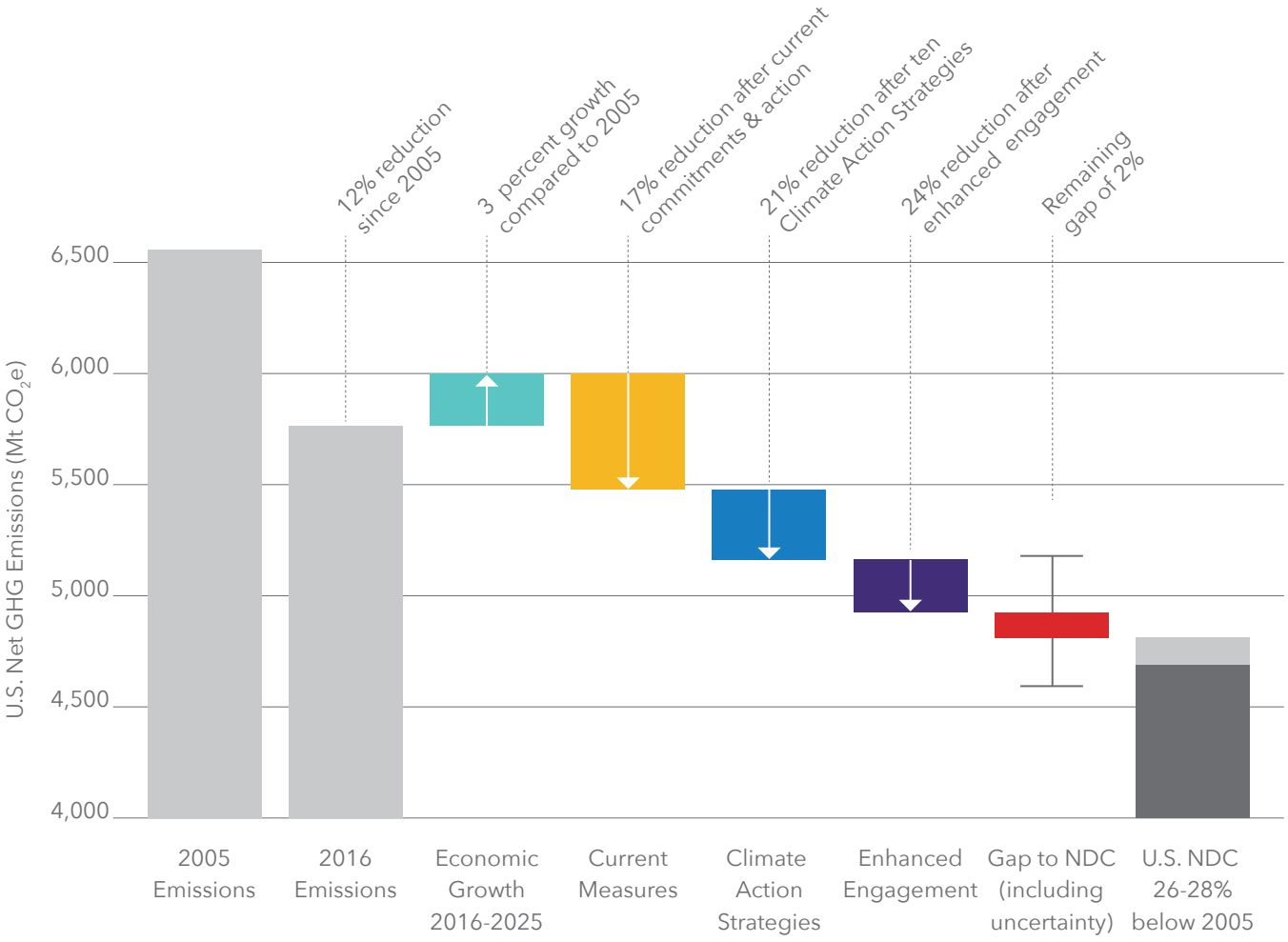
- Third, the *Enhanced Engagement* scenario models what might be possible if an even broader set of ambitious undertakings by states, cities, and businesses were implemented across the economy.

Importantly, even the most ambitious scenario modeled here focuses on what can plausibly be achieved through state, city, and business actions, prior to federal reengagement, taking into consideration limitations, including legal barriers to scaling specific policies and the political unwillingness of local government in certain regions of the United States to take up climate policies.

Photo by Werner Slocum / NREL

The basis for this analysis is an innovative modeling approach developed specifically for the America's Pledge initiative. It integrates a well-established top-down, economy-wide integrated assessment model (the Global Change Assessment Model for the United States of America, or GCAM-USA) with a new, bottom-up aggregation tool developed specifically for this effort to fully and accurately account for the GHG abatement impact of state, city, and business climate action (the Aggregation Tool for modeling Historic and Enhanced Non-Federal Actions, or ATHENA). GCAM-USA is the same economy-wide modeling tool employed by the U.S. federal government in projecting emissions for its Mid-Century Strategy (MCS) report to the UNFCCC.

Figure ES-1: State, City, and Business Actions can Significantly Cut U.S. Emissions in 2025 and Accelerate Momentum for Long-term Decarbonization



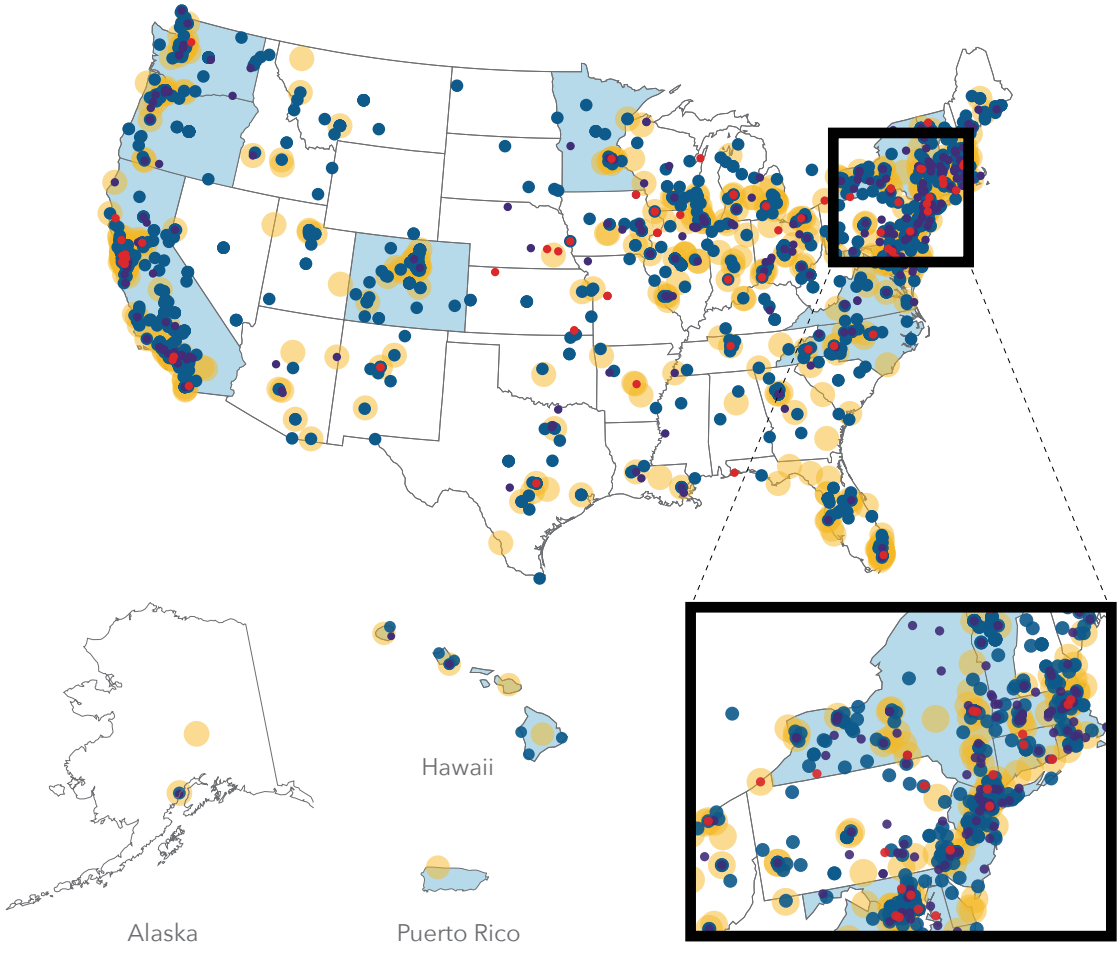
Climate Action Strategies:

- #1: Double down on renewable energy targets
- #2: Accelerate the retirement of coal power
- #3: Encourage residential and commercial building efficiency retrofits
- #4: Electrify building energy use
- #5: Accelerate electric vehicle (EV) adoption
- #6: Phase down super-polluting hydrofluorocarbons (HFCs)
- #7: Stop methane leaks at the wellhead
- #8: Reduce methane leaks in cities
- #9: Develop regional strategies for carbon sequestration on natural and working lands
- #10: Form state coalitions for carbon pricing

Source: Historical emissions data is from the U.S. EPA "Inventory of GHG Emissions and Sinks: 1990-2016"; projected emissions based on modeling from the America's Pledge research team

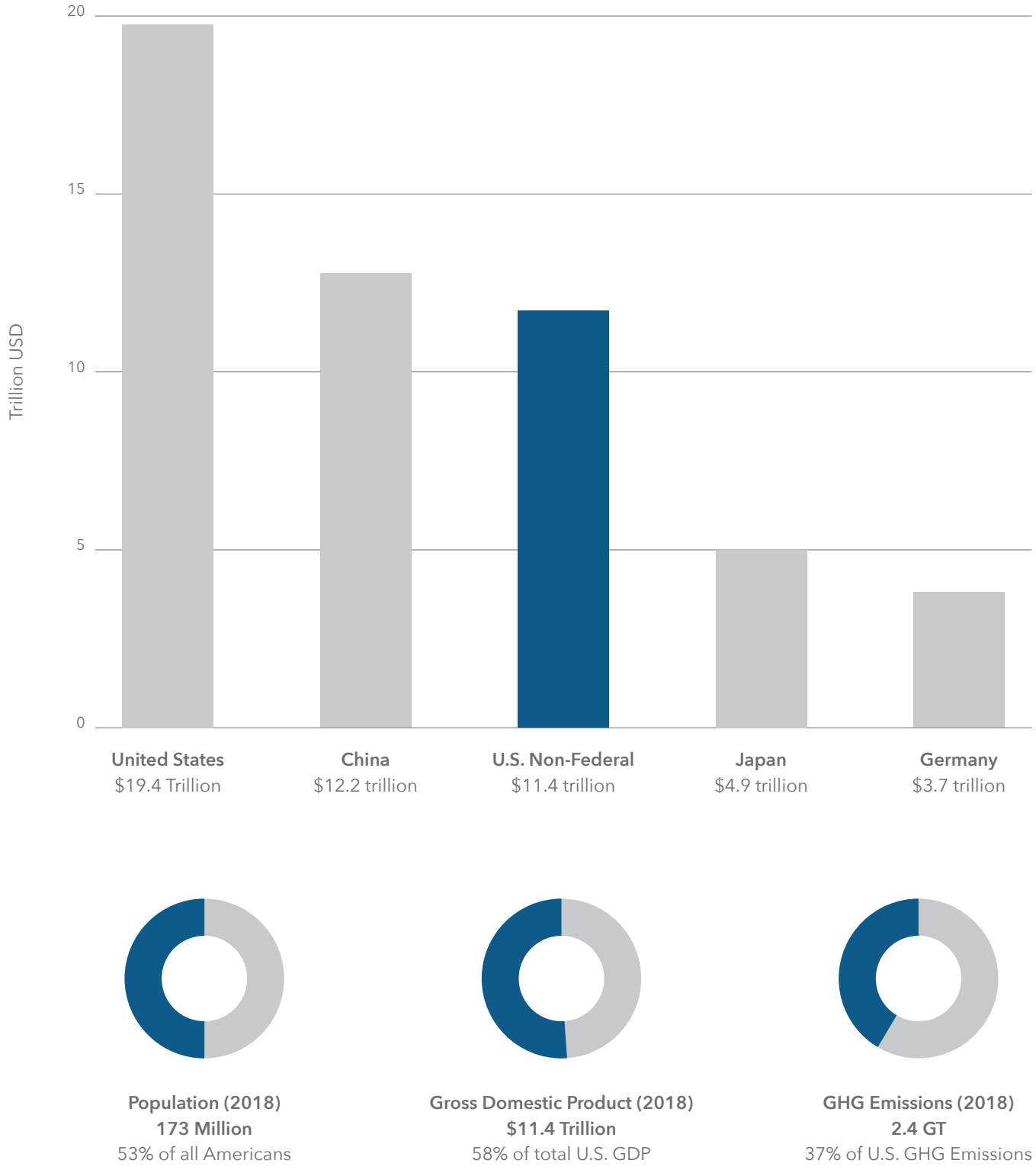
Current Efforts by States, Cities, and Businesses Are Yielding Significant Results

In the year since the Trump Administration announced its intent to withdraw from the Paris Agreement, over 3,000 real economy actors have pledged their support for the Paris Agreement and commitment to continued action on climate change by joining the "We Are Still In" declaration and participating in other networks such as the U.S. Climate Alliance and the Climate Mayors. The economic activity of this "coalition of the willing" is significant, equivalent to that of the third-largest country in the world (Figure ES-2). Specifically, the U.S. states, cities, businesses, and other leaders of the real economy that remain committed to the Paris Agreement represent over half of the U.S. population (173 million people), over half of the American economy ($11.4 trillion), and over 35 percent of nationwide GHG emissions.



States (17)
Cities, Counties and Tribes (540)
Businesses and Investors (1,914)
Faith-Based and Cultural Organizations (253)
Higher Education (343)

Figure ES-2: U.S. States, Cities, and Businesses Supporting the Paris Agreement Make Up a Large and Growing Footprint



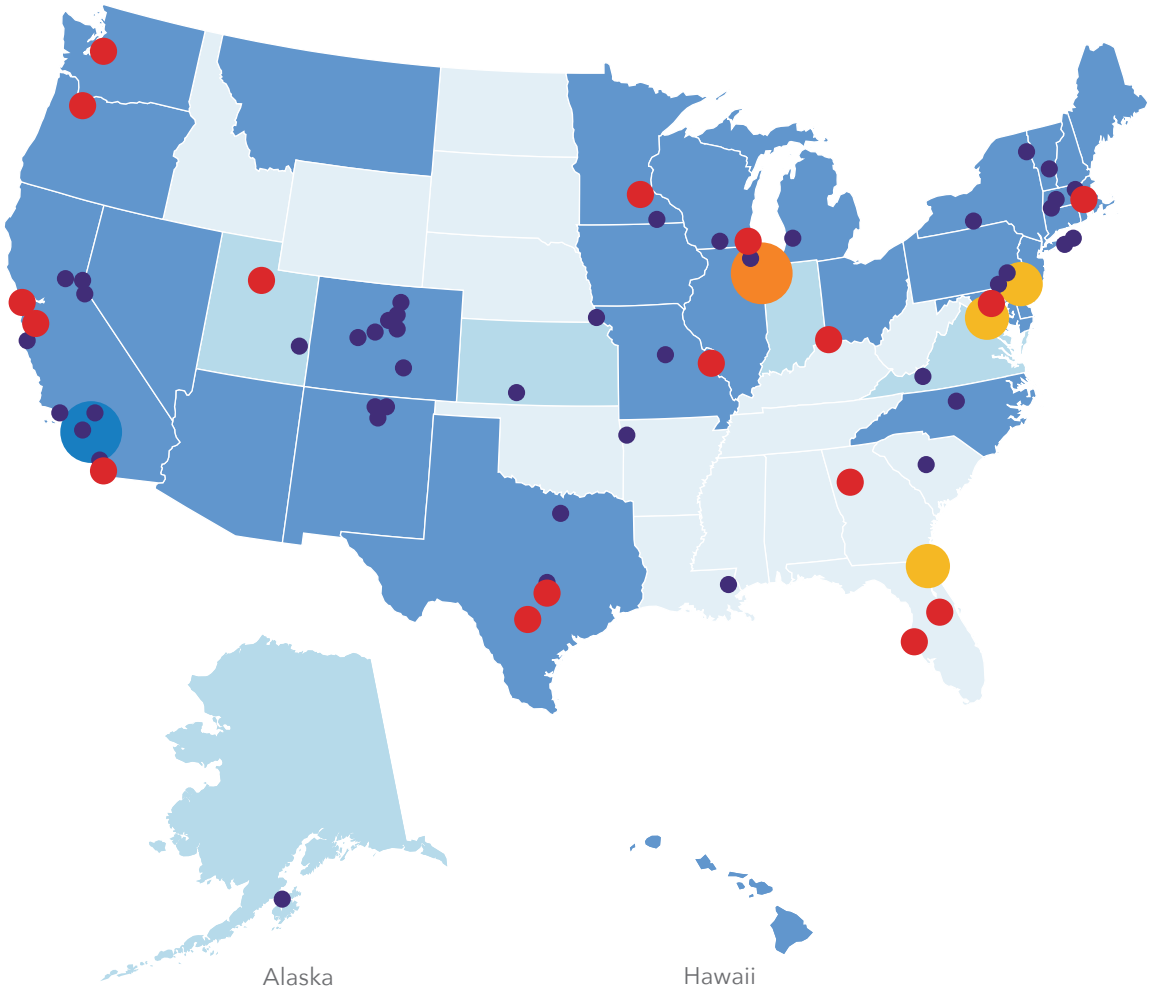
Note: Coalitions represented in the map include: We Are Still In, U.S. Climate Alliance, and Climate Mayors. Information presented on the map was based on available data as of August 2018. The coalitions represented are dynamic and the data will change over time.

U.S. real economy actors are already cutting emissions and scaling clean energy, not just to address climate change but to help create economic opportunities and jobs, and to deliver immediate benefits to public health. This report provides an updated survey of sector-specific actions across all 50 states, the largest 285 cities (with populations above 100,000), and a wide number of businesses in order to assess the impact of climate actions. Among the key findings:

- States, cities, and counties with GHG emissions reduction targets already on the books could cut annual emissions by 500 million metric tons of carbon dioxide equivalent (Mt CO_2e) from business-as-usual levels by 2025 if they are fully implemented;
- State, city, and business clean energy procurement policies (e.g. renewable portfolio standards) should increase demand for non-hydroelectric renewable generation to 500 terawatt-hours (TWh) by 2025 - enough to power 56 million homes for a year (Figure ES-3);
- Energy efficiency policies enacted by states, cities, and utilities could result in annual energy savings of over 200 TWh per year by 2025;
- Implementation of zero-emissions vehicles (ZEVs) mandates would lead to having 4 million new ZEVs on the road by 2025;
- State and city commitments to sustainable transportation networks could cut annual vehicle miles traveled by 36 billion miles, compared with business-as-usual projections by 2025;
- State, city, and business initiatives to cut hydrofluorocarbon (HFC) emissions could reduce these emissions by 6 percent from 2015 levels by 2025; and
- Policies and corporate actions designed to address fugitive methane leaks from oil and gas operations could cut national emissions by 17 percent by 2025, relative to 2005 levels.

Photo by Robert Beadle

Figure ES-3: States and Cities From Across the U.S. Have Adopted Clean Energy Targets and Goals



Source: American Council for an Energy-Efficient Economy; Lawrence Berkeley National Laboratory; World Resources Institute

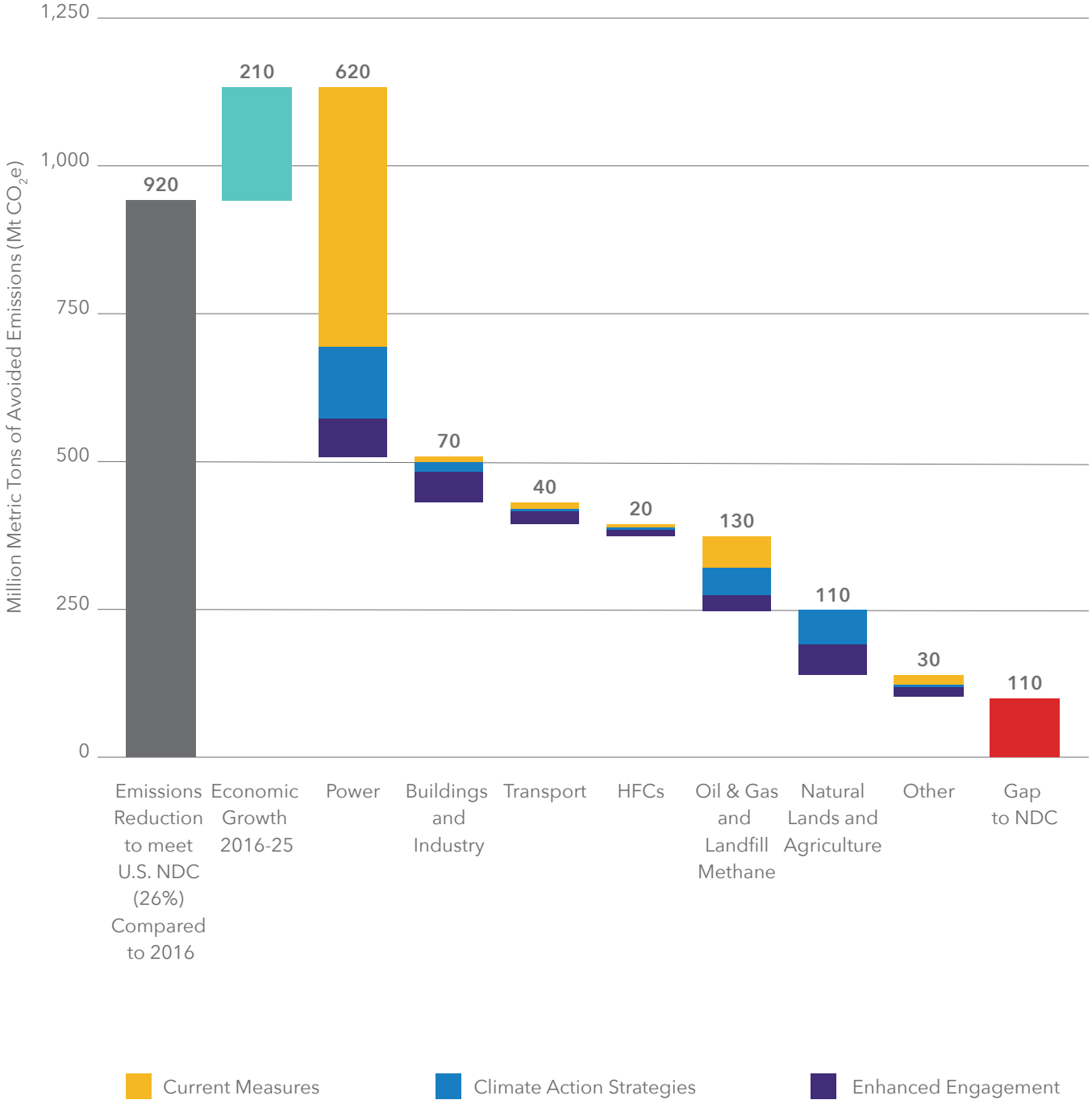
This kind of decentralized, bottom-up climate action is already delivering results. In 2017, U.S. energy-related carbon dioxide emissions fell to their lowest levels in 25 years. Despite the Trump Administration's stated pro-coal policies, announced coal plant retirements are occurring at a faster rate than ever before. Since June 1, 2017, the United States has added enough renewable energy to power more than 3 million homes for a year. States accounting for 35 percent of the U.S. economy are expected to have a price on GHG pollution by the end of this year. And more than 70 U.S. companies have announced emissions reduction targets in line with the Paris Agreement.

A Bottom-Up Opportunity Agenda for the Real Economy

Looking forward, we project that current policies and existing pledges from real economy actors, along with market forces and technology change (our *Current Measures* scenario), will deliver economy-wide emissions reductions of 17 percent below 2005 levels by 2025, even accounting for economic and population growth—taking the nation two-thirds of the way to its Paris pledge. This report goes on to build out a detailed picture of potential future actions that could go well beyond decarbonization commitments currently on the books. Such actions include a broad suite of emissions reduction opportunities spanning most major economic sectors and greenhouse gases—including electricity, transportation, buildings, oil and gas methane, natural and working lands, and hydrofluorocarbons (see Figure ES-4). We present potential sectoral impacts as a range of real-world outcomes with the 10 *Climate Action Strategies* at the accessible end and the full *Enhanced Engagement* potential at the more ambitious end. The 10 strategies were selected because they each represent significant opportunities to achieve impact by 2025 through collaborative action that can most easily begin by 2020 (see details of the 10 *Climate Action Strategies* on page 25). Moving from the low to the high end potential requires both recruiting new cities, states, and businesses to undertake commitments defined in the *Climate Action Strategies*, and expanding the range of actions by already committed real economy actors using the levers of change described in this report.

Broader engagement of this real economy coalition, within realistic legal and political limits, has the potential to reduce U.S. emissions by more than 490 additional Mt CO_2e to 24 percent below 2005 levels by 2025 (with a range of uncertainty of 20 to 30 percent). This would be within striking distance of the Paris pledge, making the 26 percent threshold achievable shortly thereafter. Moreover, such action would drive an even faster rate of economy-wide decarbonization between 2025 and 2030.

Figure ES-4: Achieving Full Potential Entails Actions Across All Major Economic Sectors and GHG Gases (Mt CO_2e in 2025)



Source: America's Pledge modeling results

Table ES-1: Key Climate Action Levers and Associated Potential

Sector	2005 Emissions ($MtCO_2e$)[1]	Change in Sector Emissions in 2016 relative 2005 ($MtCO_2e$)[2]	Percent Change in Sectoral Emissions 2016 Compared to 2005[3]	Scenario	Change in Sector Emissions in 2025 by Scenario($Mt CO_2e$)[4]	Total Feasible In-Sector Emissions Reductions 2005-25 as % of 2005[5]
Power	2,439	-593	-24%	Current	-440	-50%
				Strategies	-120	
				Enhanced	-60	
				Total	-620	
Buildings	1,696	-160	-9%	Current	-10	-14%
				Strategies	-10	
				Enhanced	-50	
				Total	-70	
Transportation	1,904	-99	-5%	Current	-10	-7%
				Strategies	-10	
				Enhanced	-20	
				Total	-40	
HFCs	103	+56	+54%	Current	-5	+35%
				Strategies	-5	
				Enhanced	-10	
				Total	-20	

For additional details on all sector assumptions and associated values for modeled emissions reductions in 2025, please see the Technical Appendix.

Oil & Gas and Landfill Methane[7]	469	-20	-4%	Current	-50	-32%
				Strategies	-50	
				Enhanced	-30	
				Total	-130	
Natural & Working Lands and Agricultural Emissions[8]	-211	+57	+26%	Current	0	-25%
				Strategies	-60	
				Enhanced	-50	
				Total	-110	
Total Net GHG Emissions[9]	6,589	-795	-12%	Current	-530	-24%
				Strategies	-250	
				Enhanced	-240	
				Economic Growth[9]	+210	
				Total	-810	

Notes:

1. Sector emissions based on 2016 U.S. EPA GHG inventory estimates. Some small sectors are omitted and therefore sum does not add to total net GHG emissions. As some sectors are estimated and calculated, values may differ slightly from EPA GHG inventory.
2. Change in sector emissions between 2005 and 2016 calculated based on 2016 U.S. EPA GHG inventory estimates.
3. Percent sectoral emissions reductions between 2005 and 2016 as % of 2005 sectoral emissions (based on 2016 U.S. EPA GHG inventory)
4. Total sector emissions reductions across three scenarios modeled by America's Pledge relative to a 2025 reference scenario.
5. Total feasible in-sector emissions reductions quantified as the total emissions reductions between 2005 and 2016 (based on U.S. EPA GHG inventory) and modeled emissions reduction between 2017 and 2025 (based on America's Pledge analysis), compared to the 2005 baseline.
6. Direct emissions from residential, commercial and industrial sectors. Does not include indirect emissions associated with electricity consumption which is included in power sector. Does not include industrial-related methane and HFCs included in other sectors.
7. GCAM assumes significant growth in methane emissions between 2005 and 2025. While total emissions grow, actions taken by real economy actors has the potential to cut emissions by over 30% against below 2005 levels. Agricultural methane included in Natural and Working Lands
8. Net change in emissions inclusive of land-sector sink and agricultural emissions. Both land-sector sink diminished in magnitude and agricultural emissions increased between 2005 and 2016, resulting in net increase in emissions of 26%.
9. Total GHG emission increases by 210 Mt CO2e in the GCAM reference scenario from 2016 to 2025. Emission reductions are measured relative to this scenario.

The Ten Climate Action Strategies

#1: DOUBLE DOWN ON RENEWABLE ENERGY TARGETS

Ratcheting up renewable energy targets at a time of plummeting solar and wind costs and rapid evolution of business model solutions could achieve a major portion of the overall potential within the electricity sector. State, city, and business renewable energy commitments embodied in this strategy could readily lead to the deployment of an additional 130 TWh of total renewable energy beyond current policies and commitments by 2025—taking the U.S. to 990 TWh of renewable energy annually, up from 600 TWh in 2016.

#2: ACCELERATE THE RETIREMENT OF COAL POWER

States, cities, and businesses can accelerate the transition from fossil fuels to clean energy and shape the evolution of the electricity grid by insisting on the retirement of coal plants that are no longer competitive, fail to meet public health standards, or violate community clean energy goals. Working together, states, cities, businesses, advocates, and other stakeholders can speed this transition and ensure that 94 gigawatts (almost 30 percent) of the 2005 U.S. coal fleet has retired by 2025.

#3: ENCOURAGE RESIDENTIAL AND COMMERCIAL BUILDING EFFICIENCY RETROFITS

Cities can collaborate with the real estate industry, utilities, and state regulators to develop and implement ambitious building energy efficiency programs and policies. Cities can accelerate building retrofits by implementing a tested suite of approaches, including energy disclosure ordinances, requirements for building upgrades at key trigger points, and scaling retrofit incentive programs. Doubling the number of cities with energy efficiency targets and associated implementation mechanisms would result in an additional savings of 13 TWh per year by 2025 compared with what is modeled under our *Current Measures* scenario, enough electricity to power 1.5 million homes for a year.

Photo by Dennis Schroeder / NREL

#4: ELECTRIFY BUILDING ENERGY USE

States, cities, and utilities can collaborate to electrify building energy use. This would begin the transition away from the 500 million tons of carbon dioxide pollution that comes from burning fossil fuels inside U.S. homes and businesses each year. Targeting collaborative action by states, cities, utilities, and industry organizations in the Northeast and Midwest regions, where electrification retrofits are most cost-effective today, could deliver a 2025 impact of over 800 tera Btu of total savings (enough energy to power 25 million homes for a year) and a significant start in the transition away from fossil fuels.

#5: ACCELERATE ELECTRIC VEHICLE (EV) ADOPTION

States, cities, corporate fleet owners, utilities, vehicle manufacturers, transportation network companies, and other private-sector innovators have the power to substantially increase the rate of EV deployment, particularly when they work together. Collaborative action can lift uptake of EVs in the United States such that an estimated 8.4 million EVs will be on the road by 2025, more than doubling the 4 million EVs anticipated to be sold under current policies and conditions.

#6: PHASE DOWN SUPER-POLLUTING HYDROFLUOROCARBONS (HFCS)

Expanding the California Significant New Alternatives Policy (SNAP) program to include HFC aerosols, replicating this program in a broader subset of states that includes all 16 current members (and Puerto Rico) of the U.S. Climate Alliance, and broadening EPA's GreenChill program could reduce HFC emissions by an additional 5 percent beyond current policies by 2025.

#7: STOP METHANE LEAKS AT THE WELLHEAD

States, supported by industry and environmental groups, can put in place important regulations and/or permitting programs to manage methane emissions from oil and gas facilities. Setting standards and implementing innovative detection technologies in seven states considering new or updated actions to address methane emissions could reduce national emissions from this source as much as 23 percent below 2005 levels by 2025.

#8: REDUCE METHANE LEAKS IN CITIES

Cities, utilities, and commercial service providers can work with urban gas distribution utilities in key states to develop and implement plans to use advanced leak detection and data analytics to identify and abate the largest leaks from municipal natural gas distribution systems. Using innovative, data-driven approaches to identify and prioritize the repair of the top 20 percent of leaks in the eight states with the highest leakage, we estimate that coordinated action by states, cities, and businesses in a subset of U.S. states with leak-prone urban infrastructure could cut nationwide distribution system emissions by 30 percent by 2025.

#9: DEVELOP REGIONAL STRATEGIES FOR CARBON SEQUESTRATION ON NATURAL AND WORKING LANDS

States and businesses, nurtured with support from coalitions of philanthropies and NGOs, can spark regional initiatives for enhanced carbon sequestration on natural and working lands. Through collaborative action in U.S. Climate Alliance states and other states, real economy actors can reduce emissions by 60 Mt CO_2e by 2025.

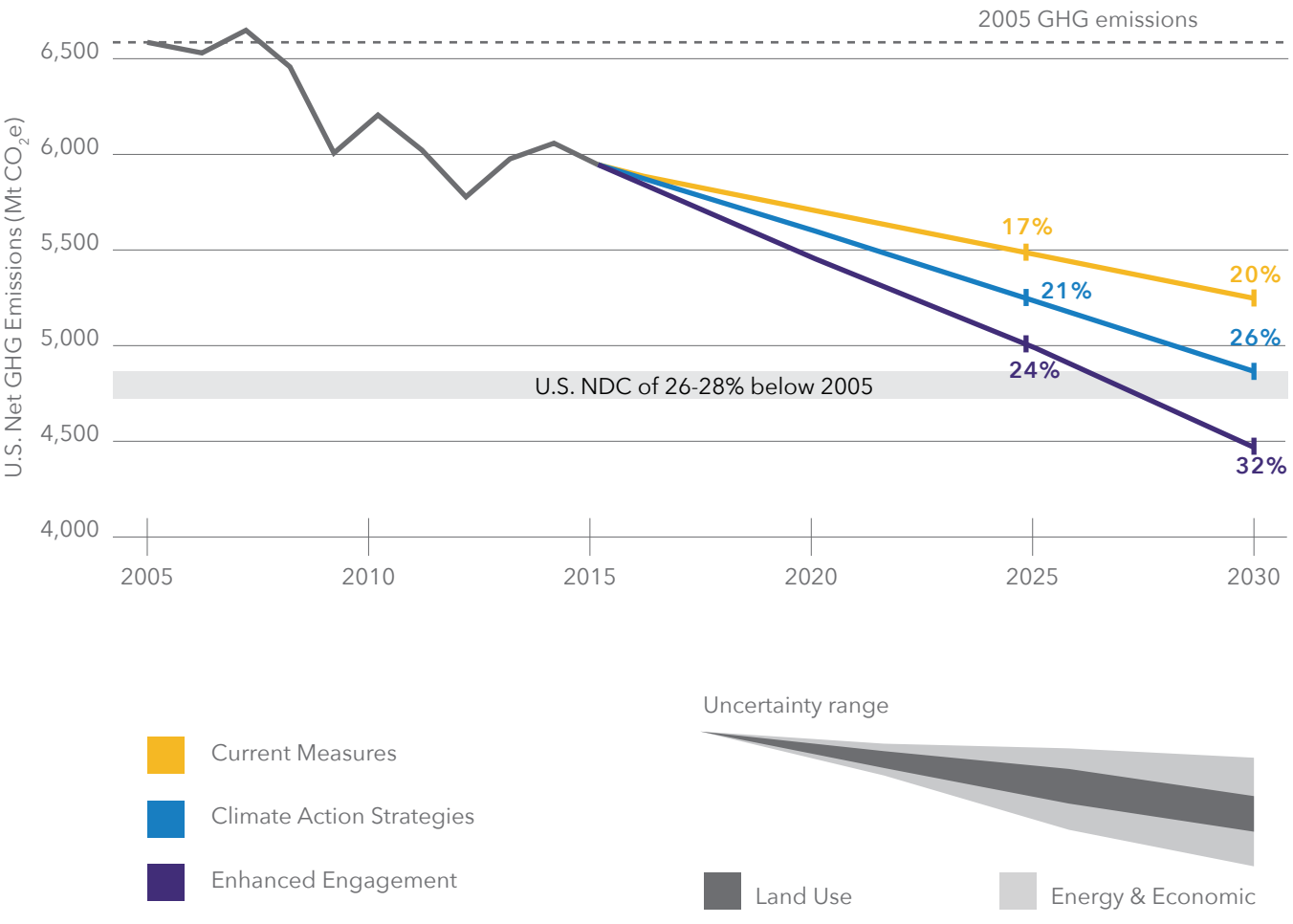
#10: FORM STATE COALITIONS FOR CARBON PRICING

Real economy actors can establish economy-wide limits on carbon pollution in geographically diverse states, using emissions targets consistent with the near- and long-term reductions necessary to achieve the goals of the Paris Agreement. Today eight states have mandatory economy-wide GHG targets, and another eight states and the District of Columbia have aspirational GHG targets (e.g., set by executive order). If these states put into place a limit on carbon pollution consistent with U.S. targets under the Paris Agreement and implement appropriate sector-specific programs and policies, the United States could reduce energy-related CO_2 emissions economy-wide by more than 350 Mt CO_2e by 2025. Note that many of the sector-specific emission reductions identified in the first nine strategies are vital components in the ability of these states to meet their economy-wide targets.

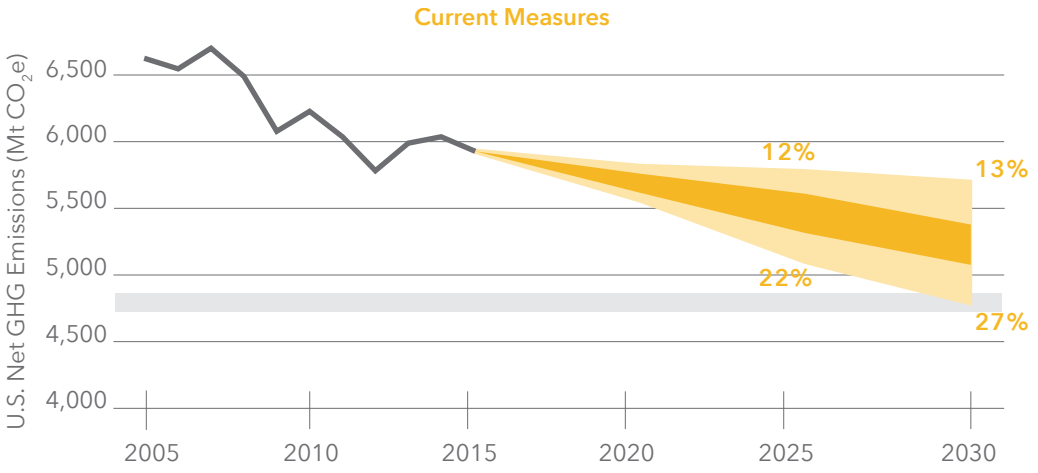
Pathways to America's Low-Carbon Future

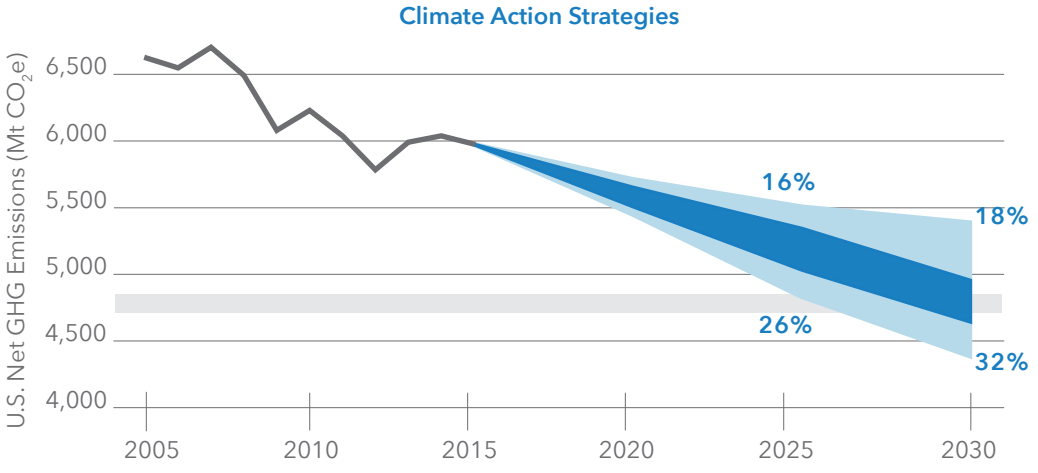
Figure ES-5 shows the modeled evolution of U.S. emissions between 2005 and 2030, illustrating both the potential of real economy impact by 2025, and the even more significant emissions reductions such action will trigger in the critical period between 2025 and 2030. This graph presents a central estimate as well as a range of potential outcomes flowing from uncertainty in key variables, specifically economic growth, energy prices , and land use changes.

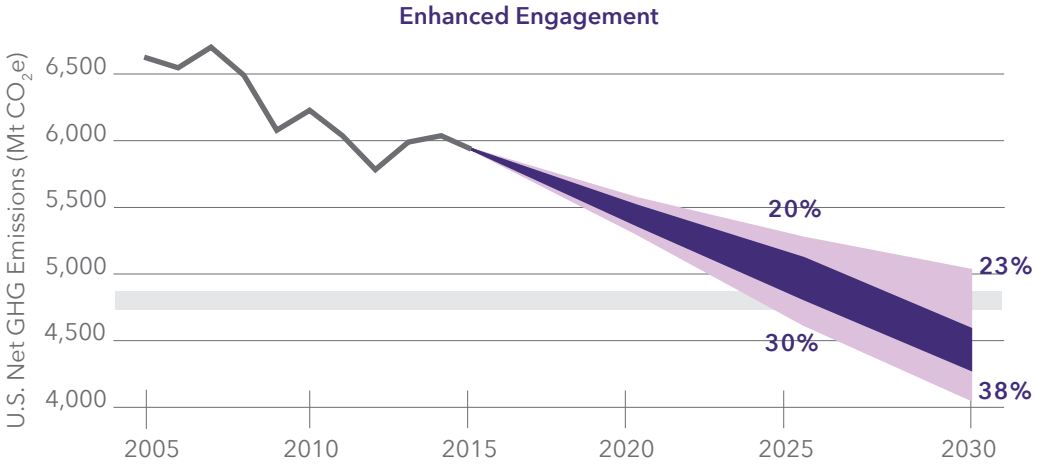
Figure ES-5: Progress Toward Near-and Long-term Climate Goals Varies Across the Three Scenarios (Mt CO_2e)



Source: America's Pledge modeling results


Current Measures
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
12%
13%
22%
27%


Climate Action Strategies
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
16%
18%
26%
32%


Enhanced Engagement
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
20%
23%
30%
38%

Broader engagement of this real economy coalition, within realistic legal and political limits, has the potential to reduce emissions by more than 24 percent below 2005 levels by 2025. This would be within striking distance of the Paris pledge, making the 26 percent threshold achievable shortly thereafter.

This result is compatible with the emissions projections presented by the Obama Administration to the global community in its 2016 Biennial Report to the UNFCCC. Those projections demonstrate that the U.S. target for 2025 is a stretch goal, but is achievable with concerted effort. However, whereas the Obama Administration's 2025 projections assumed continued, and indeed enhanced, federal engagement in the period from 2017 through 2025, our analysis demonstrates that during the current hiatus in federal leadership, real economy actors are substantially maintaining, and can fully maintain, the momentum of the nation's decarbonization trajectory for 2025 and beyond.

The annual rate of decarbonization in the *Enhanced Engagement* scenario is 1.6 percent between 2016 and 2025, accelerating to 2.1 percent for 2025–30. This is substantially higher than the actual 1.1 percent rate for the period 2005–16. The post-2025 trajectory approaches the rate of decarbonization needed to hit 80 percent below 2005 levels by 2050 (2.3 percent).[2] The acceleration we model after 2025 is attributed to the fact that several sectors of the economy—transportation and buildings, for example—have long lead times for capital turnover. Policies put in place between now and 2025 will deliver the bulk of their emissions reduction benefits only after 2025, and will continue to have an effect after 2030 as buildings, fleets, industrial processes, and other infrastructure are modernized.

Fulfilling America's Pledge

This analysis demonstrates for the first time that despite federal policy inaction, the United States can get on track to approach its Paris Agreement pledge for 2025 through the concerted effort of real economy actors. Moreover, implementing such actions today can support accelerated reductions beyond 2025, driving even steeper overall U.S. emissions reductions between 2025 and 2030. Federal reengagement undertaken as rapidly as possible will be essential in sustaining and accelerating the needed breadth and depth of emissions reductions across all sectors of the U.S. economy, both to close any remaining gap in 2025 and for long-term decarbonization.

The insights contained in this report about bottom-up climate action potential in the United States may also hold important lessons for the broader international community as policymakers and leaders across society consider how to accelerate and deepen implementation of the Paris Agreement. While national governments and policies were in the spotlight during the run-up to the Paris Agreement in 2015, the focus of international negotiations has now shifted to a more detailed examination of what it will take to formulate and implement increasingly ambitious national climate goals. The case of the United States demonstrates that real economy actors can lead ambitious and sustained commitments to climate action from all levels of government and across the economy.

The results of this analysis are therefore a call to action for the global community as a whole. Achieving the goals of the Paris Agreement has always been recognized as demanding the full participation of and deep collaboration between national governments and their broader societies. This moment presents the opportunity to make that collaboration a reality.

Chapter 1

Introduction

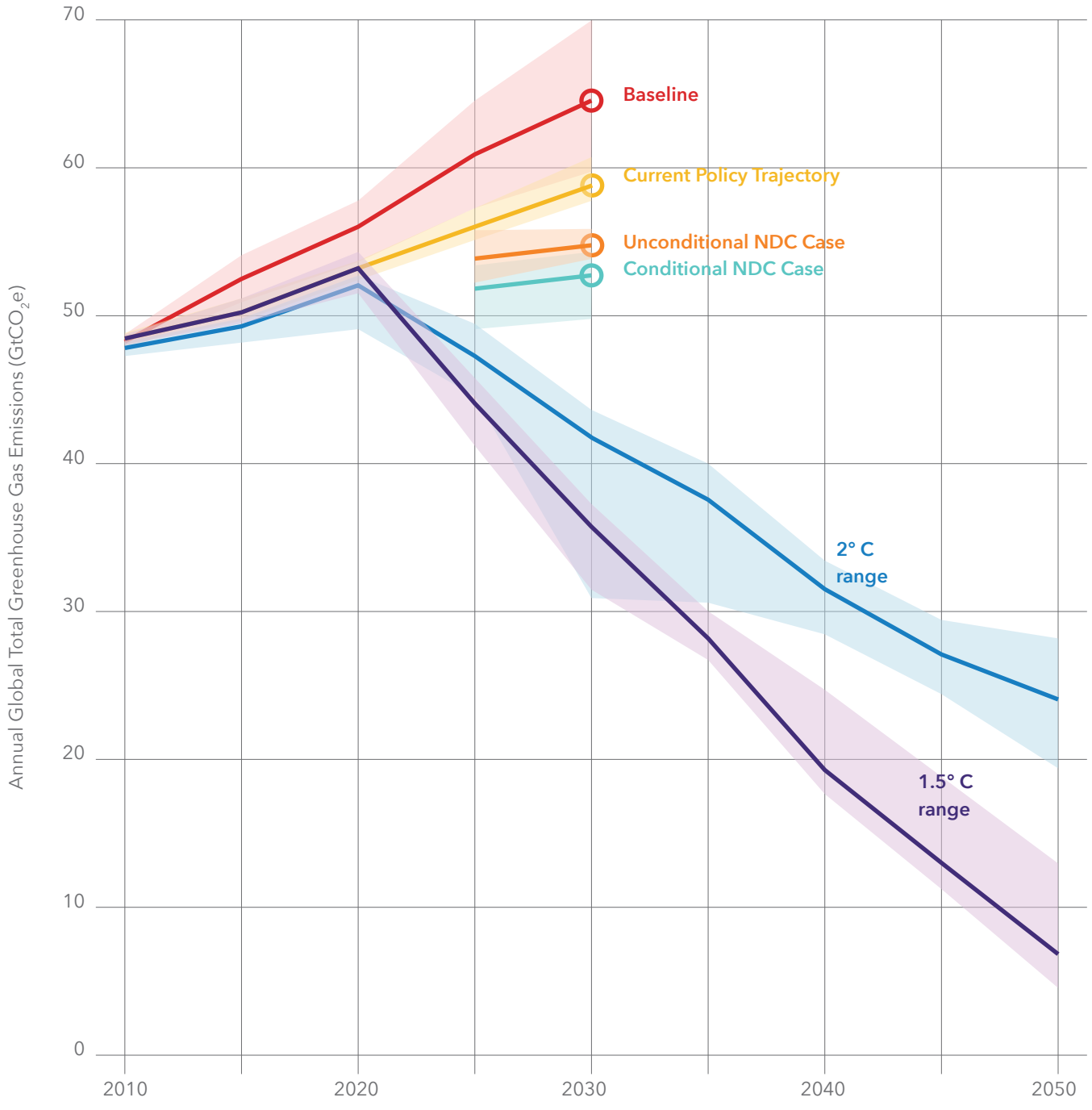
The Paris Agreement was the culmination of nearly 30 years of efforts to devise a durable strategy for ratcheting down global GHG emissions at a pace that would avoid the most dangerous effects of climate change.

This landmark accord envisages shared responsibilities among all nations and promotes continually increased ambition over time. The Paris Agreement entered into force in record time, with more than 170 national governments formally submitting their pledges—nationally determined contributions (NDCs)—less than three years after the Paris Agreement was finalized. With just one notable exception, all national Parties to the Paris Agreement, together with the many thousands of disparate actors such as states, cities, and businesses in every country around the world, remain committed to moving forward toward the goals of the Paris Agreement.[4]

Yet despite this unprecedented progress, meeting the ambitious goals of the Paris Agreement will require faster and bolder action. Although national commitments under the

Paris Agreement are an important first step, as outlined in the United Nations Environment Programme (UNEP) Emissions Gap Report (see Figure 1-1), there remains a gap between this initial batch of NDCs for 2025–30 and the rate of decarbonization needed to limit temperature rise to below 2 degrees Celsius and approach 1.5 degrees.[5] Therefore, in the coming years the world must accelerate emissions reductions, utilizing the full range of potential levers available. Such transformation demands a full partnership and deep collaboration among national governments and their broader societies: states, cities, businesses, universities, and communities whose decisions affect greenhouse gas emissions, drive innovation, and shape the speed and direction of the global energy transition. Nowhere is this kind of decentralized climate leadership more important than in the United States, where the recent change in presidential administrations has resulted in an abandonment of federal climate leadership.

Figure 1-1: Even with Current Paris Agreement Commitments, a Substantial Ambition Gap Remains



Blue area shows pathways limiting global temperature increase to below 2° by 2100 with >66% chance.

Purple area shows pathways limiting global temperature increase to below 1.5° by 2100 with 50 to 66% chance.

Source: UN Environmental Program, "The Emissions Gap Report 2017," 2017.

Real Economy Actors: Working Together to Close the Ambition Gap

Across the globe, cities, states, businesses, and other real economy actors are taking on increasing responsibility for implementing climate targets. In the multilevel U.S. federal political system, each of these actors has a powerful set of tools within its sphere of influence that it can use to reduce greenhouse gas emissions (Figure 1-2).

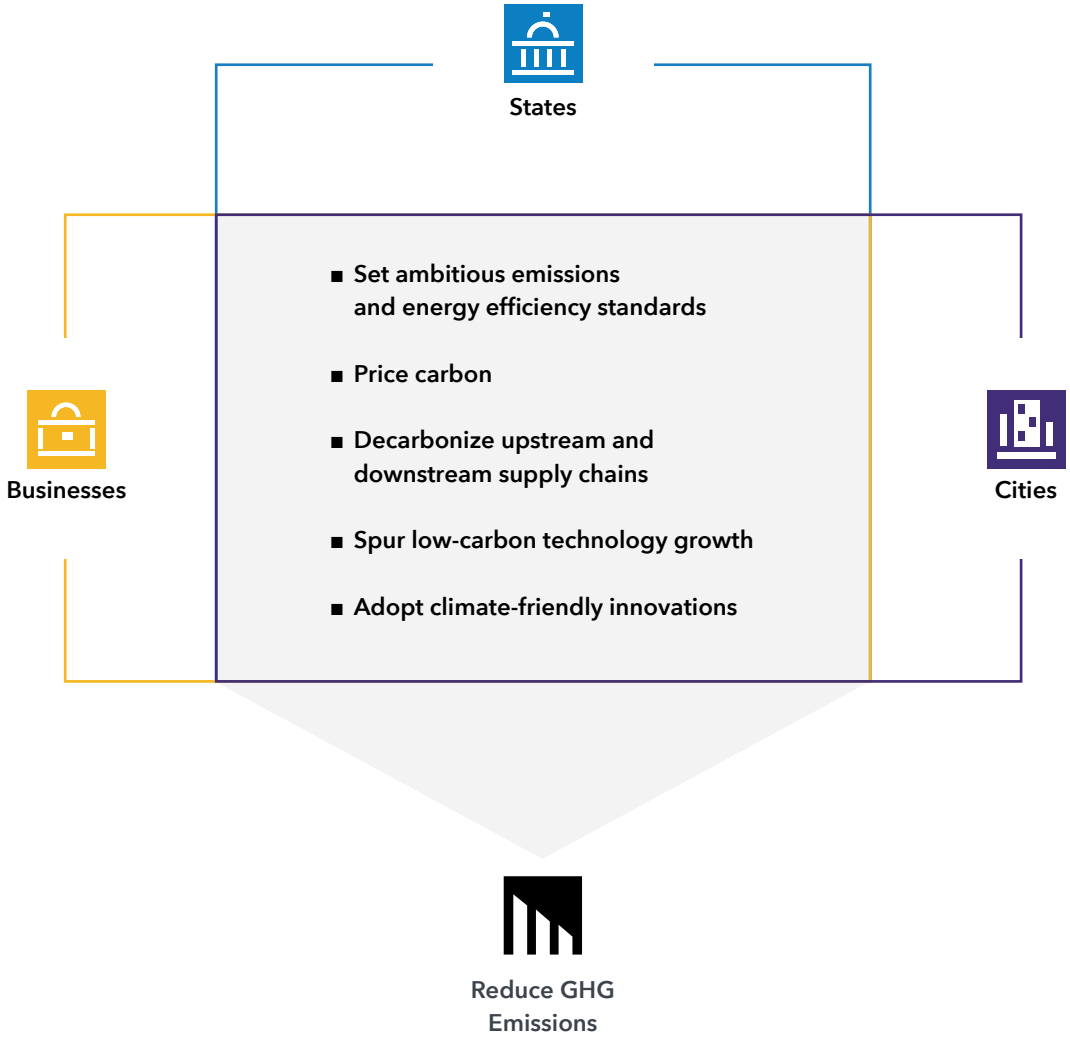
States control many of the most powerful energy and climate policy levers, such as renewable portfolio standards and air pollution regulations. States will often experiment and emulate peers: early mover states typically demonstrate successful models and then engage others to follow. U.S. Supreme Court Justice Louis Brandeis famously called states the "laboratories of democracy" thanks to their ability to innovate and experiment with diverse policy solutions. This is as true of energy and climate today as it was true of leading public policy issues in Brandeis's time nearly 80 years ago.

Cities and counties control city planning, building standards and permits, public transportation, waste management, and zoning, all critically important to climate mitigation. Increasingly they seek to serve their populations by exercising greater influence over such economic factors as the sources and prices of electricity, modes of transportation, and climate resilience. In particular, large cities and counties represent sizable shares of state and regional economies, taxes, and energy demand. Indeed, the 25 largest urban areas in the United States account for 46 percent of total

GDP,[6] 10 percent of the population, and 6 percent of climate emissions.[7]

Businesses do not set public policy; however, they direct, invest in, or influence much of the carbon-emitting asset base (energy, industry, and buildings) across wide swaths of the economy. Business leadership and policy often affect operations across multiple facilities, setting the terms of engagement for complex and multilayered supply chains across a large geographic scope, often spanning many states and even multiple countries. Businesses consume a substantial share of the nation's energy and can make decisions about how to source electricity and heat. They can heavily influence transportation-related CO_2, methane, and hydrofluorocarbon (HFC) emissions as well.

Figure 1-2: States, Cities, and Businesses have a Number of Levers at their Disposal



The importance of real economy actors stepping up to the climate challenge is vital beyond the current American federal abdication context, given that globally, initial NDCs are falling short of the required rate of decarbonization.[8] National governments are realizing that their regions, cities, businesses, and societies are both demanding and driving decarbonization. While this factor was only partly captured in the first round of NDCs, it is now especially timely as Parties to the Paris Agreement prepare to convene in 2020 to re-examine whether they can increase their climate ambition for 2030, both collectively and individually. Rather than viewing climate change as a problem for national governments to solve, the new paradigm must be one of partnership and collaboration across societies.

About America's Pledge and This Report

On June 1, 2017, President Trump announced his intent to withdraw the United States from the Paris Agreement. The response from different sectors and civil society across the United States was swift. Just 72 hours after the announcement, an unprecedented coalition composed of states, cities, businesses, universities, and others declared "We Are Still In," vowing continued climate action consistent with the goals of the Paris Agreement. The list of signatories to this declaration has since doubled in size. In July 2017, Governor Edmund G. Brown, Jr., of California and former New York City mayor and United Nations Special Envoy for Climate Action Michael Bloomberg launched the America's Pledge initiative to enable a diverse set of leaders and groups of actors in the United States to better understand and build the basis for sustained, effective climate action. The America's Pledge initiative played a critical role in the months following the Trump Administration's announcement, showcasing for the world continued U.S. climate leadership from states, cities, and businesses.

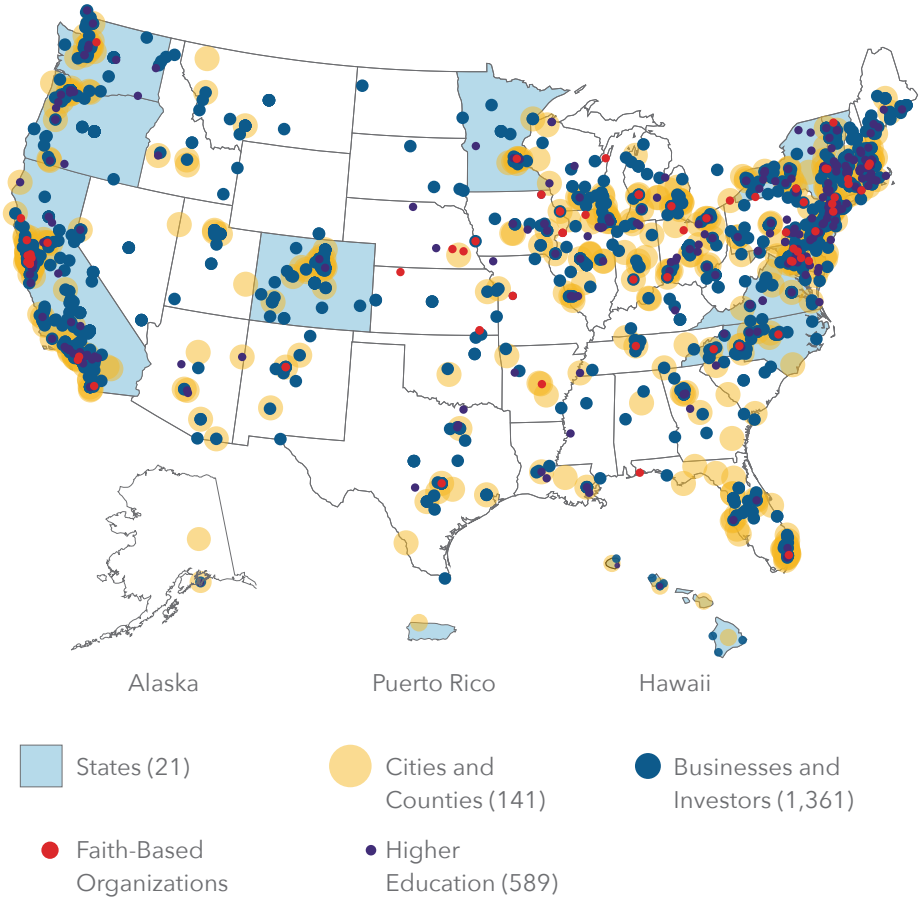
At the November 2017 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change (COP-23) in Bonn, Brown and Bloomberg highlighted the scope and scale of these commitments and actions in *America's Pledge Phase 1 Report: States, Cities, and Businesses in the United States Are Stepping Up on Climate Action*.[9] The report's key finding—that states, cities, and businesses representing over half the U.S. economy, equivalent to the third-largest economy in the world, remain committed to climate action consistent with the Paris Agreement—reverberated in the climate negotiations and around the globe. When presented to the international community, the report helped shift the tone from one of pessimism about U.S. climate efforts to one recognizing and reinforcing the momentum from states, cities, and businesses.

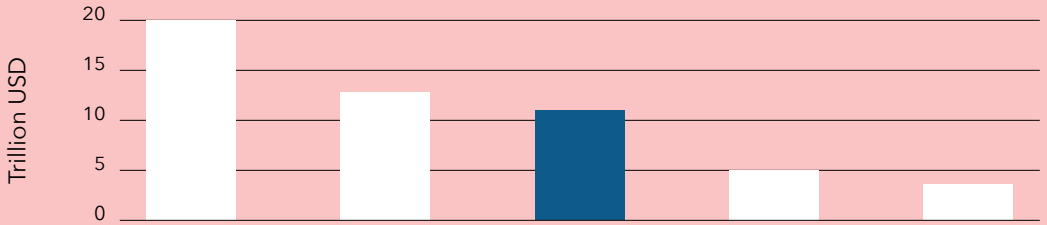
Since President Trump announced his intent to withdraw from Paris, real economy actors have issued a continual stream of ambitious policy changes, investments and decarbonization programmatic initiatives—not just local and regional governments like cities and states, but also businesses,healthcare providers, universities, rural electric cooperatives, investment bankers, community organizations, and religious congregations. Momentum continues to grow—but its aggregate impact on economy-wide emissions has not previously been estimated.

U.S. NETWORKS SUPPORTING THE PARIS AGREEMENT

Since June 2017, the world has witnessed an unprecedented mobilization of U.S. states, cities, and counties; tribal nations; businesses and investors; colleges and universities; and other civil society leaders that have declared their support for the Paris Agreement. Since the launch of the America's Pledge initiative, over 3,000 leaders from regions all across the country have committed to act on climate (see Figure 1-3).[10] The combined gross domestic product (GDP) of U.S. states and cities that remain committed to action in line with the emissions reduction goals of the Paris Agreement would be the third-largest country in the world—larger than the economies of either Japan or Germany—and would account for over 35 percent of U.S. emissions.[11]

Figure 1-3: U.S. States, Cities, and Businesses Supporting the Paris Agreement Make Up an Increasingly Large Footprint





United States
$19.4 Trillion

China
$12.2 trillion

U.S. Non-Federal
$11.4 trillion

Japan
$4.9 trillion

Germany
$3.7 trillion

Population (2018)
173 Million
53% of all Americans

Gross Domestic Product (2018)
$11.4 Trillion
58% of total U.S. GDP

GHG Emissions (2018)
2.4 GT
37% of U.S. GHG Emissions

A number of organized networks have formed to help implement policies and programs consistent with the goals of the Paris Agreement, including those below.

- "*We Are Still In*" is composed of leaders from across all sectors of the United States, including states and tribal nations, cities and counties, businesses and investors, higher learning institutions, faith groups, and cultural institutions. As of August 2018, there were over 2,800 signatories committing to the goals of the Paris Agreement. In aggregate, these leaders represent a population of over 150 million (47 percent) and GDP totaling $9.6 trillion (49 percent).[12]

- *The U.S. Climate Alliance* has grown to include 16 states and Puerto Rico, representing 134 million people (40 percent of the U.S. population) and GDP of more than $9 trillion (46 percent of U.S. GDP), making commitments to meet their share of the U.S. NDC under the Paris Agreement.[13]

- *U.S. Climate Mayors* now include 412 cities, up from 383 cities a year ago.[14] Climate Mayor cities representing more than 70 million Americans and 24 percent of U.S. GDP are committed to upholding the goals of the Paris Agreement and are mobilizing efforts to accelerate U.S. city climate action.

These networks represent the voices of change, demonstrating to the U.S. and global leadership that climate progress will continue. Beyond signing on to these pledges, states, cities, and businesses are enacting policies, making investments, and engaging communities to accelerate the transition to a clean energy economy. It is critical that states, cities, and businesses continue to implement their commitments. This report provides useful examples of current and potential future progress in order to inspire leaders to do more.

In the United States, states, cities, businesses, and other real economy actors have embraced the low-carbon, climate resilient future—helping drive better outcomes for their own citizens and business operations.

This report, *Fulfilling America's Pledge,* builds on our 2017 report and provides the most comprehensive assessment to date of how U.S. states, cities, businesses, and others (often referenced within this report as "real economy actors") are embracing new economic opportunities and technologies to implement climate targets and deliver emissions reductions within their own jurisdictions and operations under their own authority. This report includes an assessment of the impact of their existing commitments on the overall U.S. emissions trajectory, and provides a concise roadmap of 10 broad opportunities for action that together can lay the groundwork for even deeper emissions reductions from the real economy. This report also provides an internationally applicable toolkit to help policymakers and other stakeholders understand how real economy actors can drive more ambitious climate outcomes and serve as implementing partners in the context of other national governments' NDCs under the Paris Agreement.

The information included in this report is the product of a major research and analysis project coordinated by Rocky Mountain Institute and the University of Maryland Center for Global Sustainability, with substantial contributions from a core team that also included experts from World Resources Institute, the American Council for an Energy-Efficient Economy, CDP, the Environmental Defense Fund, and Meister Consultants Group. The analysis benefited from extensive engagement and consultation with a broad group of advisors from industry and civil society, as well as key state, city, business, and other real economy stakeholders (details are included in this report's Acknowledgments page).

The remainder of *Fulfilling America's Pledge* includes the following:

- **Chapter 2** focuses on the impact of *Current Measures*. It updates the survey of existing sectoral commitments from the 2017 report and develops new, bottom-up estimates of the projected impact of these measures. It also presents case studies showcasing concrete examples of these measures in action.

- **Chapter 3** outlines the opportunity for states, cities, and businesses to reach beyond their current commitments through: 1) a discrete set of 10 impactful actions that can be initiated in the next two years, comprising our *Climate Action Strategies* scenario; and 2) the broader, feasible, and even more impactful suite of actions real economy actors can deliver across the major GHG-emitting sectors: our *Enhanced Engagement* scenario. These two scenarios thus estimate the emissions reductions associated with specific, ambitious policies and actions that can be taken by U.S. cities, states, and businesses in the near term, without relying on the federal government. For each sector we lay out a range of potential real-world outcomes, with the discrete *Climate Action Strategies* at the accessible end and the broader *Enhanced Engagement* potential at the more ambitious end. This chapter demonstrates that given the rapid pace of innovation and technological change, and despite the absence in federal leadership, a robust set of attractive-but-as-yet-untapped opportunities to cut emissions remains available to real economy actors.

- **Chapter 4** integrates these current and incremental new commitments within an economy-wide analytical framework to present a novel, integrated synthesis of the quantified impact that state, city, and business actions—both committed and potential—could have on U.S. emissions through 2025. These current and new commitments are modeled as three economy-wide scenarios corresponding to the policies and programs identified in Chapters 2 and 3:

  - *Current Measures*—The impact of current policies and commitments on U.S. emissions;

  - *Climate Action Strategies*—A detailed assessment of the emissions reduction opportunity from 10 near-term, discrete ambitious climate actions led by real economy actors; and

  - *Enhanced Engagement*—A top-end estimate of what can plausibly be achieved through state, city, and business actions.

THE AMERICA'S PLEDGE MODEL AND THE ANALYTICAL APPROACH USED IN THIS REPORT

This report uses a novel approach to quantify the implications of current and potential future state, city, and business actions. It combines the bottom-up and top-down approaches to model the three scenarios discussed above (*Current Measures*, *Enhanced Engagement*, and *Climate Action Strategies*). In addition, we present estimates of the uncertainty of these results created by factors other than climate commitments, such as changes in GDP growth rates.

The immediate application of this approach is to provide an assessment of the implications for climate mitigation in the United States, but the conceptual framework also provides a possible route for similar analyses in other national contexts. The analytical approach integrates three stages:

First, it *tallies individual climate commitments* in key sectors. This report integrates data collected from several sources about current on-the-ground actions in sectors across specific states, cities, and/or businesses.

Second, it *aggregates the impact* of these commitments to the sector level, controlling for overlaps or double-counting (as discussed in the *Technical Appendix*). To understand the combined effects of different actions while more explicitly considering their interactions, World Resources Institute developed a new model, the Aggregation Tool for modeling Historic and Enhanced Non-federal Actions (ATHENA). ATHENA allowed us to quantify the total impact of individual real economy actions and control for double-counting.

Third, it *projects the varying overall impact* these actions might have across the U.S. economy on the national emissions trajectory, depending on the degree of ambition and speed of climate action by states, cities, and businesses. Using an integrated assessment modeling tool, the Global Change Assessment Model for the United States of America (GCAM-USA), the analysis captures the overall GHG impacts of the commitments and actions on the U.S. economy, incorporating interactions between the economy, energy sector, non-CO_2 emissions sources, and land use change. GCAM is an open-source, globally applicable integrated assessment modeling tool, implemented for this study by researchers at the University of Maryland.

As national and international policymakers and other stakeholders around the world seek to understand the potential impact of real economy actors on future emissions outcomes, the GCAM–ATHENA approach taken here can provide both a methodological framework and a conceptual process to guide decision making in other geographies worldwide. Like all models, GCAM and ATHENA have both strengths and limitations and must be interpreted with those in mind. The applications of the combined GCAM–ATHENA framework in this report are not predictions but nonetheless illuminate the potential contribution of real economy actors to the climate solution. More details on the analytical process and the specific tools applied are available in the *Technical Appendix* to this report, which can be found online at www.americaspledge.com.

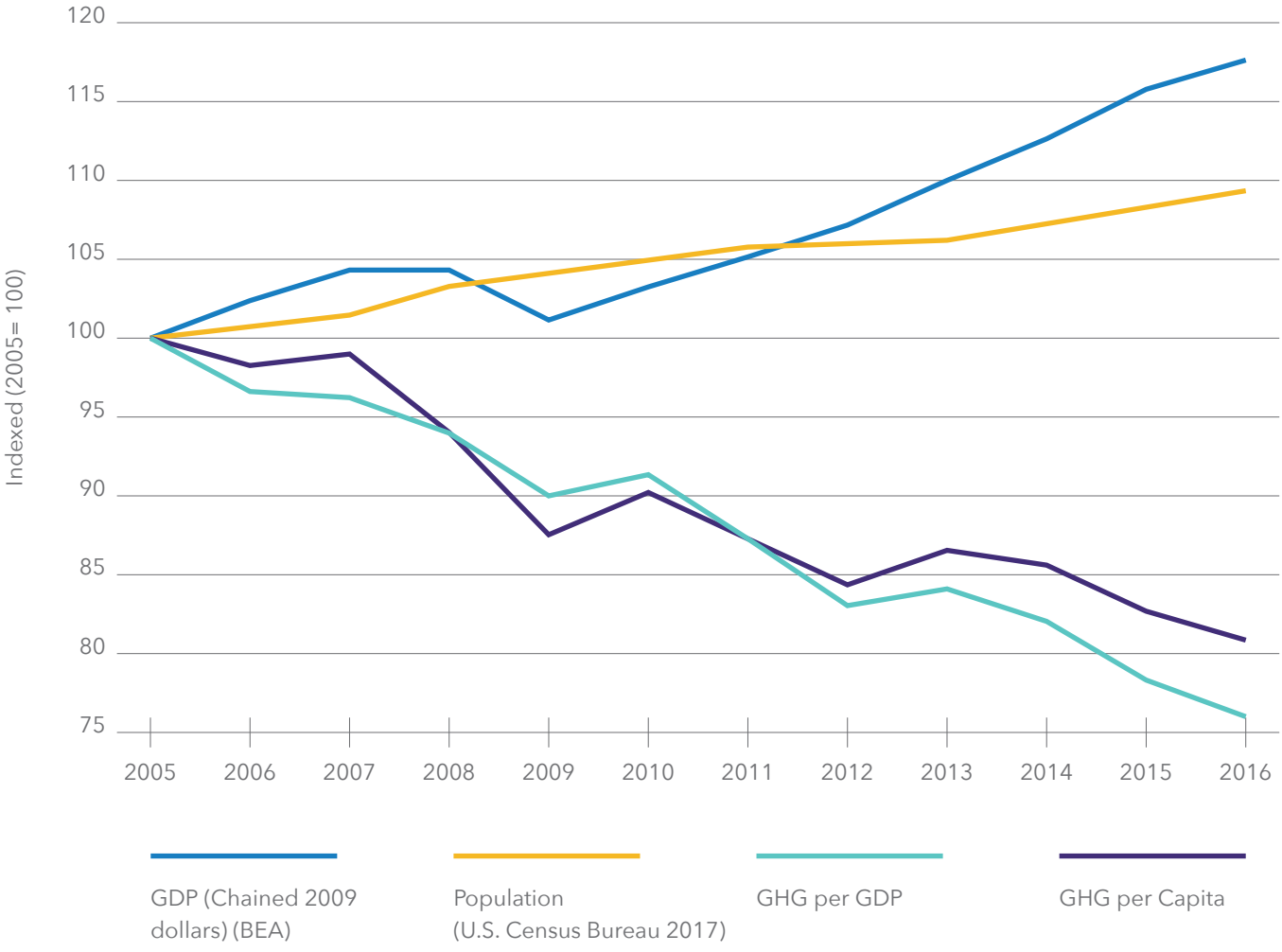
Chapter 2

Current Actions Achieving Emissions Reductions

This chapter provides an update of already committed or pledged state, city, and business actions designed to reduce emissions, building on the set of initiatives documented in *America's Pledge Phase I Report,* released in 2017, and begins to quantify their impact on overall U.S. greenhouse emissions.[15]

The U.S. economy has grown as emissions have been decreasing (Figure 2-1); however, the effort can gain momentum only if more real economy actors embrace opportunities and adopt policies for deeper emissionsreductions. Fulfilling the full potential of the real economy, bottom-up action will require sustained and energetic action on these initiatives from states, cities, and businesses, as well as continued expansion and acceleration of decarbonization efforts.

Figure 2-1: Since 2005, the U.S.has Cut Emissions Even as the Economy Continues to Grow



Source: US EPA "Inventory of GHG Emissions and Sinks: 1990-2016"

This chapter does not detail every climate-friendly activity highlighted in the November 2017 *America's Pledge* report. Instead, we focus on a selection of actions with the highest emissions impact and estimate their current and projected emissions reduction through 2025. Within this chapter, we describe the impact of current, on-the-books policies and actions contributing to greenhouse gas (GHG) abatement. These *Current Measures* include both 1) existing actions that have been formally adopted by local and regional governments and are legally binding and 2) pledged actions that represent clearly defined intentions on the part of real economy actors but that are more aspirational in nature and non-binding. In the sector-specific sections that follow, a broad set of actions and commitments are presented using this categorization to help differentiate the scale and types of policies currently on the ground. The policy categorization, however, does not make assumptions about the likelihood of future implementation. More details on the decision criteria for the policies and actions included in this analysis and their categorization can be found in the report's *Technical Appendix*.

In this chapter, we account for the inherent overlap between the policies assessed within states, cities, and investments from businesses. However, analysis in this chapter does not control for cross-sectoral interactions—such as the impact of transportation electrification or building efficiency on the power sector. To address broader economy-wide interactions, the actions and impacts described in this chapter were input into the integrated analysis presented in Chapter 4, which quantifies their aggregated contribution to GHG emissions. Given this, the impacts described in this chapter are sector-specific and not necessarily 100 percent additive from one type of action to the next. The full details on methods and criteria behind the analysis contained within this section and throughout the report can be found in the *Technical Appendix*.

Sectoral Analysis of Current Actions in the Real Economy

Our 2017 report highlighted 30 state policies, 20 city policies, and 10 corporate policies that have proven to be successful in reducing U.S. GHG emissions. This 2018 report expands our analysis, covering a broader selection of economy-wide and sector-specific actions across all 50 states, cities representing metropolitan areas, and a broader set of businesses.[16]

GHG Reduction Targets

Just as national governments have adopted GHG reduction targets under the Paris Agreement, so too have many U.S. states, cities, and businesses. Twenty-one states have GHG reduction targets adopted under various authorities and with a range of target dates, enforceability, and level of ambition. (Twelve state targets were passed by state legislation; six are executive orders. Three state targets are non-codified goals publicly expressed by governors or included in state climate action plans.)[17]

Similarly, cities have the authority to create and implement their own climate policies, but cities' authority varies depending on state, county, and local statute; revenue sources and allocation; energy regulatory context; and government structure. Since the release of our November 2017 report, 18 additional cities have set quantifiable GHG targets, bringing the total to 142 cities. (This number includes only cities with community-wide GHG reduction goals. Many more cities are part of broader coalitions supporting climate action or have GHG reduction targets for specific sectors such as municipal buildings or commercial buildings.) In total, these states, cities, and counties represent more than 194 million Americans, have a combined GDP of nearly $12.5 trillion, and account for over 40 percent of U.S. GHG emissions (see Figure 2-1). Notably, these actors' share of national emissions is lower than their share of either population of GDP in large part because they have already begun the process of decarbonizing their economies. Their emissions reductions therefore represent a disproportionate share of the 12 percent reduction in U.S. emissions already achieved between 2005 and 2017.

In addition to state and local policies, businesses are similarly setting their own targets to reduce emissions across their operations. As discussed in the 2017 *America's Pledge* report, 1,361 businesses have made voluntary emissions reduction commitments, and a smaller group of corporations have set more ambitious science-based targets.[18] These science-based targets are in line with the reductions necessary to achieve the goals of the Paris Agreement, as discussed in Case Study One. Although a large and ever-growing number of corporate commitments to reduce emissions exist, our analysis focused specifically on 155 GHG reduction targets from businesses that report their progress and implementation plans to the nonprofit data platform CDP. Accounting for their U.S.-based GHG emissions footprint only, our analysis estimates that these

pledges alone, if fully implemented, would result in annual reductions of 26 million metric tons of carbon dioxide equivalent (Mt CO_2e) in 2025.[19] This relatively small sample size suggests that every six U.S. companies making such a commitment might reduce U.S. emissions by an additional million metric ton by 2025, on average, if a larger total number of companies were to engage. Notably, this report has not attempted to estimate such projections for companies not currently reporting to CDP. Furthermore, our analysis here does not account for other types of corporate commitments, such as the voluntary procurement of renewable energy or the management of global supply chains, which themselves present important emissions reduction opportunities for both domestic and multinational firms.

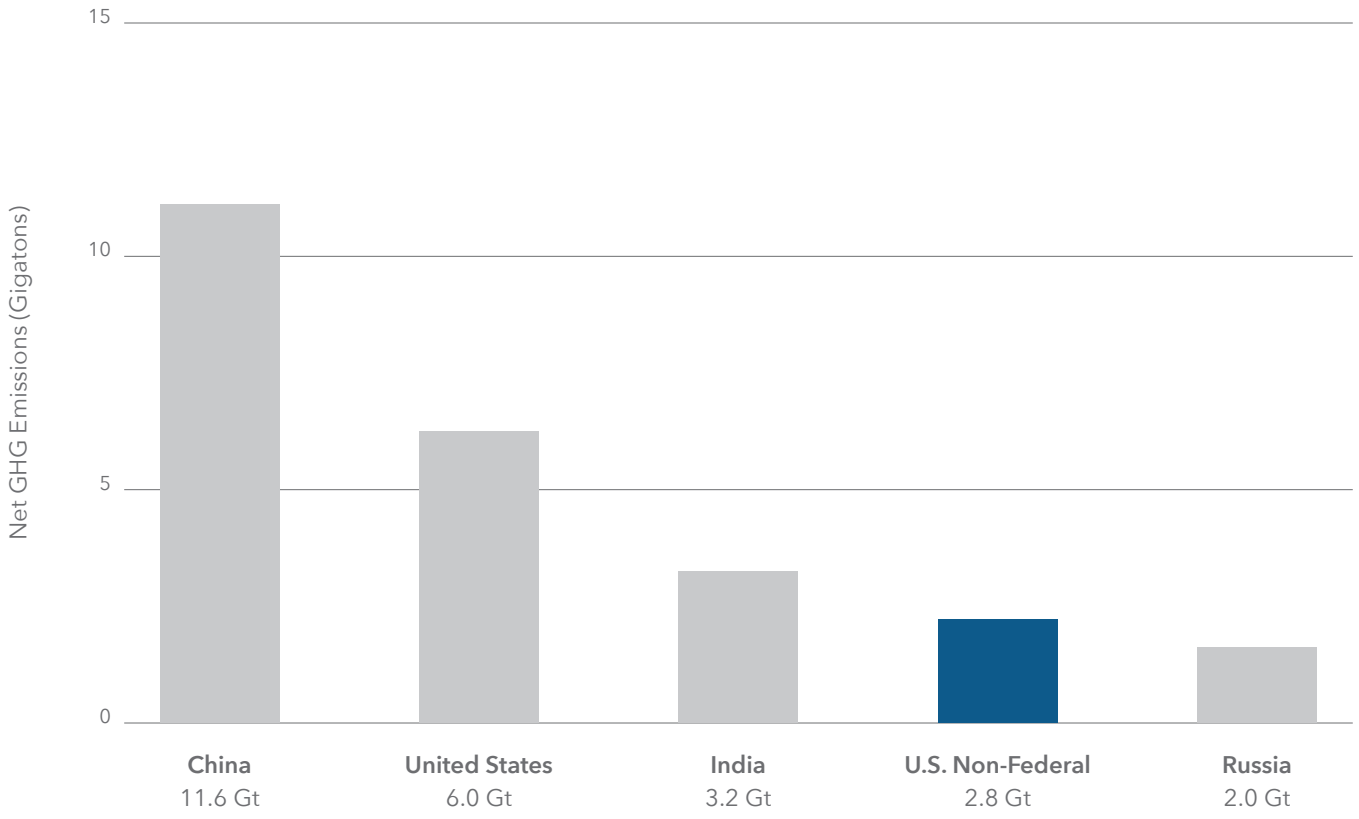
GHG reduction targets established by states and cities are important, but they are effective only if they have strong implementation plans (including monitoring, reporting, and verification) and are backed with binding policies, such as cap-and-trade, clean energy standards, methane standards, vehicle emissions mandates, and other policies covering the sectors discussed in forthcoming sections. Similarly, business pledges are effective only if they are supported by a management plan with concrete goals and timelines that have buy-in throughout leadership. Therefore, states, cities, and businesses need to report transparently on their commitments, receive support in achieving them, and be held accountable to deliver them. If states and cities were to reach these targets, we estimate that it would cut annual emissions by 500 Mt CO_2e from business-as-usual (BAU) levels in 2025—approximately 7.5 percent of 2005 net emissions. A similar analysis by New Climate Institute found that the combination of state, city, and business commitments, if fully implemented, could cut emissions by 360–560 Mt CO_2e in 2025.[20] To ensure our modeling is conservative, we have not included state, city, and corporate GHG targets in the *Current Measures* scenario unless they are backed by binding caps or policies, as in the case of California and the Regional Greenhouse Gas Initiative (RGGI).

21 States

142 Cities

1,361 Businesses

Figure 2-2: States, Cities, and Businesses Accounting for 40 Percent of U.S. GHGs Have Set Reduction Targets



Population (2018)
194 Million
59% of all Americans

Gross Domestic Product (2018)
$12.5 Trillion
63% of total U.S. GDP

GHG Emissions (2018)
2.8 GT
43% of U.S. GHG Emissions

CASE STUDY 01

"Science-Based Climate Targets" for Corporations

Corporations have a critical role to play in driving the transition to a low-carbon economy by tackling GHG emissions in their operations and value chains, driving demand for low-carbon solutions, and signaling to policymakers that greater ambition is possible. One way for corporations to engage meaningfully is to set science-based targets, which are defined as targets that are in line with the level of GHG reductions necessary to keep global temperature increases well below 2 degrees Celsius.

As of May 2018, 74 U.S. companies representing a combined market capitalization of over $2.6 trillion, including 19 companies ranked on the 2017 Fortune Global 500 list, have either set targets or committed to reduce emissions in line with a well below 2 degrees Celsius temperature goal through the Science Based Targets initiative (SBTi).[21] Driven by consumer interests, corporate social governance, and broader economic patterns, this trend is fast becoming a "new normal" in the way businesses operate, and momentum continues to grow; nearly 180 U.S.-based companies have reported to CDP that they intend to set a science-based target by 2019. As of May 2018, the U.S.-based companies that have committed to science-based targets are responsible for an estimated 2 billion metric tons of CO_2e emissions per year across their global operations and value chains, about 4 percent of total global greenhouse gas emissions.[22]

These targets provide a robust and meaningful framework upon which to base corporate climate strategies—helping companies build long-term business value, safeguard their future profitability, reduce regulatory uncertainty, and demonstrate to customers and employees their commitment to sustainability and innovation. For example, in the process of developing its science-based target, Kellogg Company decided to explore fuel cell technology, which is now being used to generate electricity at its waffle-making facility in San Jose, California. Even greater emissions reductions are possible if companies incorporate emissions from their entire value chain, including indirect emissions from electricity, in their targets.

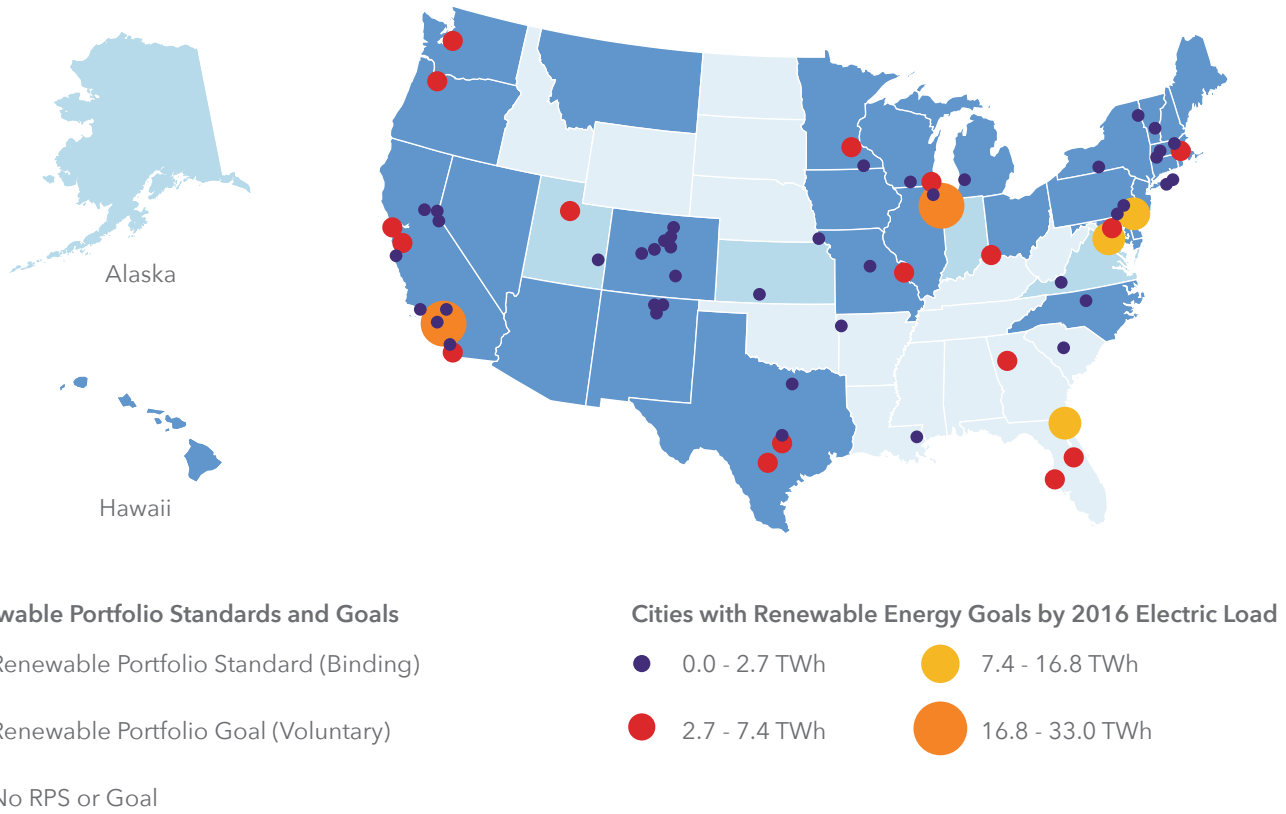
Power Sector

U.S. power sector carbon dioxide emissions have rapidly declined since 2010 after decades of growth.[23] By the end of 2017, annual emissions were 1,744 Mt CO_2e, a reduction of 670 Mt CO_2e, or 28 percent, from 2005 levels and equivalent to taking more than half of all cars off America's roads.[24] This decline is attributable to a combination of policy and market forces. Gains in energy efficiency driven by a variety of policy and market forces have lowered expected growth in demand.

The carbon intensity of the average kilowatt-hour (kWh) of electricity produced in the United States has also declined. Aging of the coal fleet, the Mercury and Air Toxics Standards and other federal public health regulations, and cheaper natural gas led to 15 percent of the U.S. coal fleet retiring between 2006 and 2016.[25] Scaled-up clean energy generation has been an additional influential factor in this trend by providing an alternative as uneconomical fossil fuel units are removed from the grid.[26] By the same token, clean energy options are driving down the demand for (and hence the future economic viability of) coal units that have not yet been retired. In fact, a 2018 retrospective analysis demonstrated that renewable generation between 2007 and 2013 was responsible for nearly a third of the overall 10 percent reduction in U.S. energy-related CO_2 emissions.[27] Increasing availability of renewables is also diminishing the percentage of retired coal that is replaced by natural gas, which has its own substantial global warming footprint.

States, cities, and businesses have undertaken an expanding array of activities to increase clean electricity and cut power-sector emissions. Of these, as previously highlighted in the 2017 *America's Pledge* report, state renewable portfolio standards (RPS) have been most influential in promoting clean energy generation. In 2016, over half of all

Figure 2-3: States and Cities across the U.S. Have Adopted Clean Energy Targets and Goals



Source: American Council for an Energy-Efficient Economy; Lawrence Berkeley National Laboratory; World Resources Institute

non-hydroelectric renewable generation in the United States supplied the RPS market, demonstrating that these policies are creating the demand for investors to install more wind turbines and solar panels in the 29 states (and Washington, D.C.) with RPS mandates.[28] Notably in 2015, Hawaii enacted a bold policy of achieving 100 percent renewable energy by 2045.

Beyond cutting carbon pollution, RPS policies have significant co-benefits. One analysis finds that they have resulted in $5.6 billion in annual health and environmental benefits due to reductions in criteria air pollutants such as SO_2, NO_x, and particulate matter.[29] Other co-benefits include annual savings in water consumption of 27 billion gallons, including in more water-stressed regions such as Texas and California.[30] Finally, a 2017 analysis found that over 250,000 Americans work in the solar power industry, an increase of 168 percent since 2010.[31]

Cities and businesses are also accelerating clean energy deployment by aggregating demand for solar and wind power. More than 80 cities and counties have adopted 100 percent renewable goals (Figure 2-3)—nearly double the number of cities that had committed to this target a year ago.[32] Including Hawaii, jurisdictions pledging to achieve 100 percent renewable energy cover a population of 10.3 million (roughly 3 percent of the U.S. population). In addition, 125 companies with a reported emissions footprint in the United States have adopted goals to either produce or source their electricity from renewables through mechanisms such as power purchase agreements (PPAs), on-site solar, and renewable energy certificates (RECs) purchases.[33]

Our analysis quantifies impact and accounts for overlap across the 29 existing state RPS policies, additional non-binding state pledges, and 104 city-level pledges. Together, these actions can push policy-driven demand for non-hydroelectric renewable energy (i.e., the electricity needed to meet city and state targets only) to over 500 terawatt-hours (TWh) annually by 2025, the equivalent of powering 56 million homes in a year (Figure 2-4).[34] However, additional targets not included in this figure—such as those from corporate actors, counties, and utilities—have the potential to further increase renewable generation in the years to come. For example, current commitments from the 44 U.S.-based RE100 companies could result in an additional 43 TWh of renewable

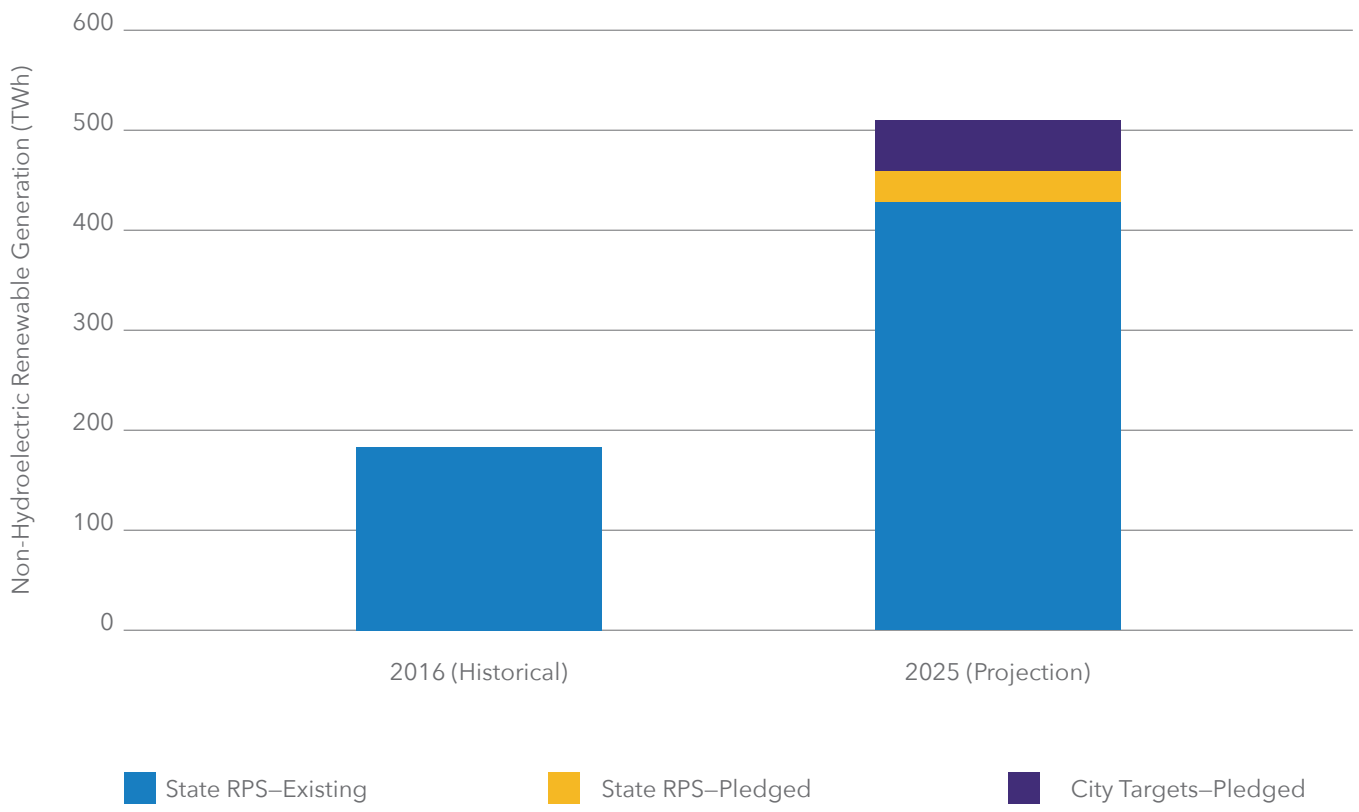
Photo by Dennis Schroeder

State, city, and business clean energy goals can

increase demand for clean energy to over 500 TWh annually by 2025

—enough to power 56 million homes for a year

Figure 2-4: By 2025, State Clean Energy Policies are Projected to Deploy Enough Renewable Generation to Power 56 Million Homes



Source: ATHENA modeling outputs

energy if fully achieved. Such targets may naturally overlap with the goals of cities and states. While they are not modeled in this report, we acknowledge the vital role they will play in helping to reinforce or even drive past the decarbonization measured in this analysis.[35]

Not all renewable generation is driven by the type of explicit policy demand estimated above. Market forces, including falling per-kWh generation costs for wind and solar, mean that a substantial share of renewable capacity will be added to the grid irrespective of top-down goals. In addition, certain types of state actions, such as investment in transmission infrastructure and relaxed siting laws for wind farms, can result in significant shares of increased renewable generation that may not be captured in estimates of RPS demand. In 2016, an estimated 54 percent of non-hydroelectric generation fed into state RPS programs. Voluntary markets—which includes demand from utility green tariff programs and power purchase agreements designed to meet corporate and city demand—represented another 28 percent of renewable energy sales (excluding large-scale hydro) in the same year.[36] These figures indicate that although total future generation will undoubtedly exceed the aggregate demand of non-federal actors– intentional clean energy demand plays a clear role in shaping the market and driving the building-out of new capacity.

At the same time, the reality that climate policy resistant jurisdictions like Oklahoma and Kansas are also among the leaders of renewables deployment signals that the market drives another large segment of renewables demand. Thus, while this section has focused on current policy measures and does not include estimates of projected non-policy or market-based generation occurring in the United States, estimates in the following chapter, as well as the modeling results included in Chapter 4, deal more holistically with the full potential of the U.S. power sector.

CASE STUDY 02

Breaking Barriers to Renewable Energy in Electric Markets

Renewable portfolio standards (RPS) have been a core driver in the shift to renewables, but they are not the only policies that state leaders have at their disposal. State regulators, such as public utility commissions (PUCs), are influential in managing electricity markets and have the opportunity to promote smart rate structures and procurement policies that drive deployment of clean energy and lower prices for consumers. PUCs can also ensure that beneficial low- and zero-carbon generation is deployed by utilities by requiring infrastructure projects to account for either the social cost of carbon or the social cost of abatement. For example, Minnesota requires power companies to evaluate all future investments against the broader social cost of climate change. In general, renewables are often the most cost-effective option. Minnesota's wind industry is at cost parity with natural gas even without subsidies, ranks eighth in the country in terms of generation, and has positioned the state to surpass its existing RPS target a few years ahead of schedule.[37]

States are unlocking potential for large and small consumers to drive greater clean energy deployment on their own initiative by allowing retail choice and community choice aggregation (CCA). To date, seven states (California, Illinois, Massachusetts, New Jersey, New York, Ohio, and Rhode Island) have adopted CCA and another four are considering it. According to analysis by the National Renewable Energy Laboratory, voluntary purchases account for about one-third of total renewable purchases to date, making them an important driver of continued growth.[38] CCA programs sold 7.4 TWh of renewable energy to 1.9 million customers in 2015, enough to power half a million homes for a year.[39]

Large corporate entities are making investments in renewables. More than 100 large companies—including Citi, GM, Johnson & Johnson, Google, and Walmart—have pledged to use 100 percent renewable energy, and many other companies have committed to other renewable energy targets.[40] In 2017 alone, large corporate buyers announced the purchase of 2.78 gigawatts of renewable energy, more than enough to power the state of Rhode Island, marking a 70 percent increase over 2016.[41] Similarly, public utilities in a number of states, including West Virginia, have committed to move toward cleaner generation sources in response to pressures from their customers.[42]

Photo by Dennis Schroeder / NREL

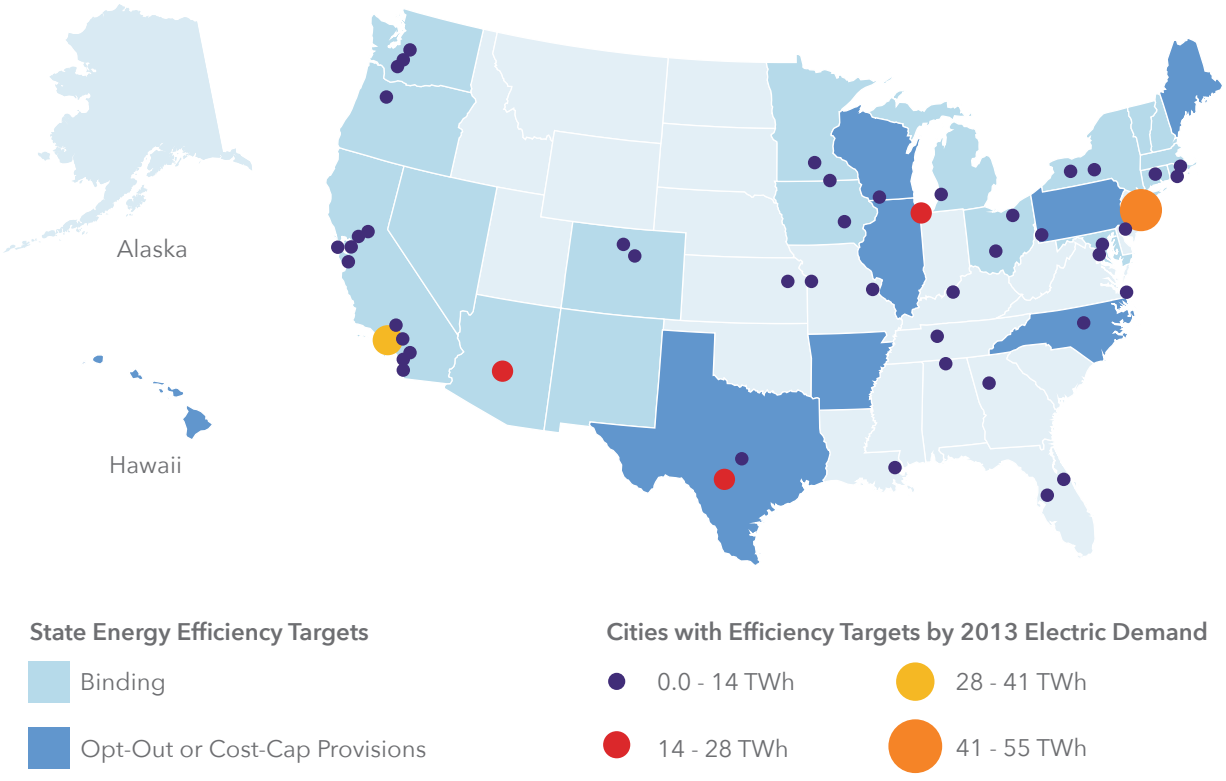
Residential and Commercial Building Energy Use

Residential and commercial building sectors contribute to GHG emissions both directly, through the use of fuels for heating, and indirectly, through the use of electricity. Because much residential and commercial energy use is electrified (e.g., lighting and appliances), this sector closely interacts with the power sector. For example, energy efficiency in the building sector can reduce demand, and hence lessen GHG emissions in the electric sector. Similarly, promoting electrification of end uses—heat pumps, for example—can typically eliminate direct emissions from the use of natural gas and petroleum for heating, hot water, and cooking.

The energy intensity of U.S. residential and commercial sectors has decreased steadily since 1970 as a result of federal, state, and city policies and programs.[43] These include appliance and equipment efficiency standards, building codes, energy efficiency targets, utility regulatory reforms, consumer awareness programs, tax incentives, and other programs.[44] Efficiency measures are one of the most common (and most varied) types of climate actions that real economy actors may implement. At the state level, the analysis of current commitments focuses on energy efficiency resource standards (EERS), a policy that establishes energy savings targets that electricity utilities are required to meet (See Figure 2-5). Twenty-six states have enacted EERS policies, which are typically established through state legislation and refined by PUC rulemaking.[45] Nineteen states have binding EERS, and seven states set a cost cap or allow certain groups of customers to opt out of the program. Sixteen of the 19 also have EERS policies for natural gas utilities. In recent years, a number of states have increased their EERS targets; for example, California, Illinois, Maryland, Michigan, Nevada, New Hampshire, and New York have all set new targets since 2015.[46]

EERS have been demonstrated to improve efficiency and reduce GHG emissions while saving consumers money. In 2016, states with EERS achieved annual electricity savings of 1.2 percent of total electricity sold, compared with 0.3 percent in states without EERS.[47] The savings resulting from state efficiency programs totaled 220 TWh in 2016.[48] An EERS policy is also often paired with complementary policies such as performance incentives or penalty mechanisms to further spur utilities to meet targets. In Case Study Three, we show how utilities can use a range of customer programs to deliver energy savings through EERS.[49]

Figure 2-5: 26 States and 56 of the Largest Cities in the U.S. have set Energy Efficiency Targets



Sources: American Council for an Energy-Efficient Economy and World Resources Institute

Note: This includes Seattle and New York which do not have specific energy efficiency targets but have GHG targets that will include energy efficiency measures

Cities are implementing a wide range of actions that will help utilities meet the state-level EERS goals or have adopted a range of measures on their own to achieve their own energy efficiency targets. Of the 285 most populous U.S. cities, 56 have targets to explicitly reduce energy consumption from residential, commercial, industrial, and/or municipal buildings (see Figure 2-4). These targets are impactful and achievable. But they are only a small portion of the toolkit available to cities to implement efficiency gains, which can work in alignment with, but also in the absence of, top-down targets. These include providing incentives and financing for efficient buildings, setting green building standards and adopting the highest-performance building codes, requiring energy audits, undertaking retrofits, and setting benchmarking and transparency (B&T) standards.[50] These added incentives have proven to be successful. For instance, as discussed in Case Study Four, after Washington, D.C., required commercial and multifamily buildings over 50,000 square feet and municipal buildings over 10,000 square feet to benchmark and report energy use data, these buildings reduced their energy use by almost 6 percent, on average.

Our analysis finds that combined, existing state EERS policies along with city-level goals could achieve over 200 TWh in electricity savings by 2025 after accounting for overlap, or nearly 5 percent of projected electricity demand in the same year. This estimate includes the 26 state-level EERS standards (both binding and non-binding, pledged standards), as well as community-wide targets in 36 cities with a population greater than 100,000.[51] Owing to modeling limitations, this estimate does not capture the full range of efficiency measures currently taking place at the city level, but rather represents a quantifiable subset.[52]

Although these measures are significant, it is notable that only six of the 25 states examined in this analysis have already extended their EERS policies post-2020.[53] Between expanding and extending EERS policies and advancing building and appliance standards, states, cities, and businesses can do far more to drive emissions reductions from improvements in energy efficiency, as discussed in Chapter 3.

CASE STUDY 03

Energy Efficiency Resource Standards in Arkansas

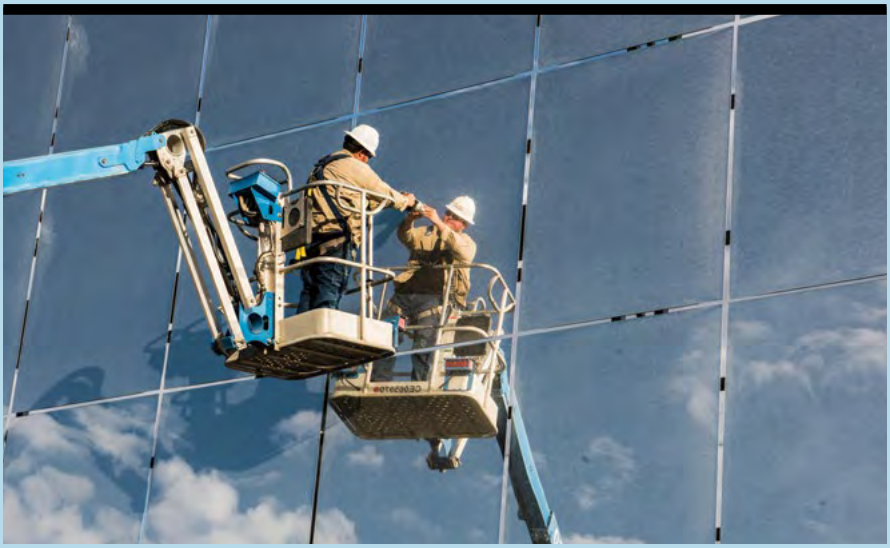
Arkansas is the only state in the Southeast with an EERS, which was first established in 2007, requiring electric and natural gas utilities to propose and administer energy efficiency programs. Arkansas's energy savings targets started out low, initially requiring utilities to reduce annual electricity use by 0.25 percent with respect to sales, ramping up to 0.75 percent in 2013.[54] Natural gas reduction targets were set at 0.2 percent in 2011, increasing to 0.4 percent in 2013. The Arkansas Public Service Commission has strengthened these goals with 1.0 percent reductions to take effect in 2019.

The gradual and deliberate approach to evolving utility programs has allowed Arkansas to achieve and build upon early successes to garner increasing support for energy efficiency. For example, in 2008 the home energy efficiency services market in the state did not yet exist. Utilities worked to improve their understanding of the scope of recruiting and training resources needed and focused on building partnerships with contractors. A significant factor in the success of many of the programs has been ongoing classroom and field training for contractors undertaken in coordination with trade allies and regional technical colleges. Through careful monitoring of program results with the help of a third-party evaluator, utilities have been able to make a variety of adjustments over time to improve program effectiveness. These have included the gradual addition of new measure offerings, such as incentives for heat pump water heaters, behavioral benchmarking through home energy reports, and measures targeting multifamily property. Other refinements have included making programs easier for customers to access, studying new technologies, and making more concerted efforts to reach certain customer segments that might have more difficulty accessing utility efficiency programs.

Taken together, Arkansas electric utilities have increased energy savings more than fivefold over the past decade through these programs, raising savings from 60,000 megawatt-hours (MWh) in 2009 to more than 300,000 MWh in 2016, or enough to power more than 28,000 homes for a year.[55] Through these efforts, Arkansas has emerged as a Southeast energy efficiency leader, and an example to its neighbors of the diverse benefits achievable when a state and its utilities come together to value and pursue efficiency as an energy resource on the same level as other fuel sources.

According to the American Council for an Energy-Efficient Economy (ACEEE), if states were to continue to meet savings targets and legislators and regulators were to extend expiring targets in the years leading up to 2020, the combined annual electricity savings from the 26 states with EERS policies would be equivalent to 6.2 percent of overall electricity sales in the United States in 2020.[56] As noted below, existing policies and pledges described in our *Current Measures* scenario, which accounts for standards that could expire, are expected to reduce annual electricity demand by as much as 200 TWh by 2025.

Photo by Rachel Renaud



CASE STUDY 04

Benchmarking and Transparency Policies for Buildings

Buildings account for about 50 percent of carbon dioxide emissions from cities (including indirect emissions from electricity use); in some large cities, the portion could be as much as 75 percent.[57] However, given the variety of buildings, including their age, use, and ownership, it has been difficult to achieve this sector's full energy savings potential.

To better incentivize building efficiency improvements, cities have adopted new innovative benchmarking and transparency (B&T) policies that improve knowledge of energy use and aid in planning and implementing energy-saving measures. By increasing building owners' understanding of their asset's energy performance, these policies create market value for energy-efficient buildings.

Most B&T policies set by local officials call for property owners of large buildings—typically commercial and/or multifamily buildings—to benchmark their buildings' energy using ENERGY STAR® Portfolio Manager, through which building owners can understand how much energy their buildings are using in relation to buildings of a similar type and size in a similar climate. B&T policies also generally call for owners to disclose their annual energy consumption to local governments on a regular basis.

These policies have gained traction across the United States. As of December 2017, 26 municipalities, including many of the largest, had a B&T policy for public, commercial, and/or multifamily buildings.[58] Nearly 10 percent of the U.S. population across 17 states lives in a municipality with a B&T policy.[59]

In 2008, Washington, D.C., adopted the Clean and Affordable Energy Act of 2008 (CAEA). The CAEA amended the city's Green Building Act of 2006 and required that owners of commercial and multifamily buildings over 50,000 square feet benchmark their energy use annually and share that data with the

Photo by Dennis Schroeder / NREL

city for public release. The law also required that the city annually benchmark its own buildings that are greater than 10,000 square feet and report results to the public.[60] After a multiyear stakeholder process, local electric and gas utilities provided building owners with the whole-building aggregated energy data that was necessary to comply with CAEA. Washington, D.C., also adopted legislation requiring utilities to provide this data in 2014.[61]

Washington, D.C., commissioned a third-party evaluation of benchmarking data submitted voluntarily between 2009 and 2012 by a sample of office property owners. Although it was not representative of all district buildings, the analysis revealed that energy use in these benchmarked buildings decreased by 5.8 percent (124 billion Btu) and led to carbon emissions reduction of 5.2 percent (13.8 thousand Mt CO_2e). The average ENERGY STAR score for these buildings also increased from 73 to 81.[62] Recently the city used reported benchmarking data along with data obtained from partners to model potential greenhouse gas emissions reductions from lowering the energy use of buildings. Compared with a BAU scenario, the plan's building-related actions are forecast to reduce 11.8 percent of community-wide greenhouse gas emissions by 2032. These actions account for more than a quarter of the city's anticipated greenhouse gas emissions reductions.[63]

If the 26 municipalities with policies experienced a 5 percent energy savings due to their benchmarking policies, it would avoid nearly 5 Mt CO_2e and save over 35 million MMBtu.[64] The impact is even clearer when looking at the potential effect if the largest cities in the United States' largest metro regions pursued benchmarking. If these cities adopted a policy that saved 5 percent of large building energy, it would avoid 8.8 Mt CO_2e—roughly equivalent to the CO_2 emissions from 950,000 homes' energy use in a year—and nearly 60 million MMBtu.[65]

Transportation Sector

The transportation sector accounts for nearly a third of net annual emissions in the United States. In 2016, it surpassed the power sector to become the largest sectoral source of emissions.[66] Within the transportation sector, passenger cars, light-duty trucks, and medium- and heavy-duty trucks are, by a substantial margin, the largest sources of GHG emissions (though ships, aircraft, and rail transport also emit significant levels of greenhouse gases).[67] Transportation emissions declined during the 2008–12 period but have started to increase again as low gasoline prices, increasing vehicle sizes, and expanding economic activity outpace efficiency gains from federal fuel economy standards.

In 2010, the Obama Administration worked with the State of California and the auto industry to begin the process of establishing new fuel economy and GHG standards. These were projected to achieve a fleetwide fuel economy average of 54 mpg by 2025 and were projected to reduce climate pollution by a cumulative 6 billion metric tons of carbon dioxide—equal to a year's worth of emissions for the entire United States.[68] However, the Trump Administration is moving to dismantle or roll back these standards for model years 2021 through 2025,[69] despite public, state, and industry resistance to such a move.[70] States, cities, and businesses are playing a crucial role in defending these standards, challenging the administration's attempts to place corporate profits over public health and consumer savings. They can also act independently of federal rules. For instance, California has the authority (granted through a waiver by the EPA) to set its own air emissions standards for motor vehicles, provided they are more stringent than federal standards.[71] Other states with air pollution problems can adopt California's standards (13 states already have, and Colorado has an executive order in place and is developing a rule that would make it the 14th).[72] In early May 2018, California led an 18-state coalition (representing over 40 percent of the U.S. car market) to sue the EPA to preserve the nation's light-duty vehicle emissions standard.[73]

States and cities are enacting policies in addition to GHG emissions standards. Two states—California and Oregon—have low-carbon fuel standards (LCFS), which require fuel suppliers to reduce the carbon intensity of fuels at all points through the fuel supply chain.[74] California's standard requires a 10 percent reduction in the carbon intensity of transportation fuels sold into California markets by 2020 and 20 percent by 2030.[75] LCFS promote alternatives such as electric vehicles, hydrogen vehicles, and carbon-beneficial forms of biofuels, and if a number of states copied California and Oregon, the fuels market might change quite dramatically in the coming years.

States and cities are promoting zero-emissions vehicles (ZEVs) through a range of actions, including statewide ZEV regulations and government fleet procurement goals.

California's ZEV policy requires vehicle manufacturers to produce an increasing number of light-duty ZEVs through the year 2025.[76] In January 2018, California set a goal of having 5 million ZEVs on the road by 2030 and identified a number of actions to help it achieve that goal.[77] Nine other states have joined California in a ZEV program requiring automakers to sell electric cars and trucks: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. These states, with the exception of Maine, are also part of a Memorandum of Understanding that commits the states to coordinating actions to ensure successful implementations of programs that support ZEV adoption in each state.[78] It is expected that the ZEVs will account for approximately 15 percent of new vehicle sales in these states by 2025 in part due to these regulations.[79] This analysis suggests that this would likely lead to approximately 4 million new ZEVs on the road by 2025, with annual sales reaching 1.2 million by 2025 (Figure 2-6).

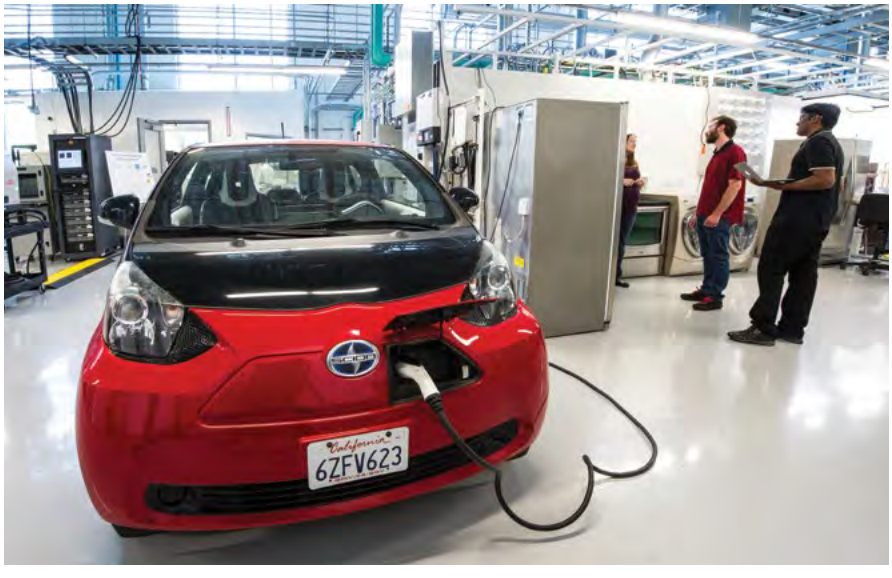
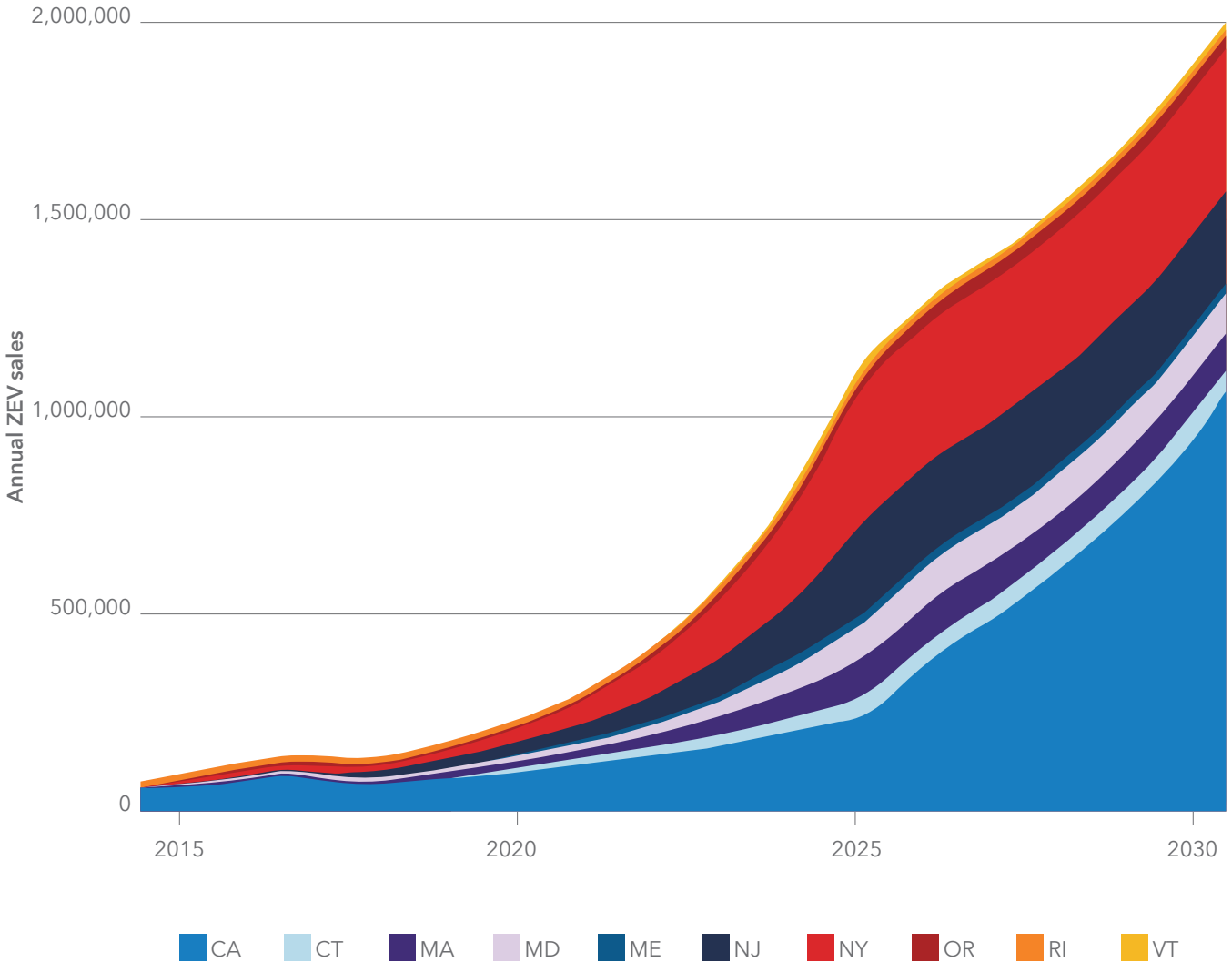


Photo: U.S. Department of Energy, 298 031 005

Figure 2-6: State ZEVR Targets Increase Steadily with Annual EV Sales Reaching a Projected 1.2 Million Vehicles in 2025 and Growing to 2 Million by 2030



Source: ATHENA modeling outputs.

Five states (California, Illinois, Maryland, Rhode Island, and Vermont) have fleet procurement goals that are aimed at increasing the number of ZEVs owned and managed by the state government.[80] Fleet procurement creates a reliable demand for electric vehicles, which in turn helps EV technologies achieve economies of scale. At least 34 out of the 285 most populous U.S. cities have goals to procure alternative fuel vehicles (AFVs) such as hybrids, electric plug-in vehicles, and vehicles that run on biodiesel or renewable natural gas that can lower the emissions of city-owned buses, cars, and trucks. Our analysis specifically included eight goals from major U.S. cities (Atlanta; Austin, Texas; Chicago; Denver; Indianapolis; Los Angeles; New York; and Portland, Oregon) to procure light-duty ZEVs for their municipal fleets, as well as electric bus procurement targets in Madison, Wisconsin; Los Angeles; and New York. Taken together, these fleet procurement goals will promote investment in advanced vehicle technology including developing efficient batteries for buses that could have applications in other transportation subsectors (e.g., other medium-and heavy-duty vehicles).[81]

Finally, real economy actors are promoting sustainability and working to reduce emissions by cutting the total number of miles that citizens drive each year. Vehicle miles traveled (VMT) have been increasing since 1990 (after a brief plateau following the recession in 2008, growth has picked back up again).[82] Strategies that involve mode-shifting—encouraging people to use public transit, bike, or walk—will not only decrease air pollutants from vehicle emissions but also improve human health through physical activity and reduce the incidence of motor vehicle accidents.[83] Three states (California, Vermont, and Washington) have targets to reduce VMT explicitly, and 32 cities (out of the 285 most populous in the United States) have goals to reduce VMT either directly or indirectly through the promotion of non-automobile modes of transportation.

Despite the importance of VMT-related policies, the direct impact of these policies is difficult to measure, owing to the long lead times for the interventions to take effect and the complexity of estimating more indirect goals to shift traffic patterns. Our analysis—which focuses more narrowly on the three current state-level targets and quantifiable goals from 15 cities (including Boston; Los Angeles; Louisville, Kentucky; Pittsburgh; Portland, Oregon; San Antonio; and Seattle)[84]—finds that if these targets alone are achieved, annual VMT would fall by over 36 billion miles compared with BAU projections. Case Study Five, featuring mechanisms used to motivate behavior change designed to reduce VMT in Portland, Oregon, shows how such actions could have multiple benefits. Finally, although these actions are undoubtedly significant, broader adoption of such strategies could have much greater impact on the total number of miles driven by Americans.

CASE STUDY 05

Developing Low-VMT Planning in Portland, Oregon

In the 1990s, the Portland metro area adopted a comprehensive system-wide approach guiding transportation policy. The Transportation Planning Rule requires transportation and land use planning to be explicitly linked with the ultimate goal of reducing the community's reliance on automobiles.

Portland's Transportation System Plan (TSP), which guides transportation investments, contains mode share targets aimed at increasing the percentage of trips taken using non-automobile modes of transportation. Out of 51 of the largest cities in the United States, 25 have some sort of mode share target.[85] By 2014, residents of the Portland metro area were driving 14 percent fewer miles per capita than they had 20 years earlier, compared with other metro areas in the United States, where driving rates increased by 8 percent on average in that time. Portland also tops U.S. cities for bicycle commuting and scored the highest in ACEEE's 2017 City Energy Efficiency Scorecard for transportation.[86] Between 1994 and 2011, the Portland region also saw a reduction in drive-alone mode share of approximately 4 percent, while the VMT fell by 7 percent in the region.

If Portland were to achieve a combined drive-alone and carpool 2035 target of 42.5 percent by 2035, the city could save a cumulative 47 million gallons of gasoline, or 422,000 metric tons of CO_2, by 2035. However, there is potential for greater energy savings from a combined package of strategies and interactions between approaches in addition to multimodal targets. Other city, regional, and state policies that can support further ambition include the city's Urban Growth Boundary policy, which encourages the creation of denser communities with access to multiple modes of transportation, and investment in infrastructure that supports walking and biking.

If the 24 other cities in ACEEE's 2017 City Energy Efficiency Scorecard with mode share targets were to strive for the same reductions in single-occupancy drives and carpool rides as Portland by 2035, the amount of gasoline saved would increase to 1.3 billion gallons, or 11,505,000 metric tons of CO_2.

Hydrofluorocarbons

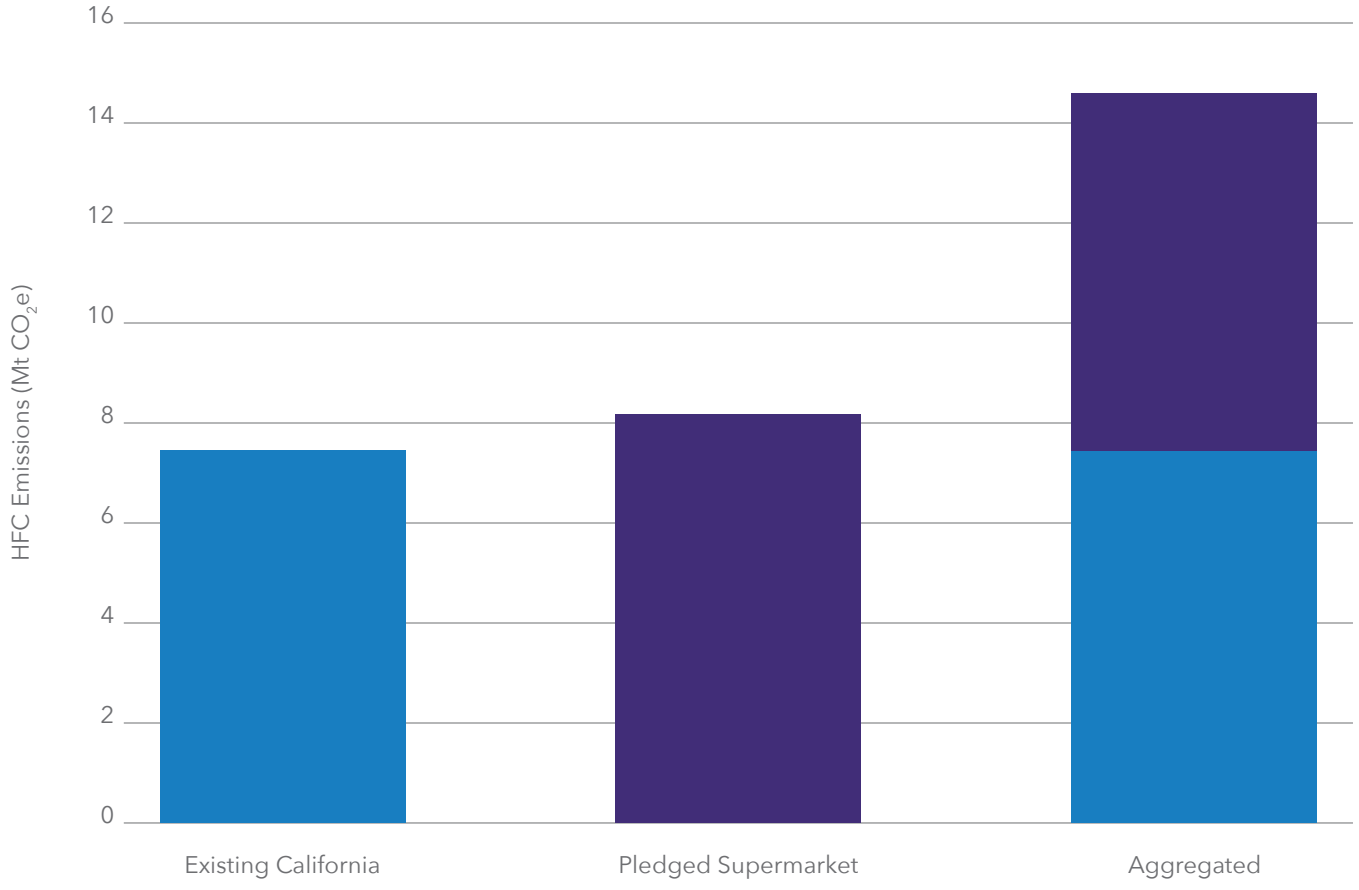
Hydrofluorocarbons (HFCs), chemicals commonly used in industrial applications including air conditioning, refrigeration, insulation, aerosol propellants, and flame retardants, remain a significant threat to the goal of keeping global warming well below 2 degrees Celsius. Although HFCs make up a relatively low percentage of emissions by volume, they are up to 12,000 times more potent a greenhouse gas than carbon dioxide. Without immediate regulatory action, HFC emissions are projected to grow rapidly in the coming decades. The parties to the Montreal Protocol, the international treaty originally established to address ozone-depleting substances, agreed to the landmark Kigali Amendment in October 2016. This amendment calls for a global phasedown of HFCs starting in 2019 and has a strong backing from industry. Developed countries are to begin ramping down production and consumption starting in 2019–20, with an 85 percent total reduction achieved by 2036.[87] Developing countries are required to freeze their HFC production by 2024, with an 80–85 percent reduction achieved in the mid-2040s. In keeping with this international ambition, the EPA originally sought to phase down HFCs for certain uses; however, these restrictions on HFCs have been partially blocked by courts.[88] This ruling is currently being challenged by a coalition of industry and nonprofit groups. Meanwhile, the Trump Administration's EPA has issued new guidance that further dismantles restrictions on HFC production and use. This rollback is also facing legal challenges from NGOs and states.[89]

While federal efforts are stalled, states, cities, and businesses are moving forward with their own actions, most recently with the commitment by the U.S. Climate Alliance—a coalition of states representing approximately 30 percent of U.S. HFC emissions—to phase down HFCs along with other short-lived climate pollutants.[90] In 2011, California established the first regulations addressing HFCs (including the Refrigerant Management Program [RMP]), requiring leak inspections, registration, and reporting to the Air Resources Board. [91] In March 2018,

Existing state, city, and business initiatives could cut HFC emissions by

6% from 2015 levels by 2025

Figure 2-7: State and Corporate Actions Designed to Reduce HFC Emissions Are Projected to Cut Emissions by 15 Mt CO_2e in 2025



Source: ATHENA modeling outputs.

Note: Figure relies on a potentially conservative estimate of BAU HFC emissions. Given the uncertainty of future HFC emissions, the abatement impact of non-federal actions may be larger than represented in this figure. More information on baseline projections used in this analysis can be found in this report's technical appendix.

California adopted regulations requiring a 40 percent reduction in HFC emissions below 2013 levels by 2030. California's guidance is also broadly consistent with the EPA's original rules that were vacated, thus creating a backstop against current federal inaction.[92] Together California's RMP and 2018 regulations are projected to significantly cut HFC pollution. The RMP is estimated to avoid 5 Mt CO_2e each year, and the 2018 regulations are projected to reduce emissions by 13.2 Mt CO_2e in 2030 compared with BAU.[93]

Businesses, including large supermarkets, are also taking action by signing voluntary agreements to reduce their HFC impact (Figure 2-7). According to the EPA, the average U.S. supermarket emits over 1,500 Mt CO_2e annually as a result of refrigerant leakage, equating to a leakage rate of about 25 percent.[94] Through the EPA's GreenChill program, 43 supermarket chains have committed to reducing their HFC emissions. This represents over 10,000 individual stores or about 28 percent of all stores in the United States.[95] GreenChill partners have, on average, reduced their leakage rate about 44 percent compared with a typical supermarket.[96] As of March 2018, 215 stores were certified as having achieved even greater emissions reductions. These stores have taken a wide range of actions to reduce their emissions, including addressing leaks, upgrading equipment, and switching to refrigerants with lower global warming potential (GWP).

Oil and Gas Methane Emissions

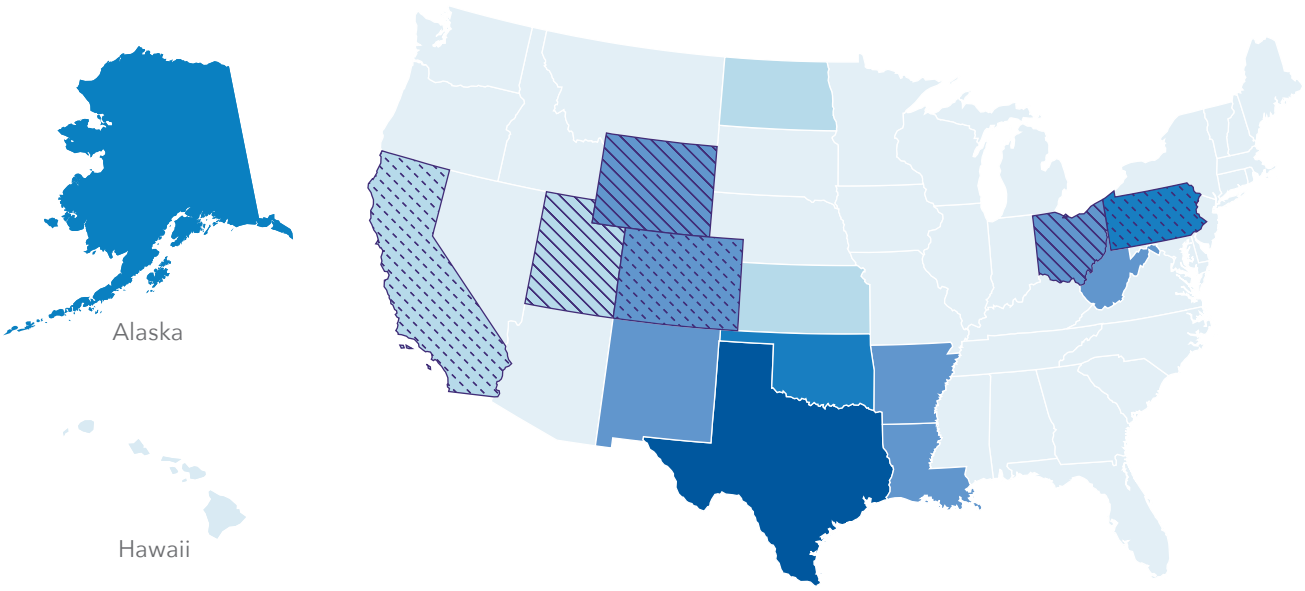
Oil and natural gas systems leak large amounts of methane to the atmosphere throughout the entire supply chain, from well site to end-user, due to poor extraction practices, aging infrastructure, and leaky components. In 2016, methane emissions from oil and gas systems reached roughly 200 Mt CO_2e (about 4 percent of total U.S. GHG emissions).[97] As the United States continues to increase its oil and gas production, methane emissions will grow.[98] Moreover, a 2018 peer-reviewed analysis found emissions to be 60 percent higher than the EPA's official estimate, suggesting that the real numbers are much larger, and underscoring the urgency in addressing these sources.[99] Notably, the numbers used in this report are based on official EPA estimates, so the real-world benefits of methane emissions reduction efforts are likely to be significantly greater than estimated herein.

Under the Obama Administration, the federal government enacted performance standards to reduce methane and other harmful air pollution from new oil and gas production and processing equipment.[100] While the Trump Administration is seeking to roll back federal standards, a coalition of states have sued successfully to keep these rules on the books.[101]

Yet states do not have to wait for federal standards to take effect, nor are they prevented from adopting more ambitious policies on their own. Colorado was the first state to establish methane pollution standards, in 2014, and California followed suit by adopting similarly rigorous standards in 2017. These state-level standards go beyond federal standards by covering not only new and upgraded equipment, but also existing, high-emitting sources, and thus are particularly impactful in the near term. They require operators to conduct periodic reviews of equipment to catch and repair methane leaks (referred to as Leak Detection and Repair [LDAR]). Moreover, the list of states with oil and gas pollution standards is growing, with New Mexico, Ohio, Pennsylvania, Utah, and Wyoming in the process of adopting or expanding commonsense standards and monitoring requirements that will further reduce these emissions (Figure 2-8).[98] If successfully implemented, these rules will not only reduce methane emissions, but also reduce smog-forming pollution, thereby improving public health while creating jobs and preventing revenue losses.

Beyond mandatory policies, natural gas producers and distributors have adopted voluntary measures through the EPA's Natural Gas STAR program. The program currently is composed of 105 domestic corporate partners

Figure 2-8: Some of the Highest Oil and Gas Producing States have Enacted Policies to Address Methane Leaks but Significant Opportunities Remain



Source: World Resources Institute, Environmental Defense Fund, Energy Information Administration

and 25 international partners making commitments across the natural gas supply chain that have avoided an estimated 15 Mt CO_2e of potential CH_4 emissions annually (average of 2012–16 reported reductions).[102]

Taken together, we estimate that current state policies and corporate actions will yield a national reducton in oil and gas methane emissions of 17 percent, relative to 2005 levels, by 2025.[103] This estimate includes the projected impact of standards that will lower methane emissions in California, Colorado, New Mexico, Ohio, Pennsylvania, Utah, and Wyoming, and assumes maintained ambition of voluntary measures based on historical EPA reporting. Although these figures are significant, more will need to be done to bend the curve and avoid a net increase in national emissions from increased oil and gas production. Recent scientific evidence shows that emissions from this sector may be significantly underestimated, suggesting that the potential for abatement—and necessity of further action—may in fact be much greater.[104] Additional priority policies and programs for oil and gas emissions will be discussed in Chapter 3.

Current state policies and corporate actions to address fugitive methane leaks could cut emissions from national oil and gas operations by

17% from 2005 levels by 2025

Landfill and Wastewater Methane

Landfills and wastewater treatment were responsible for approximately 123 Mt CO_2e of methane emissions (about 2 percent of total national GHG emissions) in 2016.[105] This methane is generated when organic materials decompose in the absence of oxygen. Rather than winding up in the atmosphere as potent GHGs, these emissions can be captured as a source of renewable natural gas (RNG) to be used for power generation, heating, and vehicle fuel.[106] Combustion of RNG for such uses can result in net GHG reductions on a life-cycle basis, particularly if the gas would not otherwise have been captured or flared, is transported efficiently (without leakage), and is used to displace more carbon-intensive fuels such as diesel.[107] The RNG market has significant potential to expand. Federal policy has helped incentivize RNG in recent years; following a 2014 EPA update[108] to the classification of RNG, production increased nearly sixfold from 2014 to 2016.[109] RNG can also be used to meet California and Oregon's low-carbon fuel standards. Finally, 632 operational landfill gas projects across the United States have resulted in 14 Mt CO_2e in avoided emissions in 2018 so far.[110]

Better yet, states, municipalities, and businesses can help prevent the generation of methane in the first place by promoting policies that divert waste before it can go to a landfill. Our 2017 report documented the fact that 12 out of the 51 largest U.S. cities have waste methane reduction goals[111] and have enacted organic waste diversion and recycling programs as a strategy to achieve this target. For instance, Austin, Texas, aims to divert 75 percent of its solid waste from landfills by 2020 in order to prevent methane emissions.[112] Rhode Island, New York, Massachusetts, California, Vermont, and Connecticut have similarly set statewide goals.[113]

A final bottom-up opportunity available to non-federal real economy actors is curbing methane emissions from wastewater facilities. In 2015, Washington, D.C., installed biodigesters at its Blue Plains water treatment facility and used the captured methane to supply 50 megawatts of power.[114]

Natural and Working Lands

America's natural lands, including forests, grasslands, and wetlands, serve an important function in absorbing and sequestering carbon. In 2016, these ecosystems sequestered 755 Mt CO_2e—more than 10 percent of U.S. GHG emissions.[115] Achieving long-term climate goals will require bolstering America's natural carbon sink, especially by protecting, managing, and expanding existing forests and integrating trees into urban and agricultural landscapes. To date, mitigation opportunities in this sector have suffered from a lack of finance. Persistent challenges in measurement and monitoring also affect prospects for deployment at a large scale. Modest investments in these capabilities (improved land-sector monitoring, inventories, and mapping programs) combined with public and private finance could unlock significant untapped potential from the nation's natural and working lands on the order of hundreds of millions of metric tons of carbon storage.

While forests and other lands sequester carbon, some land uses are large sources of emissions. Agricultural production results in methane and nitrous oxide emissions. In 2016, methane emitted from livestock and manure accounted for 240 Mt CO_2e, and nitrous oxide from agricultural soils emitted nearly 285 Mt CO_2e.[116] It is possible to cut methane and nitrous oxide through more efficient climate-smart agricultural practices that have added benefits to farmers. For instance, typically half of nitrogen fertilizer is not absorbed by plants but instead volatizes or is washed into waterways—adversely impacting air and water quality.[117] More efficient application of nitrogen fertilizer (using precision agriculture techniques or slow-release fertilizer) could maintain crop yields while decreasing fertilizer expenses and saving farmers money.

To date, despite the large share of emissions from this sector, few initiatives have attempted to address them, underscoring the need for enhanced ambition, as is discussed in Chapter 3. One example is California's SB 1383, which, along with HFC targets, established a target to cut methane emissions by 40 percent, including methane from manure management, and direct funds to programs that support installation of dairy digesters and other methane reduction tools and strategies.[118] Furthermore, California credits methane abatement as an offset under its cap-and-trade program,[119] and credits renewable natural gas from manure methane under its LCFS regulation.[120]

A second example is a voluntary program run through the EPA's AgSTAR program. Under the program, U.S. farms share basic information on anaerobic digesters installed, including the farm's location, operational date, and estimated methane emissions reductions in Mt CO_2e per year.[121] It is estimated that the United States has 265 digesters either operating or under construction on livestock farms.[122] Assuming that each digester continues to avoid the same amount of methane each year after its reported operational date, and that no new digesters are installed and none are retired, U.S. livestock farms will avoid about 5 Mt CO_2e of methane emissions annually by 2025. This would amount to about 9 percent of 2005 methane emissions from manure management.

GHG Emissions Limits and Market-Based Policy Frameworks

Compared with the sector-specific actions outlined above, a cross-sector approach to reducing emissions can be taken. Economy-wide prices on GHGs can be set through mechanisms such as cap-and-trade, and a carbon tax or fee. Ten states are implementing some form of emissions limit and pricing, including California's economy- wide cap-and-trade program and the RGGI, a cooperative effort of nine states to reduce power- sector CO_2 emissions. California phased in its GHG emissions pricing regulation in 2012, mandating the adoption of a comprehensive strategy to reduce GHG emissions to 1990 levels by 2020.[123] Senate Bill 32 (2016) mandated a statewide goal to reduce GHG emissions by at least 40 percent below 1990 levels by 2030. Legislation passed in July 2017 clarified the role of California's Cap-and-Trade Program as a key part of the strategy to achieve the 2030 limit.[124] The RGGI program caps CO_2 emissions from large power plants and creates a market where emissions allowances are auctioned. The resulting revenue is then reinvested into public programs focused primarily on energy efficiency. Since the program was first adopted, New Jersey withdrew, but has subsequently announced its intent to rejoin in 2018. Similarly, Virginia is considering creating a GHG limits program that would be compatible with the RGGI system.[125] RGGI's market has been effective at reducing emissions in the power sector. Because it applies only to the power sector, RGGI states have not made progress in reducing emissions from other important sectors, such as transportation (although states in the Northeast are in active discussions about developing a program for the transportation sector). By using a cap-and-trade system, RGGI states and California allow for flexibility and help achieve GHG reduction targets in the most comprehensive manner.

Photo: ENMAX

Finance as a Key Driver of a Low-Carbon Economy

Installing new solar panels, retrofitting existing buildings, and deploying clean all-electric buses and passenger vehicles will all require access to new capital. Fortunately, markets are responding, with private-sector clean energy or climate finance totaling over $270 billion per year globally in 2015–16, according to Climate Policy Initiative.[126]

States and cities can issue bonds to either fund projects directly or help attract private capital. They can also set policies or regulations that enable new and innovative finance models. Property Assessed Clean Energy (PACE) financing is one example of how states are facilitating clean energy investments through policy. As of July 2018, 33 states and the District of Columbia had enabled PACE legislation to support the deployment of energy efficiency and renewable energy.[127] As of January 2016, PACE models supported more than $3.6 billion in clean energy investments.[128] States and cities are also contributing to the financing of clean energy through the use of publicly owned, commercially operated green banks. These institutions specifically target clean energy and climate mitigation projects by helping to decrease project risk and attract additional private capital. Case Study Six provides a more in-depth look at how New York's green bank is sparking new clean energy markets and encouraging private investment in clean energy.

The private sector is continuing to identify innovative approaches to clean energy finance, often in collaboration with the public sector. Several

third-party ownership models have been deployed that allow investment groups to provide the up-front funding in exchange for a portion of the savings over time. Examples include energy performance contracts (EPCs) commonly used to support investments in energy efficiency, the solar lease model that helped unlock the residential and commercial rooftop solar market, and the use of power purchase agreements (PPAs) or virtual PPAs (VPPAs) that has led to significant scaling of the utility solar market.

CASE STUDY 06

New York's Green Bank: An Innovative Approach to Mobilizing Private Capital

The largest state green bank in the country, NY Green Bank (NYGB) was created in 2013 as a division of the New York State Energy Research and Development Authority (NYSERDA) with a $1 billion capitalization.[129] Funding comes from utility ratepayers as well as revenues from carbon trading under the RGGI. Whereas some green banks have focused on individual households or businesses, NYGB addresses gaps in wholesale markets by providing wholesale financing to large-scale developers and projects that require investments in the range of $5 million to $50 million. All potential transactions must meet key investment criteria, which include investments on commercial terms that mobilize private capital contribution to financial market transformation and greenhouse gas emissions—all in support of New York's clean energy policies. Proposed investments are also assessed to ensure they are additional to, and do not "crowd out," private capital providers and investments.

As of March 2018, NYGB had invested $457.5 million toward energy efficiency, solar power, sustainable transportation, and fuel cell projects, which has helped leverage a total project value of $1.39 billion to $1.63 billion in public and private funds. This means that the NYGB is currently mobilizing at least $3 in total project value for every $1 of NYGB funds.[130] NYGB is able to reinvest not only its original capital as individual investments mature and repay, but additional retained earnings. At this rate, NYGB is expected to recycle its $1 billion initial capital almost twice by 2025, meeting its 10-year investment goals.[131] This is expected to result in 29 million tons of greenhouse gas emissions reductions over financed projects' lifetime, equivalent to taking 6.2 million cars off the road for a year.[132]

In October 2017, New York Governor Andrew M. Cuomo announced that NYGB would seek to raise an additional $1 billion in capital from third-party investors, as well as expand its activities nationally. NYGB is also working with the United States Climate Alliance and the Coalition for Green Capital to establish local green banks in other states, and will potentially provide financing for sustainable infrastructure as well as leveraging NYGB's existing credit underwriting abilities and infrastructure.[133] As federal initiatives to create a green bank are deadlocked in Congress, NYGB's nationwide expansion is an innovative example of how state-led climate initiatives can fill the gap.[134]

Alongside NYGB's moves to expand nationwide, Nevada and the District of Columbia passed legislation creating their own green banks in 2017 and 2018, respectively; Massachusetts has a green bank bill under consideration in its legislature; and more than six other states are looking at establishing their own green banks, including Colorado, Missouri, and Pennsylvania.[135] By addressing perceived risks and demonstrating new financing models, states can build confidence in the private sector, sparking independent investment in clean energy, allowing a self-sustaining green economy to flourish.

Chapter 3

Accelerating Progress: State, City, and Business Opportunities

Existing commitments, policies, and programs lay the groundwork for achieving America's current 2025 target under the Paris Agreement and drive the deep reductions necessary to avoid the most dangerous impacts of climate change over the long term.

Ultimately, successful decarbonization will require full implementation of existing and more ambitious policies and greater engagement from all institutions and sectors, including the federal government. However, in the immediate future, real economy actors have direct control and influence over the bulk of U.S. climate emissions through bottom-up action, wielding a diverse and growing toolbox of levers.

This chapter outlines the opportunity for states, cities, and businesses to reach beyond their current commitments and promote a faster transition to a clean and prosperous economy. We present the potential for continued real economy leadership under two nested scenarios: *Climate Action Strategies* and *Enhanced Engagement*.

Climate Action Strategies

Climate Action Strategies provides a detailed assessment of 10 near-term, discrete climate leadership opportunities for states, cities, businesses, and other real economy actors. The strategies represent opportunities that can be initiated in the near term, can build on momentum under way in key sectors of the economy, and can deliver meaningful impact by 2025.

The 10 *Climate Action Strategies* were developed through a collaborative process with experts from industry and civil society using the following criteria:

- **Impact:** Substantial, quantifiable emissions reduction potential by 2025
- **Technical viability:** Technology exists and is deployable at scale in the near term
- **Cost-effectiveness:** Economically attractive; existing business models
- **Political feasibility:** Likely political support in the near term
- **Progress under way:** Similar action is taking place, momentum is building, and one or more standard-bearers exist
- **Innovation and excitement:** Innovative approaches to emissions reduction

Using these criteria, we identified the following *Climate Action Strategies*:

#1: DOUBLE DOWN ON RENEWABLE ENERGY TARGETS

#2: ACCELERATE THE RETIREMENT OF COAL POWER

#3: ENCOURAGE RESIDENTIAL AND COMMERCIAL BUILDING EFFICIENCY RETROFITS

#4: ELECTRIFY BUILDING ENERGY USE

#5: ACCELERATE ELECTRIC VEHICLE (EV) ADOPTION

#6: PHASE DOWN SUPER-POLLUTING HYDROFLUOROCARBONS (HFCS)

#7: STOP METHANE LEAKS AT THE WELLHEAD

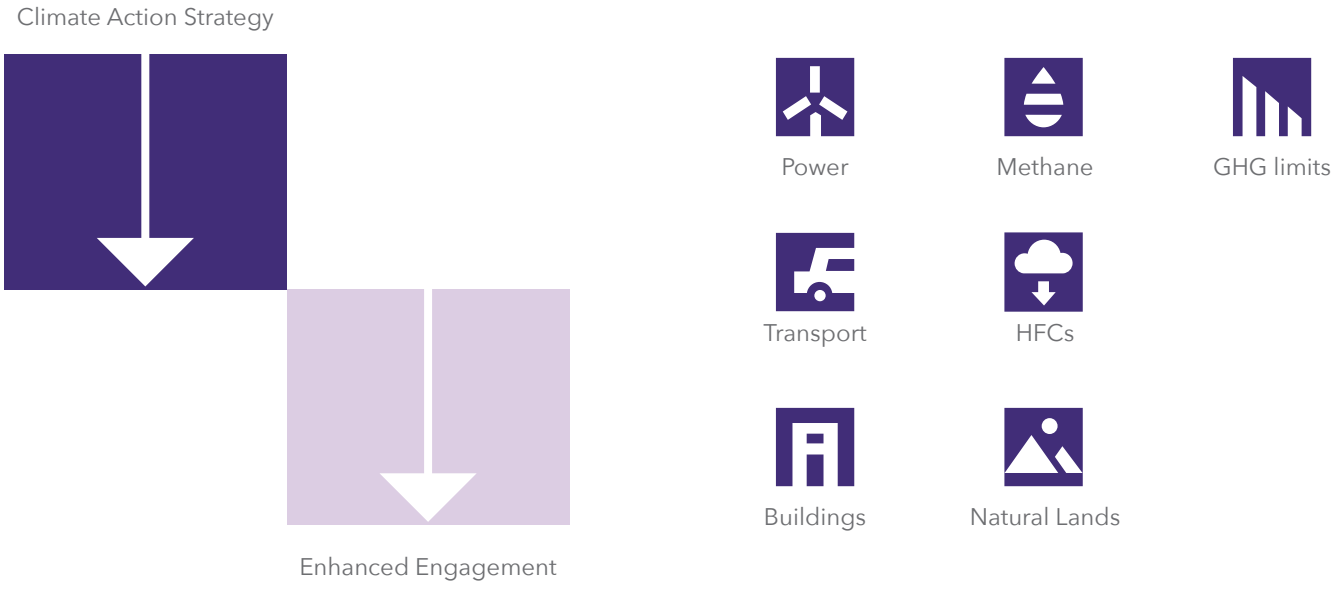
#8: REDUCE METHANE LEAKS IN CITIES

#9: DEVELOP REGIONAL STRATEGIES FOR CARBON SEQUESTRATION ON NATURAL AND WORKING LANDS

#10: FORM STATE COALITIONS FOR CARBON PRICING

For each of the seven sectors, this chapter presents one or more Climate Action Strategies to accelerate progress and Enhanced Engagement to go even farther.

Figure 3-1: Illustrative Depiction of Scope of Climate Policies and Impacts in *Ten Climate Action Strategies* and *Enhanced Engagement* Scenarios



Enhanced Engagement

Enhanced Engagement captures the impact if real economy actors are highly ambitious in adopting a broader, feasible suite of actions across each major GHG-emitting sector. This scenario envisages more states, cities, and companies joining those already acting to cut emissions, as well as accelerated and more aggressive actions by those real economy actors who have already started down the decarbonization trajectory. Building on both the *Current Measures* and the *Climate Action Strategies* scenarios, the *Enhanced Engagement* scenario presents a top-end estimate of what can reasonably be achieved through state, city, and business actions. It takes into consideration limitations, including legal barriers to scaling up some specific policies as well as the political unwillingness of local governments in some regions of the U.S. to take up climate policies.

These two scenarios are presented in this chapter as a range of potential real-world outcomes with the discrete *Climate Action Strategies* at the accessible end and the broader *Enhanced Engagement* potential at the more engaged end. Moving from the low to the high end of potential requires both more actors undertaking commitments defined in the *Climate Action Strategies* and an expanded range of actions across the economy, defined as levers of change under *Enhanced Engagement*.

This chapter demonstrates that given the rapid pace of innovation and technological change, and despite the absence in federal leadership, a robust set of as-yet-untapped opportunities to cut emissions remain available to real economy actors. Such opportunities can be seized immediately, at low cost, while also creating jobs and growing the economy.

The complete GHG implications of the *Climate Action Strategies* and the overall opportunity for *Enhanced Engagement* is modeled and presented in Chapter 4, where we account for the complex linkages between the various sectors.

Power Sector

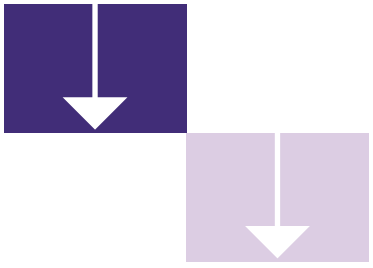
The power sector is undergoing rapid change and cutting emissions faster than any other sector.[136] At the same time, the United States must expand electric generation to absorb increasing demand due to electrification of end-uses (such as vehicles, building heating and cooling, and industrial processes).[137] Decarbonizing the electric grid will require both the retirement of aging fossil units, such as coal, and the ambitious scale-up of clean energy technologies and electricity services (including wind, solar, demand response, energy storage, improved efficiency, and, eventually, carbon capture and sequestration technology). In the case of nuclear power, it will also require retention efforts. According to the U.S. Energy Information Administration, 14 gigawatts (GW) of renewable energy capacity came online in 2017.[138] This is impressive but insufficient. The U.S. Mid-Century Strategy (MCS) estimates that the United States would need to deploy roughly 30 GW of new renewable energy per year between 2016 and 2035, with this pace accelerating to 50 GW per year thereafter.[139]

Despite the proposed rollback of federal policies such as the Clean Power Plan, declining federal tax incentives for renewables, and ongoing discussions of federally mandated subsidies for uneconomic coal plants, U.S. states, cities, and businesses have many powerful tools at their disposal to significantly scale up renewable power generation and accelerate the retirement of coal-fired electricity generating units, two of the most important changes needed for continued emissions reductions from the power sector.

Motivation to take action is not solely environmental reasons; economic reasons are also compelling. Low-carbon electricity is cheaper in many cases, it is better for public health, and it provides a competitive edge in attracting business.

Compared to the reference case scenario and *Current Measures*, the outlook under the *Enhanced Engagement* scenario foresees the retirement of coal power plants and scales up renewable energy (see Figure 3-2). We estimate that state, city, and business leadership implementing *Climate Action Strategies* could drive 990 terawatt-hours (TWh) of total renewable generation and 94 gigawatts of coal retirements by 2025 (130 TWh and 25 GW beyond *Current Measures*). Full uptake of the *Enhanced Engagement* scenario would see the deployment of 1,050 TWh of renewable generation (Figure 3-2) and 128 GW of incremental coal retirements. In addition, the Enhanced Engagement scenario reflects retention of 6,500 MW of existing nuclear capacity otherwise scheduled to retire within the next decade.

ACCELERATING PROGRESS



We estimate that state, city, and business leadership could drive

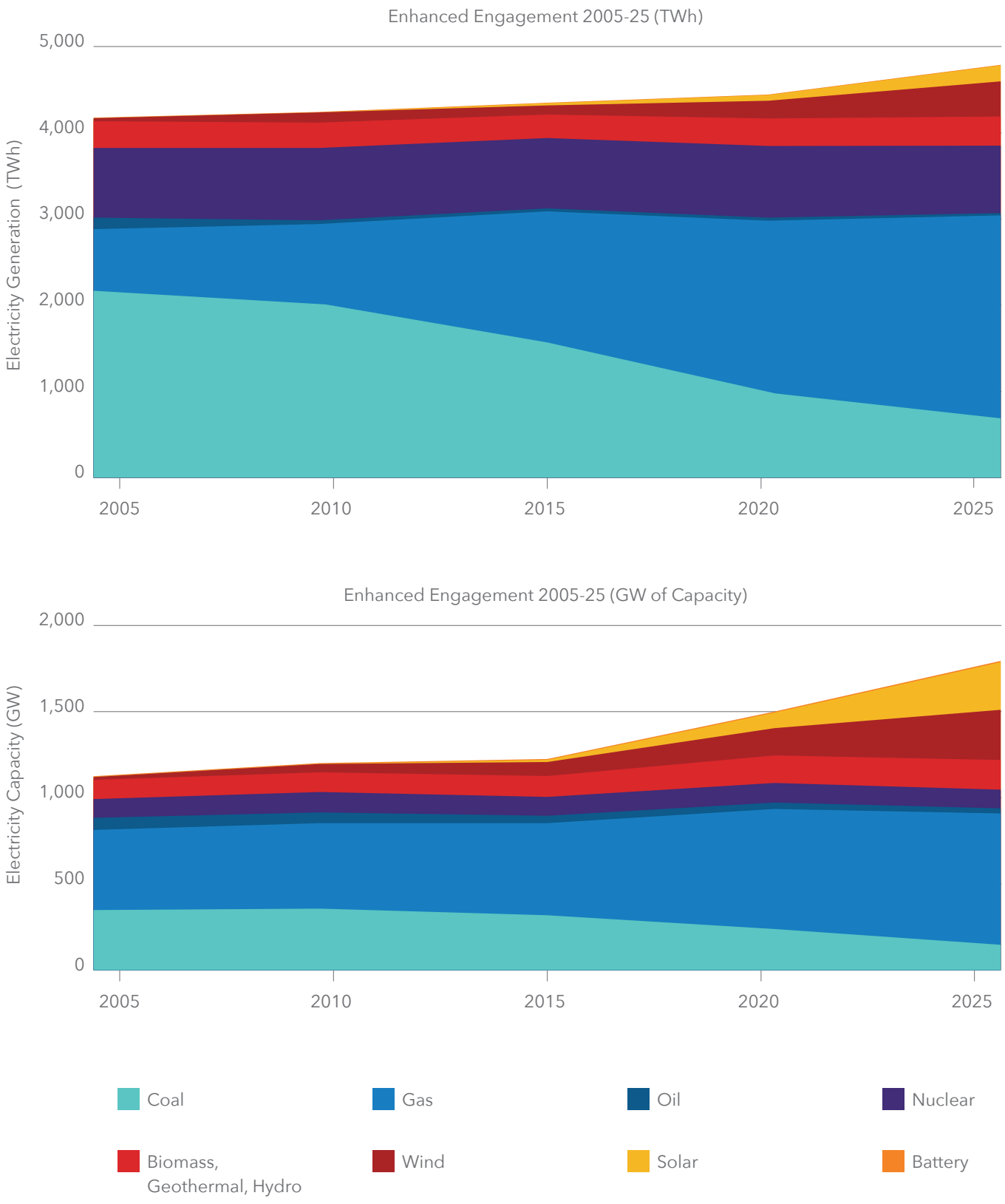
990-1,050 TWh

of total renewable generation and

94-128 GW

of coal retirements by 2025 (through implementation of the *Climate Strategies* and *Enhanced Engagement*).

Figure 3-2: Ambitious Action by States, Cities, and Businesses and Significantly Increase Renewables and Retire Coal by 2025



Source: America's Pledge modeling outputs

Levers of Change

States, cities, and businesses can achieve the ambitious outcomes outlined above by supporting implementation of the following interventions.

- Foster broad coalitions of support in favor of clean energy programs by highlighting the full range of climate, economic, health, and equity benefits to help reduce political barriers to clean energy standards, tax incentives, net metering, and retail choice (see Climate Action Strategy #1 for additional details);
- Pursue policies to source electricity from clean energy sources, such as wind and solar, and that support increasingly at-risk nuclear generation (see Climate Action Strategy #1 for additional details);
- Work collaboratively with states, public utility commissions (PUCs), utilities, and affected communities to phase out uneconomic and environmentally damaging coal generation (see Climate Action Strategy #2 for additional details);
- Promote innovative utility business models and rate structures (such as variable time-of-use rates) that can help optimize grid load, promote flexibility, and otherwise incorporate smart grid technology (such as demand response, distributed generation, and energy storage);
- Collaborate to improve transmission corridors that will allow for the transport of renewable energy from generation sources to demand markets; and
- Identify and take advantage of opportunities to cost-effectively deploy carbon capture and storage (CCS) technology in order to capture emissions from remaining fossil sources and from industry (although not yet economically viable at scale, certain CCS activities are subject to recently passed federal tax incentives).

Economic and Health Benefits of Climate Action

Mitigation and economic growth go hand in hand, as demonstrated by the continued growth in the U.S. economy as emissions have fallen steadily. At the state level, California GHG emissions peaked in 2004, and in 2016, the state's GHG emissions fell below 1990 levels, meeting California's 2020 target four years ahead of schedule. California law requires that emissions return to 1990 levels by 2020 and reach 40 percent below that marker by 2030. California has reduced its emissions by over 13 percent since the state's peak in 2004, while also growing the economy by 26 percent during the same time period.[140]

Transitioning to a clean electric grid will shift valuation of assets and create jobs in new and different industries. Real economy actors must ensure that public policies adequately promote new employment opportunities for their citizens. States and cities would reap the benefits of promoting clean energy industries in their region, either through promoting local residential or commercial energy policies that spur project development, or through attracting clean energy manufacturing. By attracting these viable new business models, states and cities are all able to support job creation for their citizens.

In addition to the climate benefits, closing coal plants can improve the air and water quality of local communities. Estimates vary, but between 7,500 and 52,000 people in the United States meet early deaths because of small particles resulting from power plant emissions.[141] The Sierra Club's Beyond Coal campaign has helped prevent at least 7,000 premature deaths every year.[142]

CLIMATE ACTION STRATEGY #1

Double down on renewable energy targets

States, cities, corporations, and utilities all have proven tools at their disposal to promote clean energy through renewable energy targets, and the approaches they have pursued to date hold promise for accelerated deployment. When cities, state policymakers, corporate renewable energy buyers, and utility companies work together to develop integrated strategies across stakeholder groups, they can drive progress even faster.

We estimate that this Climate Action Strategy could readily lead to the deployment of an additional 130 TWh of renewable energy beyond what is assumed under the *Current Measures* scenario by 2025—reaching 990 TWh of total renewable energy annually—while also saving consumers money on their energy bills and improving public health.

The Opportunity

- **States** enact new commitments that put states with an RPS on track toward 25 percent renewables by 2025 and bring new states on board by adding an RPS.
- **Cities and businesses** can leverage ambitious city and corporate renewable targets and develop integrated strategies across the state/city/corporate/utility stakeholder groups to drive faster progress. Cities and businesses can also build coalitions of support for higher state RPS, for more ambitious clean energy commitments from utilities, and for policies that enable cities' renewable energy goals. Cities can partner with one another and with corporations and universities to aggregate energy demand and facilitate bulk purchasing of renewable energy.

Example of This Approach at Work

The Renewable Energy Buyers Alliance (REBA) is a collaborative effort led by four nonprofit organizations to accelerate and scale up procurement of renewable energy. REBA exists to help energy buyers such as corporations, cities, and public institutions power their operations with clean energy by helping them understand the benefits of moving to renewables, connecting large buyer demand to renewable energy supply, and helping utilities better understand and serve the needs of all energy buyers. REBA brings together all market actors through annual gatherings and monthly calls to collectively overcome the largest barriers to meeting ambitious renewable energy targets. Today, over 250 companies and institutions participate in REBA to accelerate the transition in the energy sector toward a low-carbon future. Since 2013, these organizations have announced over 12 GW of new renewable energy capacity.

Salesforce, one organization participating in REBA, is more than halfway toward its goal of matching 100 percent of its global electricity use with renewable energy. The majority of that progress has come from virtual power purchase agreements in West Virginia and Texas, as well as renewable energy tariffs. The company is focused on building a diverse portfolio of renewable energy projects that minimize risk and maximize emissions reductions. However, company leaders recognize that matching electricity use is only an initial step toward the long-term goal of shifting the world's power supply completely to clean energy resources. To pursue that long-term goal, Salesforce relies on collaboration through groups like REBA to effect change on a global scale.

CLIMATE ACTION STRATEGY #2

Accelerate the retirement of coal power

Coal was an important engine of American economic growth 100 years ago, but its prime has passed for both economic and environmental reasons. According to recent analysis by the International Energy Agency, to avoid 2 degrees Celsius of warming, advanced economies like the United States would need to phase out all conventional coal generation and capacity by 2035. Between 2009 and 2017, 60 GW of U.S. coal capacity was retired, and a further 45 GW will be closed by 2025. These retirements are the result of local, state, and citizen action and the eroding economics of coal against clean energy. Now, the economics alone are more compelling than ever, as renewable cost reductions in recent years have made the majority of the remaining U.S. coal fleet uneconomic relative to regional wind and solar resources.

Yet the pace of phaseout remains too slow for U.S. and global climate goals. Even as utilities face increased shareholder and ratepayer pressure to phase out coal, PUC policies, utility planning, and local priorities do not always align. Working together, we estimate that states, cities, businesses, advocates, and other stakeholders can accelerate the retirement of coal capacity by an additional 25 GW beyond what is assumed under Current Measures, resulting in 94 GW of total reductions, which would equate to almost 30 percent of the total installed capacity in 2005. Adding up retirements to date, the assumed retirements under Current Measures, and what could be accomplished through the additional actions outlined in this *Climate Action Strategy,* 45 percent of the 2005 coal fleet could no longer be polluting in 2025.[143]

The Opportunity

Environmental and consumer advocates are already deeply engaged in many of the venues that affect decisions about the remaining coal plants and have played an important role in securing the progress to date. States, cities, and businesses have not yet seized their full potential in accelerating the transition from fossil fuels to clean energy and shaping the evolution of the electricity grid. Specifically, they can map out where decisions are pending on existing coal-fired power units and:

- Participate actively in PUC meetings, utility resource planning processes, rate structuring, and other public proceedings to shape decisions in favor of clean, cost-effective alternatives;
- Work with investors and other stakeholders to develop novel financial, regulatory, and tariff structures that provide customers with the opportunity to take advantage of falling renewable costs to achieve their carbon and clean energy goals while reducing their rates from day one;
- Work directly with utilities to actively plan how electricity demand and reliability criteria can be met by improving efficiency, scaling renewables, and promoting demand response when fossil fuel generation retires;
- Make choices in electricity procurement at the municipal and corporate level as outlined in Climate Action Strategy #1 above; and
- Collaborate with coal plant owners, workers, and local communities to promote employment opportunities as the grid transitions from coal (and gas) to a clean grid.

Example of This Approach at Work

Colorado's Xcel Energy announced plans in June 2018 to implement the single largest national proposal to replace retiring coal power with renewable energy in American history. Xcel plans to accelerate retirement of one-third of its coal fleet, replace that with major new additions of wind, solar, and battery storage, and add no new utility-owned gas builds, bringing the utility's portfolio to 55 percent renewable energy. In its request for proposals for this plan, thanks to falling renewable costs and federal tax credits, Xcel received the lowest bids for wind and solar ever received by any U.S. utility, and this shift will save its customers an estimated $215 million. The utility is also investing in an economic transition pathway for the community that is home to the coal units. The utility was pushed toward this pathway by sustained, multiyear engagement by key stakeholders and grassroots advocacy that included thousands of its customers sending comments and attending hearings to demand this change. The cities of Pueblo, Aspen, and Boulder have all declared their commitment to meet 100 percent of their electricity needs with the low-cost clean energy sources that already employ more Coloradans than coal and gas combined. Xcel's plan by the numbers includes:

- Constructing 1,131 megawatts (MW) of new wind, 707 MW of new solar, and 275 MW of new battery storage;
- Accelerating retirement of 660 MW of its coal fleet (about a third of its Colorado fleet);
- Purchasing 383 MW of existing gas plants, but beginning no new gas construction;
- Increasing its share of renewable energy in Colorado from about 29 percent to more than 50 percent by 2026;
- Reducing carbon emissions by 59 percent as compared with a 2005 baseline; and
- Achieving at least $213 million in savings as compared with continued operation of all Comanche coal units.

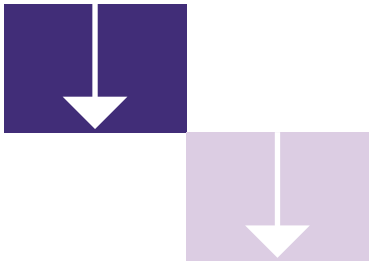
Residential and Commercial Energy Use

Energy efficiency has been a cornerstone of the decoupling of energy use from economic growth and recent reductions in U.S. GHG emissions.[144] This has been achieved by reducing overall energy demand through energy efficiency—and increasingly through dynamic demand management—and complemented with low-carbon energy generation (as discussed above in the Power Sector section, 3.2). Energy efficiency continues to be one of the more cost-effective mitigation options compared with other interventions,[145] and if counted alongside generation assets it would be the third-largest electricity resource.[146] If the country is to achieve its near- and mid-term climate goals, additional action on building energy use is needed, and luckily there is significant low-cost potential for greater efficiency (Figure 3-3).

We estimate that implementing the policies described in the *Climate Action Strategies* would lead to an additional 13 TWh in energy savings by 2025 beyond current measures. Scaling these actions to full potential in the *Enhanced Engagement* scenario could help drive total 58 TWh in energy savings by 2025 beyond current measures. In these scenarios consumers would also save 800-1,050 tera British thermal units (TBtu) by transitioning from direct fossil fuel use for end-uses to electricity by 2025.

Photo: David Dodge, GreenEnergyFutures.ca

ACCELERATING PROGRESS



We estimate that implementing policies would lead to an additional

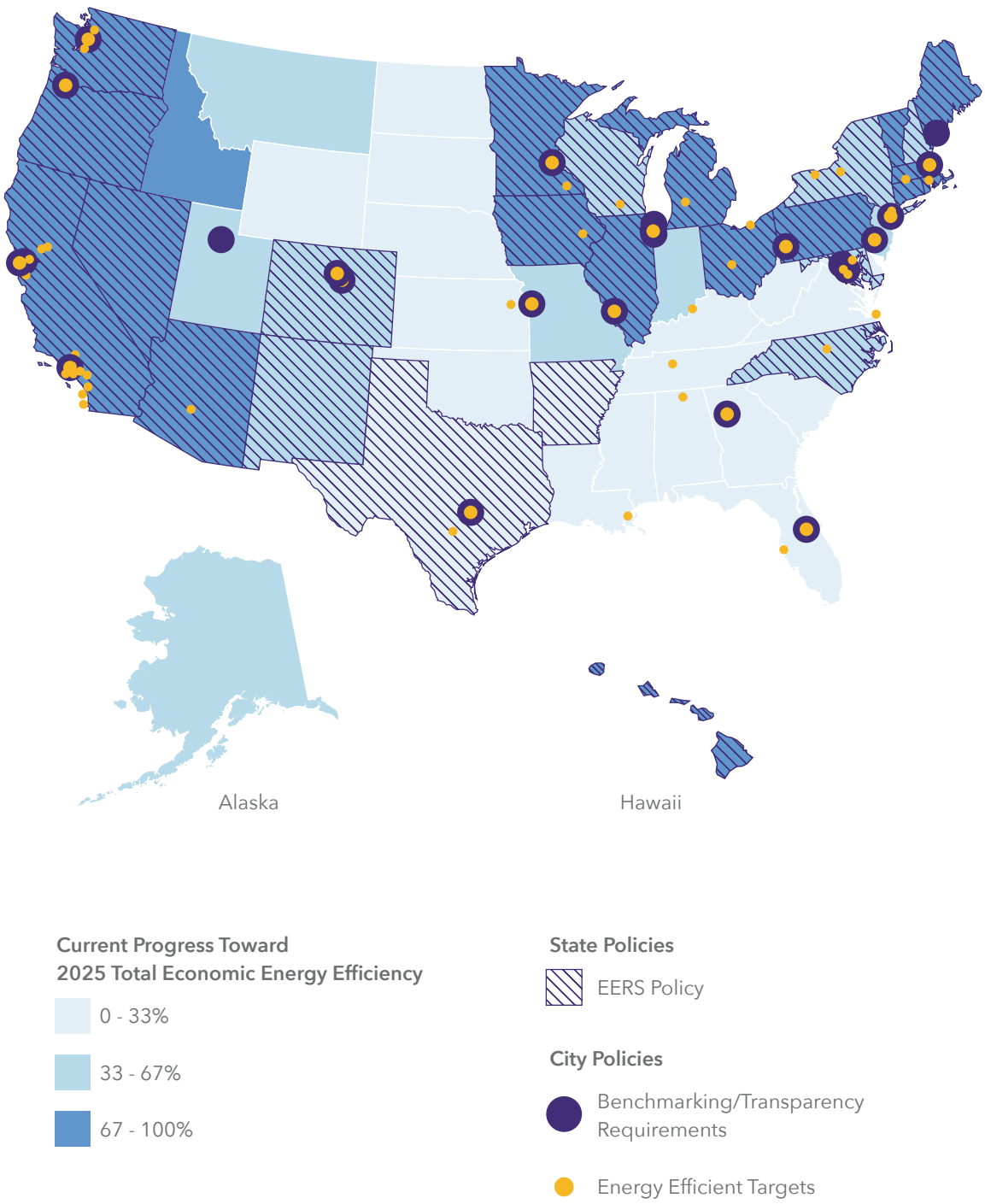
13 TWh-58 TWh

in energy savings by 2025 beyond current measures (through implementation of the *Climate Action Strategy* and Enhanced Engagement). Additionally, under these scenarios, consumers would also save

800-1,050 TBTU

by transitioning from direct fossil fuel end-uses to electricity by 2025

Figure 3-3: Many Areas of the U.S. are Making Progress on Energy Efficiency, but there is Signficant Opportunity for Additional Ambition



Source: Electric Power Research Institute's "State Level Electric Efficiency Potential Estimates" (May 2017) report; Institute for Market Transformation; World Resources Institute

Levers of Change

In order to meet the goals of the Paris Agreement, the United States will need to: 1) make new and existing buildings more efficient and grid connected and responsive; 2) switch heating systems from fossil fuels to clean electricity generated from renewable sources; and 3) ensure that any remaining fuel used comes from clean sources. State and city levers can prove even more effective than federal leadership in achieving these goals, particularly because states and cities regulate building efficiency codes, implement city planning and zoning, set state-level appliance standards, and control utility efficiency programs. Businesses can also electrify and improve the efficiency of their buildings. Key levers include:

- Requiring retrofits for residential and commercial buildings at key trigger points during structures' life cycle, including when changing ownership and during major renovations (see Climate Action Strategy #3 for further details);
- Setting and enforcing advanced building and appliance codes that vastly improve energy efficiency, promote smart, grid-connected end-uses, and promote electrification of fossil-based end-uses, such as water heating (see Climate Action Strategy #4 for further details). This includes adopting the latest minimum codes determined appropriate by DOE but ideally reaching beyond that to match stretch targets;
- Working with utilities and PUCs to adopt time-based electricity rate pricing to promote demand response and load shifting that will save utilities and ratepayers money;
- Setting state, city, utility, or business energy efficiency targets that drive improvements to existing residential and commercial buildings, including utility EERS programs; incentivizing the adoption of system-wide efficiency certifications such as "ISO50001 Ready"; adopting ENERGY STAR goals; or committing to state, municipal or business-owned retrofits;
- Enhancing energy efficiency programs that provide resources to support home and business energy upgrades and ensuring that these programs are available for all socioeconomic levels;
- Launching private-sector challenge programs to promote innovation and growth in energy efficiency in buildings (such as the Advanced Rooftop Unit [RTU]) campaign to save cities and building owners money on cooling[147]); and
- Creating and standardizing benchmarking, audit, and retro-commissioning policies for existing buildings.

Economic and Health Benefits of Climate Action

Beyond emissions and environmental benefits, investing in building energy efficiency yields significant economic benefits. The American Council for an Energy-Efficient Economy (ACEEE) estimates that residential households each save as much as $460 per year on electricity due to energy efficiency programs and policies.[148] According to a 2018 U.S. Energy and Employment Report, employment in the energy-efficient technologies and related services sector grew by just over 3 percent from 2016 to 2017, employing approximately 2.25 million workers.[149]

When properly structured, energy efficiency programs can reduce energy burdens for renters and low-income households. The amount spent on energy costs as a percentage of income, also known as the energy burden, is approximately three times as high for low-income households, due to building inefficiencies.[150] Energy efficiency programs that address traditional barriers for low-income households can improve indoor air quality while bringing older building stock up to code.

CLIMATE ACTION STRATEGY #3

Encourage residential and commercial building efficiency retrofits

New homes and commercial properties are getting more energy efficient, but addressing the carbon footprint of existing buildings is challenging. Fortunately, advances in technology and business models have opened up new opportunities to implement building retrofits in cost-effective ways. And federal policy is not needed to achieve major progress: local governments, real estate companies, and utilities can come together to implement new programs and policies in order to maximize carbon savings achievable through retrofits.

Over 40 cities have set ambitious energy efficiency targets and are implementing policies and programs in support of these stated targets. Looking at the U.S. cities with a population over 100,000 that are engaged in existing climate coalitions or clean energy efforts, we see a realistic potential to double the number of cities with building-specific energy targets and associated programs. We estimate that new cities recruited into this Climate Action Strategy could achieve a target similar to those set by existing participants, which would reduce overall annual building electricity use alone by 13 TWh by 2025 in addition to what is outlined in our *Current Measures* scenario.

The Opportunity

Cities can collaborate with the real estate industry, utilities, and state regulators to set policies and implement ambitious building energy efficiency programs. Several cities have begun to explore new approaches to scaling energy efficiency within their own buildings and across their communities. An assessment of innovative actions highlights several opportunity areas for additional action:

- **Require energy disclosure** to create market value for energy-efficient buildings. As discussed in Case Study Four in Chapter 2, 26 cities currently require building energy benchmarking and transparency policies to improve knowledge of energy use and aid in planning and implementing energy-saving measures. Cities without a benchmarking and transparency policy can implement one; cities with a current policy can build on existing policies with additional programs, including rating systems, energy disclosure for all buildings, and retrofit requirements.
- **Require upgrades at key trigger points in the building life cycle,** including through minimum efficiency standards for residential rental units and policies to retrofit residential and/or commercial buildings at time of sale. In the United States, rental properties make up more than 50 percent of all residences, and because owners can pass along energy costs to renters, there is a lack of incentive for both owners and renters to invest in efficiency upgrades. Cities can lead the way in overcoming this barrier by requiring rental units to achieve efficiency standards at the point of rental licensing. Today, two cities have implemented rental efficiency standards, and several others plan to launch similar policies.
- **Scale up retrofit incentive programs,** which are often a direct collaboration between local governments and utilities, providing financial incentives and additional resources with which to implement energy efficiency. These programs are particularly effective when pairing utility financial incentive programs with city challenge programs or retrofit requirements. Best-in-class programs provide models others can follow when considering additional opportunities to scale up building energy efficiency.

Example of This Approach at Work

Retrofit Chicago is a voluntary program that encourages and promotes energy efficiency in buildings. The program includes all building types—from small residential properties to larger properties such as offices, hotels, college buildings, large multifamily residences, nonprofits, and houses of worship. Under Retrofit Chicago, the City is also improving the efficiency of its own buildings and has reduced energy use by approximately 18 percent across 60 City-owned properties. The portion of the program addressing large buildings has also achieved approximately 18 percent energy reduction in 88 participating buildings spanning more than 56 million square feet of space.

Building on the success of this program, as well as the City's mandatory energy benchmarking requirement for large properties, Chicago will begin assigning a building energy rating of between zero and four stars to all properties over 50,000 square feet, starting in 2019. Property owners will be required to post their rating in a prominent location and to share it at time of listing for sale or lease. The new Chicago Energy Rating System is expected to increase the transparency and simplicity of energy information reported under the Chicago Energy Benchmarking Ordinance.

CLIMATE ACTION STRATEGY #4

Electrify building energy use

Homes and commercial buildings burn fossil fuels (natural gas, propane, and oil) for end-uses such as heating and hot water—resulting in over 500 million tons of carbon pollution per year. Electrifying the primary end-uses that consume fossil energy, such as space heating, water heating, and cooking, would result in significant climate and public health benefits, particularly when combined with decarbonizing the electricity grid itself.

Targeting collaborative action by states, cities, utilities, and industry organizations in regions where electrification retrofits are most cost-effective today, we estimate that this Climate Action Strategy could save over 800 TBtu of building energy use by 2025—enough energy to power 20 million homes for a year—as well as leading a significant transition away from fossil fuels.

The Opportunity

Utilities, cities, and states can each contribute to achieving the full potential of this opportunity. Utilities primarily control the design and implementation of energy efficiency programs, including incentives for implementation of new technologies. Cities direct policies and regulations for building standards and, in particular, codes that set the bar for new construction and in many cases for major retrofits of existing buildings. States set energy policy and strategy, appliance standards, and building codes. Yet there is significant work to be done. It is estimated that over 70 million homes and businesses across the United States use natural gas, oil, or propane to heat their space and water.[151] Turnover of existing systems is slow, retrofitting existing homes and businesses to support all-electric equipment can be costly, and consumers lack awareness of the more efficient electric systems.

States, cities, and utilities can therefore collaborate to electrify building energy use by:

- **Evaluating local or regional potential** from a technical and economic standpoint prior to setting a goal and implementing a specific strategy. While building electrification is broadly applicable, an assessment of the local or regional economic and technical potential for electrification can help tailor a strategy to the existing fuel mix, climate zone, and composition of the building stock.
- **Setting an electrification target or goal,** and backing it up by implementing policies or regulations that address new appliances and building standards. Setting a target or goal can signal to a broader set of stakeholders the intent to take action, as well as engaging with other actors with similar goals (see the multi-city initiative example below).
- **Coming together through regulatory processes** to advocate for rules and requirements that support electrification goals. These include establishing fuel switching rules; promoting smart, grid-responsive appliances and buildings; implementing cost-effectiveness requirements; adjusting rate structures; and providing financial performance incentives for utilities.
- **Implementing programs** to encourage electrification, in particular in existing buildings where the financial challenge is the greatest. Potential options include providing incentives, establishing new or innovative financing models, and running outreach and education campaigns.
- **Identifying funding opportunities,** including the nearly $10 billion in demand-side management funding from utilities to encourage electrification.[152]

The regions of the country with the biggest opportunity to electrify existing residential and commercial buildings are in areas that have not already begun to address this, where there is a meaningful heating load (i.e., colder climates), and where fuel costs for direct fuels are higher, particularly propane and oil. The Northeast and Midwest regions are well poised to electrify residential and commercial buildings for these reasons. In addition, all regions of the United States should consider opportunities to encourage policies to support electrification of new construction and where there are significant industrial sectors.

Example of This Approach at Work

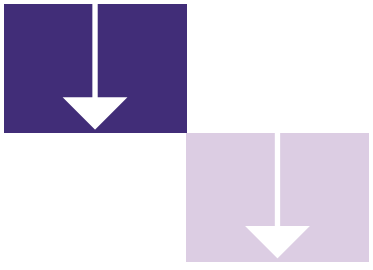
Boulder, Colorado, has helped launch a multi-city initiative to rapidly wean buildings off their dependence on natural gas for space and water heating by replacing existing units with high-efficiency heat pumps—with the goal of transitioning 80 percent of residential building stock to heat pumps by 2050. A consortium of over 20 cities including Boulder; New York City; San Francisco; Seattle; Salt Lake City; Palo Alto, California; Burlington, Vermont; Washington, D.C., and others have initiated a broad public–private collaboration working with most of the world's major heat pump manufacturers as well as suppliers and installers in the HVAC industry to develop policy, market development, and financial mechanisms to facilitate this rapid transition.

Transportation

Although transportation surpassed electricity generation as the largest source of GHG emissions in the United States in 2016,[153] there is significant innovation under way. The cost of electric vehicles continues to decline as their range increases and the variety of electric vehicles available to consumers expands.[154] Battery and hybrid electric vehicles could reach cost parity with gasoline vehicles by 2025—even when not considering the lifetime benefits of fuel savings associated with electric vehicles versus gasoline-powered alternatives.[155] Cities are implementing multifaceted approaches to support alternative transportation modes; states are adopting policies such as zero-emissions vehicle (ZEV) mandates; and companies are ramping up their commitments to low-carbon vehicles. If such trends are harnessed, real economy actors can help transition the United States away from a fossil fuel–based transportation system to the low-carbon transportation system of the 21st century.

We estimate that states, cities, and businesses could take actions that would help boost annual new electric vehicle sales from 128,000 in 2017 to 1.9 million in 2025, resulting in over 8.4 million EVs on the road (see *Climate Action Strategy #5*). Through broader engagement, the real economy can accelerate deployment to 2.2 million new electric vehicle sales in 2025, or over 9 million EVs on the road (*Enhanced Engagement* scenario) (Figure 3-4). We also project that real economy actors could reduce annual passenger and freight vehicle miles traveled by 1 to 2 percent nationally relative to our current measures case in 2025 (a modest and achievable estimate compared with the significant progress some leading cities and states are currently targeting).[156]

ACCELERATING PROGRESS



We estimate that states, cities, and businesses could help boost annual new electric vehicle sales to

1.9-2.2 million

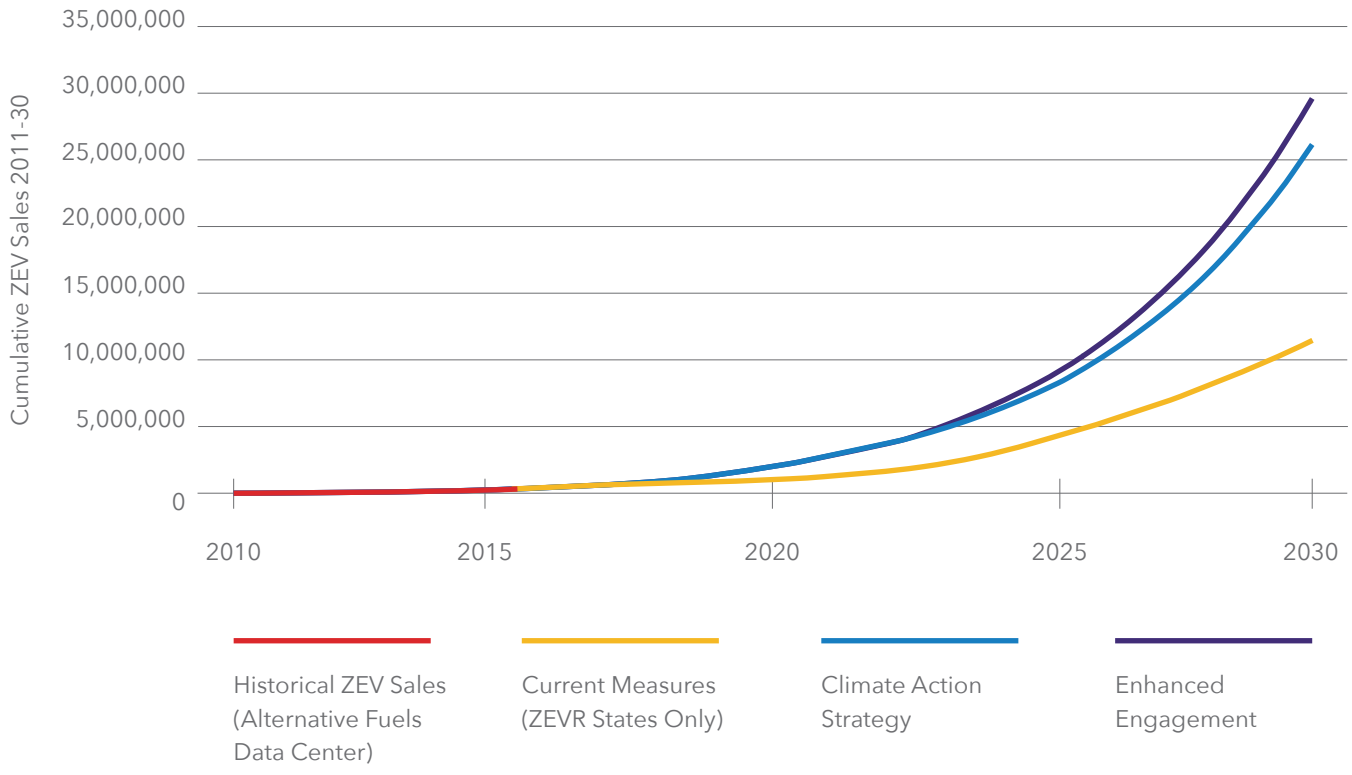
in 2025, resulting in

8-9 million EVs

on the road (through implementation of the Climate Action Strategies and Enhanced Engagement).


Electric Vehicle Infrastructure
WARNING!
DO NOT USE AN
EXTENSION CABLE TO
CHARGE THIS CAR

Figure 3-4: Through Accelerated Ambition by Real Economy Actors, the U.S. could Achieve as much as 9 million ZEVs on the Road by 2025



Source: Historical ZEV sale data from Alternative Fuels Data Center; projections based on America's pledge modeling output (using BNEF 2018 EV Outlook data)

Levers of Change

Key strategies for reducing transportation emissions: 1) increased adoption of ZEVs and other low-carbon vehicles; 2) reductions in emissions from vehicles attained by reducing the carbon intensity of fuel production and fuel combustion; 3) the densification of urban development; and 4) the expansion of public transportation networks, ride-sharing, and non-vehicle modes of transportation. Fortunately, states, cities, and businesses have many tools to help them achieve all four goals, including the selection listed below.

- Commit to procuring EVs for state, city, and business fleets and accelerate efforts to electrify medium- and heavy-duty vehicles, including municipal vehicles, that serve or transit through underserved communities, which often suffer disproportionate health impacts from diesel and gasoline pollution.

- Enable greater EV penetration by building infrastructure, adjusting regulatory structures to enable greater private investment in charging infrastructure, and encouraging public acceptance of these vehicles. This includes providing public access to EV charging at multifamily apartment buildings and in municipally owned or business-owned parking lots; expanding EV education and incentives; and promoting community-scale transition to EVs with commercial fleets and carsharing programs.

- Adopt statewide policies such as GHG standards for cars and trucks, ZEV regulation (ZEVR) mandates, or low-carbon fuel standards (such as California's and Oregon's low-carbon fuel standards [LCFS]).

- Reduce vehicle miles traveled in the short, medium, and long term by prioritizing investments in public transit, including deployment and cost-effective rapid transit, and by promoting compact, dense, walkable development through land-use planning.

As discussed in Chapter 2, states recognize the co-benefits that accompany strong policies addressing transportation emissions and are acting accordingly. However, the need for higher ambition in addressing transportation emissions is coupled with a need to counter the Trump Administration's regressive fuel economy policies and recent challenge to California's ability to set its own standards. Additional states could join the 13 states that are moving forward with California's rigorous GHG standards for cars and trucks or could join California's ZEV regulation program. In addition, states can engage the Transportation Climate Initiative, a collaboration of states and the District of Columbia working together on accelerating clean vehicles and fuels.[157] State, cities, businesses, community organizations, and universities can also concurrently enact programs that expand the accessibility and range of ZEVs, as discussed in Climate Action Strategy #5.

New mobility solutions are on the horizon, in particular the predicted growth of shared and autonomous vehicles. Autonomous vehicles have the potential to significantly change the transportation system by making roads safer, limiting congestion, and reducing overall vehicle ownership, but they also run the risk of increasing overall vehicle miles traveled (VMT).[158] Regulators are working to keep pace with the development of autonomous vehicles; four U.S. states (Nevada, California, Florida, and Michigan) plus the District of Columbia have legalized the testing of driverless vehicles on their roads, in order to better understand these potential opportunities and challenges.[159] It is critical that autonomous vehicles be all-electric (and ideally shared) to ensure that growth in this mobility solution does not result in backsliding on GHG emissions.[160]

States, cities, and businesses can also pursue policies to promote non-vehicle-based transportation and reduce VMT, as highlighted in Case Study Five. Among these strategies are advantageous pricing, particularly of parking and travel; infill development and additional land use or zoning decisions; regional and local transportation investments, including pedestrian, bike, and transit; and transportation demand management.[161]

Economic and Health Benefits of Decarbonizing Transportation

Transitioning from traditional gas-powered or diesel-powered vehicles to clean vehicles will result in significant public health benefits. Within the transport sector, diesel engines emit especially high quantities of short-lived pollutants that cause global warming, such as black carbon, a major component of PM2.5, a particularly harmful type of particulate matter.[162] A study by MIT found that 53,000 premature deaths annually in the United States can be attributed to road transportation–related PM2.5, and it disproportionately affects the most vulnerable populations, such as children, the elderly, the chronically ill, and people in low-income communities.[163] In addition, slowing down progress in efficiency and electrification would increase oil demand and make the United States more exposed to foreign oil suppliers.

Furthermore, low-income communities in particular face transportation barriers, such as inadequate access to affordable transportation.[164] Innovative clean energy transportation programs can benefit disadvantaged communities (see the example in Climate Action Strategy #5 below).

CLIMATE ACTION STRATEGY #5

Accelerate electric vehicle (EV) adoption

U.S. light-duty electric vehicle sales are steadily growing, from 50,000 in 2012 to more than 187,000 in the U.S. market in 2017. The number of EV models on the market is on track to double between 2016 and 2020, and the offerings are expanding to all vehicle classes and market segments—light-duty trucks, commercial delivery vehicles, transit buses, and even semi trucks. This growth and expanded vehicle availability is impressive, but market penetration is still tracking well below the rate needed to put a dent in the greenhouse gas emissions of the U.S. transportation sector.

We estimate that real economy actions taken through this Climate Action Strategy can accelerate uptake of EVs such that an estimated 8.4 million EVs will be on the road by 2025—with annual sales of over 1.9 million in 2025—4 million EVs beyond what is anticipated to happen under current commitments. This would represent 4 percent of all light-duty vehicles across the United States in 2025.[165]

Photo by Felix Kramer, CalCars

The Opportunity

States, cities, corporate fleet owners, utilities, vehicle manufacturers, transportation network companies, and other private-sector innovators have the power to substantially increase the rate of EV deployment, particularly when they work together.

- **State ZEV targets:** States can set and expand proactive ZEV policies and regulations. As discussed in Chapter 2, 10 states have already adopted the ZEV regulation program goals to enhance vehicle availability and support overall ZEV deployment. Additional states can follow in the footsteps of these leading states to adopt the same goals. States with ZEV program goals can collaborate with cities and businesses to complement state-level programs and accelerate deployment of EVs.
- **Group procurement can drive down EV costs:** Cities and counties can work directly with manufacturers to organize a "group buy" in which public-sector organizations or residents of their areas are able to take advantage of a large discount on EVs if they go through a certain dealer, typically within a specific window of time. This approach can save up to 25 percent on the price of a ZEV.[166]
- **Educate and promote:** Cities and states with substantial EV incentives and outreach activities often have higher rates of EV penetration.[167] Education and advertising programs, opportunities to test-drive electric vehicles, and carshare programs can address common customer concerns such as range anxiety and demonstrate the benefits of EVs to potential consumers. By gathering around a common cause, these organizations can share the program costs, pool resources, and expand reach and influence.
- **Expand charging infrastructure:** To scale up EVs, the 38 percent of Americans who own or rent units in multifamily buildings will need the ability to charge their vehicle. This can be achieved on-site by requiring developers of new or renovated multifamily buildings to install charging stations. More generally, states and cities have a major role to play in working with private developers and utilities to build out public charging infrastructure access points, especially direct current fast charging (DCFC), which charges EVs at a much higher speed than other options, as well as incentivizing workplace charging options.

An Example of These Approaches at Work

Los Angeles Mayor Eric Garcetti pioneered BlueLA, the nation's first all-electric carshare program designed to serve low-income residents. BlueLA exemplifies a successful public–private partnership with a comprehensive community outreach and engagement process. The program is a unique blend of leveraged funds from California's cap-and-trade program, a local city match, and the backing of a committed carshare operator identified through a competitive solicitation to the private sector. Stations are located throughout some of LA's most disadvantaged neighborhoods, and members of the local community are employed by BlueLA to lead on outreach and education. The program is expected to take at least 1,000 vehicles off the road by 2020 while saving Angelenos money and giving them high-quality, affordable, and clean mobility options.

HFCs

HFCs have been the fastest-growing greenhouse pollutant, growing by more than 50 percent between 2005 and 2017.[168] HFCs are such potent greenhouse gases that the landmark 2016 Kigali Amendment to the Montreal Protocol to phase them down could prevent as much as 0.5 degrees Celsius of warming by the end of the century. But stalled federal policy places greater importance on real economy actors to fill the ambition gap and forge ahead on key actions to cut these harmful pollutants.

We estimate that increased real economy actions could cut 2025 HFC emissions an additional 5 percent below 2015 levels (through implementation of *Climate Action Strategies*) and an additional 16 percent (through implementation of full *Enhanced Engagement*) below 2015 levels (see Figure 3-5).[169]

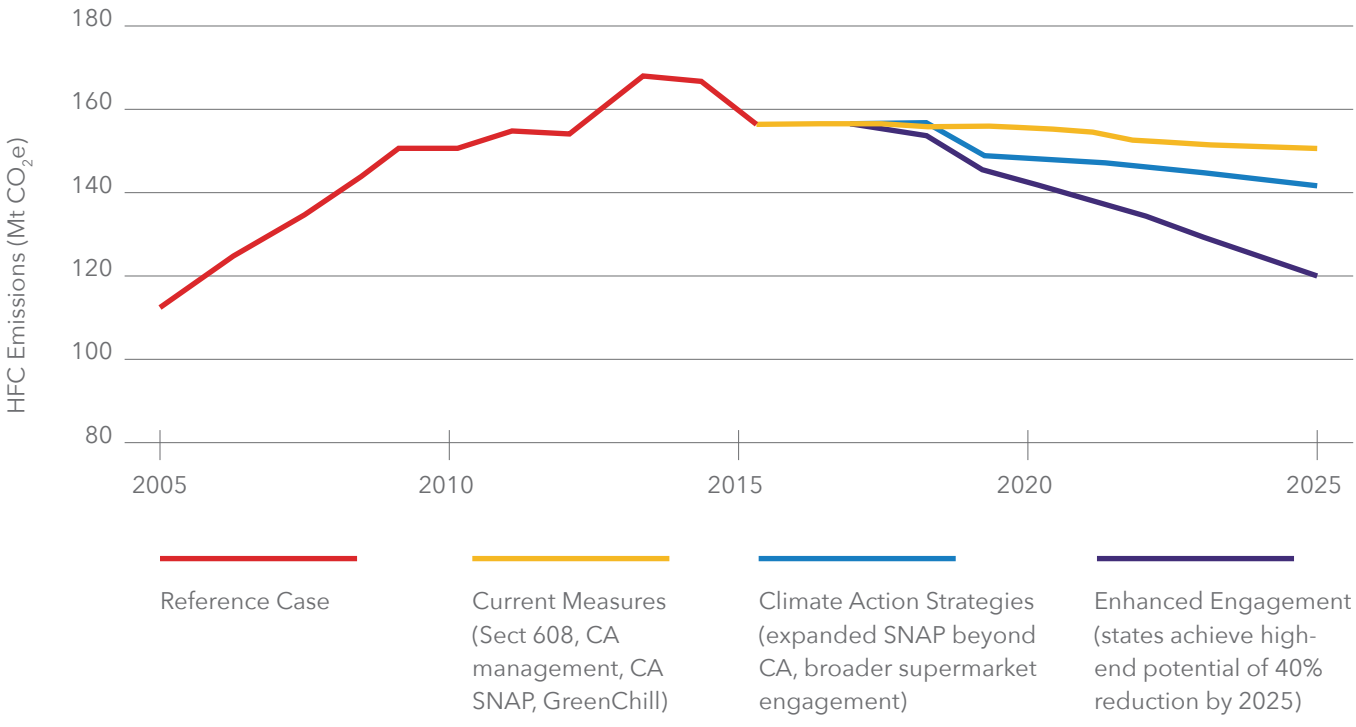
ACCELERATING PROGRESS

We estimate that increased real economy actions could cut 2025 HFC emissions an additional

5-16% below 2015 levels

(through implementation of *Climate Action Strategies* and *Enhanced Engagement*)

Figure 3-5: Through the Climate Action Strategies and Enhanced Engagement, Real Economy Actors could cut HFC Emissions an Additional 5-16 percent below 2015 levels by 2025



Source: ATHENA modeling outputs

Note: Figure relies on a potentially conservative estimate of BAU HFC emissions. Given the uncertainty of future HFC emissions, the abatement impact of non-federal actions may be larger than represented in this figure. More information on baseline projections used in this analysis can be found in this report's technical appendix.

Levers of Change

State and business actions can set the United States back on track to meet its obligations under the Kigali Amendment and achieve even greater reductions by expediting the phasedown of harmful HFCs across the full range of end-uses and capturing legacy pollutants from leaks and end of life. Specifically, these levers include:

- Adopting state HFC standards (such as California's Significant New Alternatives Policy [SNAP] program) and partnering with businesses and manufacturers that are already transitioning away from super-polluting HFCs to remain competitive in international markets (discussed in Climate Action Strategy #6 below);
- Working with businesses, including supermarkets, to expand participation in voluntary refrigerant-leak management programs by providing technician training and education of co-benefits (discussed in Climate Action Strategy #6 below);
- Incentivizing businesses and residences to switch to HFC alternatives; and
- Improving HFC inventories and monitoring, reporting, and verification of emissions.

Although the actions included in Climate Action Strategy #6 highlight significant potential and build on existing efforts, up-front costs for alternative refrigerants remain high, and there is a general lack of familiarity and training in key sectors. Real economy actors will have to work collaboratively across sectors to identify alternative options and build capacity in order to achieve greater emissions reductions for HFCs. However, if all states set more ambitious policies similar to the California SNAP rule and achieve a 40 percent reduction from 2013 levels by 2030, the United States could reduce HFC emissions by an additional 15 million metric tons of carbon dioxide equivalent (Mt CO_2e) beyond current measures by 2025.

Economic and Health Benefits of Phasing Down Use of HFCs

The HFC industry is already headed toward a low-GWP future. American companies have brought many low-GWP alternatives to market, and the Kigali phasedown schedule has strong industry backing.[170] In 2015, the Air-Conditioning, Heating, & Refrigeration Institute (AHRI, which represents 90 percent of related U.S. manufacturing) committed $5 billion through 2025 in R&D and capital investment to commercialize efficient equipment that uses next-generation refrigerants.[171] Moreover, a recent analysis commissioned by AHRI and the Alliance for Responsible Atmospheric Policy found that 1,400 jobs and $1 billion in capital investment could be at risk if Kigali is not ratified and the United States cedes its leadership in this space.[172] The same analysis found that implementing the HFC phasedown schedule outlined under the Kigali Amendment would lead to the creation of 33,000 jobs and $38.3 billion per year in economic impact.[173] In addition, transitioning to low-GWP alternatives and reducing refrigerant leaks not only reduces HFC emissions, but also increases efficiency and helps save on energy costs.

CLIMATE ACTION STRATEGY #6

Phase down super-polluting hydrofluorocarbons (HFCs)

California's actions, including the March 2018 SNAP rule, demonstrate the opportunity for states to drive progress themselves. California has set out to reduce HFC emissions by 40 percent from 2013 levels by 2030 in supermarket refrigeration and other refrigeration uses. Its recent ban on the use of HFCs in certain sectors would prevent 2.7 million Mt CO_2e emissions annually by 2025, but its rules can also be expanded to cover additional end-uses, including aerosol propellants.

Expanding the California SNAP program to include aerosols, growing this program to include additional U.S. states (including all U.S. Climate Alliance states) representing roughly 54 percent of U.S. HFC emissions, and expanding the EPA's GreenChill program could reduce HFC emissions below 2015 levels an additional 5 percent beyond current policies in 2025. In addition to addressing a potent greenhouse gas, the phasedown of HFCs could lead to increased energy efficiency for end-use products. As stated in a California Air Resources Board (CARB) analysis, transitioning to low-GWP equipment could improve the efficiency of refrigeration systems by 10–18 percent.[174] These efficiency improvements would save money on energy bills and lead to additional reductions of GHG emissions as a result.

The Opportunity

The U.S. Climate Alliance, which released a statement of its commitment to reducing short-lived climate pollutants in June 2018, could adopt the California SNAP standards on HFCs. These states make up more than 30 percent of the U.S. HFC market.

Supermarket chains and associated suppliers are also key actors. Collaborative campaigns involving states, cities, and supermarket chains can encourage additional commitments across the supermarket industry. These efforts can complement existing or new state and city policies, which may include updating building codes and providing incentives for converting to new or retrofitted HFC-free air conditioning systems. These policies can be enhanced by programs that support training and education on HFC alternatives and their co-benefits (as the EPA's GreenChill program has done). The Consumer Goods Forum established an initiative to reduce HFCs associated with refrigeration, and to date its members have installed low-carbon refrigeration systems in over 4,000 supermarkets.[175]

Example of This Approach at Work

After a federal court blocked a portion of the EPA's authority to regulate HFCs, CARB was left in a bind because of its reliance on the EPA's Significant New Alternatives Policy rules to help meet California's preexisting emissions reduction goals for HFCs, which in turn are important in ensuring California ultimately meets its larger climate goals. "As a result of the recent court decision, California had to pass its own regulation to ensure it could meet these goals," CARB said in a statement.

The regulation CARB promulgated in March 2018 affects certain stationary refrigeration and foam end-uses. It preserves emissions reductions from specific sectors with past or shortly upcoming compliance deadlines and will "prevent manufacturers from backsliding or [starting to use] high-global warming HFCs again," according to the CARB statement. The regulation applies mainly to equipment manufacturers, which cannot use prohibited HFCs in new refrigeration equipment or foams.

Prohibited HFCs cannot be used in new equipment and materials in California for the following end-uses:

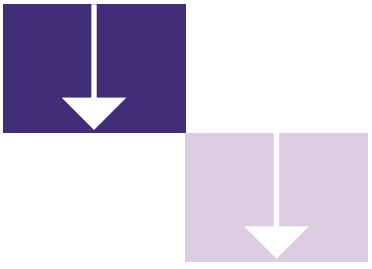
- Supermarkets and remote condensing units used by convenience stores;
- Refrigerated food processing and dispensing equipment, such as Slurpee machines and frozen yogurt dispensers;
- Stand-alone or small self-contained refrigeration units;
- Refrigerated vending machines; and
- Foams used in buildings and other places.

Oil and Gas Methane

Oil and gas operations are responsible for more methane emissions than any other source in the United States.[176] Methane emissions originate from both the wellhead and throughout the distribution system, and recent analysis indicates that we may be underestimating the full emissions impact.[177] As highlighted in Chapter 2, real economy actors have already begun to address these sources by enacting policies to upgrade equipment and limit fugitive methane leaks. In addition, recent advancements in technology, led by collaborations between industry, local policymakers, and technology providers, are making leak detection cheaper and more effective.

Through these measures alone, we estimate that real economy actors could go beyond current state and federal-level policies to reduce emissions by an additional 6-14 percent (through implementation of *Climate Action Strategies* and *Enhanced Engagement* scenarios respectively), relative to 2005 levels (see Figure 3-6).

ACCELERATING PROGRESS

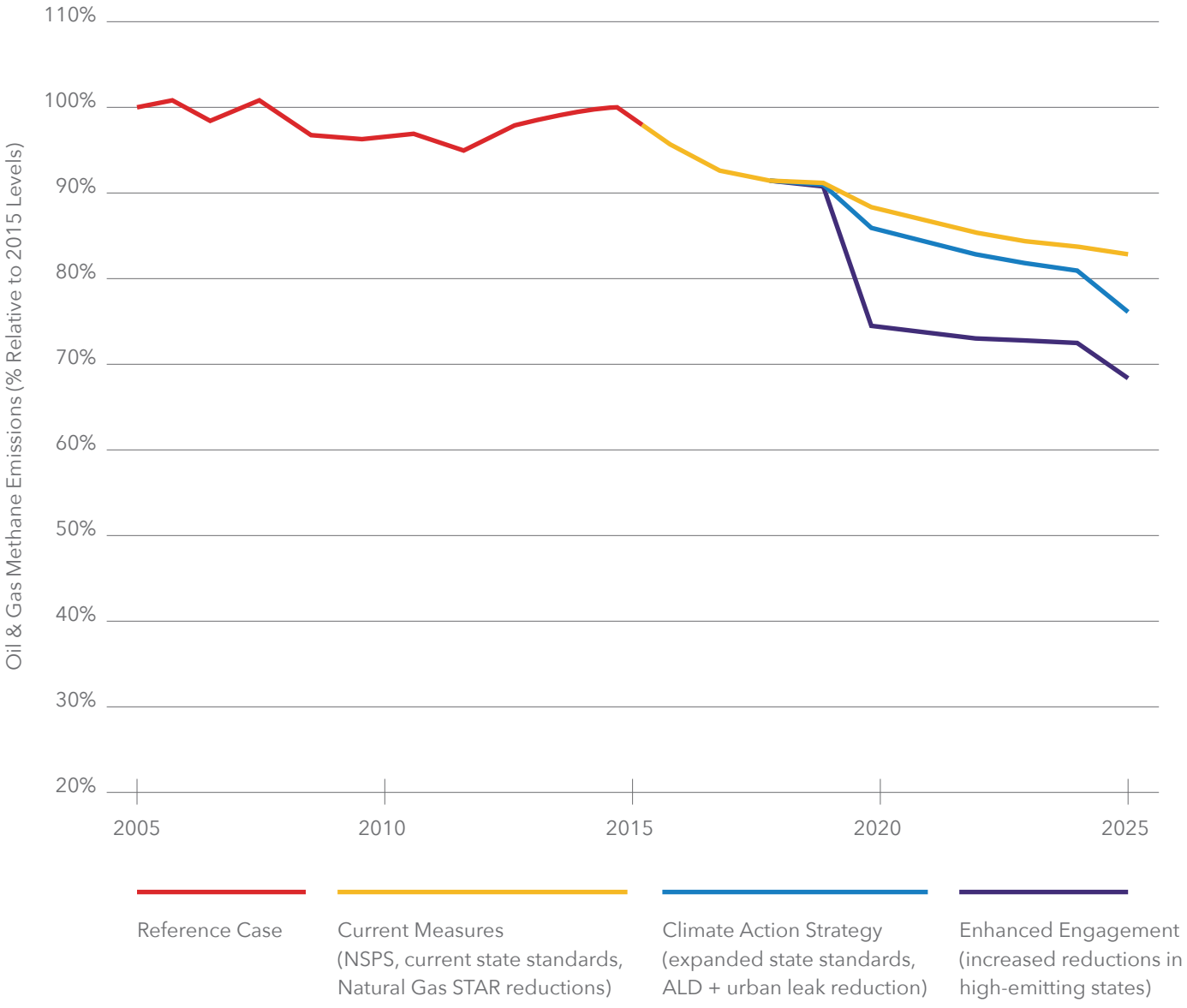


We estimate that real economy actors could reduce oil and gas methane emissions by an additional

6-14%

(through implementation of *Climate Action Strategies* and *Enhanced Engagement* scenarios respectively), relative to 2005 levels by 2025.

Figure 3-6: Real Economy Action can cut Oil and Gas Methane Emissions an Additional 6-14 percent below 2005 levels by 2025



Source: ATHENA modeling outputs

Levers of Change

Monitoring for fugitive methane leaks is one of the most powerful and low-cost interventions with which to mitigate emissions; it is a cornerstone of existing oil and gas standards in states such as Colorado and California. In addition to setting equipment and leak detection and repair (LDAR) standards, we explore two commonsense solutions for cutting methane emissions at different points along the supply chain in Climate Action Strategies #7 and #8 below. In addition, improved leak monitoring, which can be performed using satellite imaging, is critical to detecting and rapidly repairing these leaks early. This is a tool that real economy actors can readily ramp up in the coming years. For instance, a NASA pilot program helped California pinpoint 300 major sources of methane across the state.[178] States, academic institutions, utilities, and businesses can build on this blueprint to advance research and develop better tools that effectively measure and monitor methane leaks.

Economic and Health Benefits of Cutting Oil & Gas Methane Emissions

Addressing oil and gas operations will have an immediate impact on criteria and climate pollutants. Mitigating gas leaks has safety benefits and improves environmental welfare. Furthermore, adopting technologies to prevent methane leaks can provide oil and gas businesses with a competitive advantage by decreasing inefficiencies that affect sales.[179] According to the EPA, voluntary measures taken to reduce emissions have already led to an increase of over $264 million in revenue from natural gas sales for businesses.[180] In 2017, the Environmental Partnership was launched by American Petroleum Institute, with 26 other companies such as BP and Shell, to reduce methane leaks from operations. Participating companies began implementing the voluntary program as of January 1, 2018. A 2012 Natural Resources Defense Council (NRDC) study of the cost savings opportunity if legislation or standards moved the entire industry to use best practices found that it would generate revenue of more than $2 billion annually (at gas prices of $4 per thousand cubic feet).[181]

CLIMATE ACTION STRATEGY #7

Stop methane leaks at the wellhead

Recent scientific studies have shown that methane leaks associated with the exploration, production, and distribution of oil and especially natural gas are far higher than initially estimated. But those studies also show that because of the value of the natural gas recovered, simple leak detection and repair strategies can cut over 40 percent of these emissions. **California, Colorado, New Mexico, Ohio, Pennsylvania, Utah, and Wyoming** plan to put in place regulations or permitting programs to address emissions from oil and gas production facilities. There is an opportunity for other states to follow in their footsteps and drive action on methane now. In addition to reaping the climate benefits, such states can increase the efficiency of natural gas production, with the royalties and tax revenue that it brings. In support of adopting state-level standards, collaborations among real economy actors can develop and pilot innovative approaches in order to detect and repair leaks at oil and gas exploration and production sites.

We estimate that this Climate Action Strategy can reduce methane emissions in these states by an additional 6 percent beyond *Current Measures* in 2025. In addition to addressing methane emissions, these actions will help remove other harmful pollutants that are released into the atmosphere contributing to poor air quality and public health issues.

The Opportunity

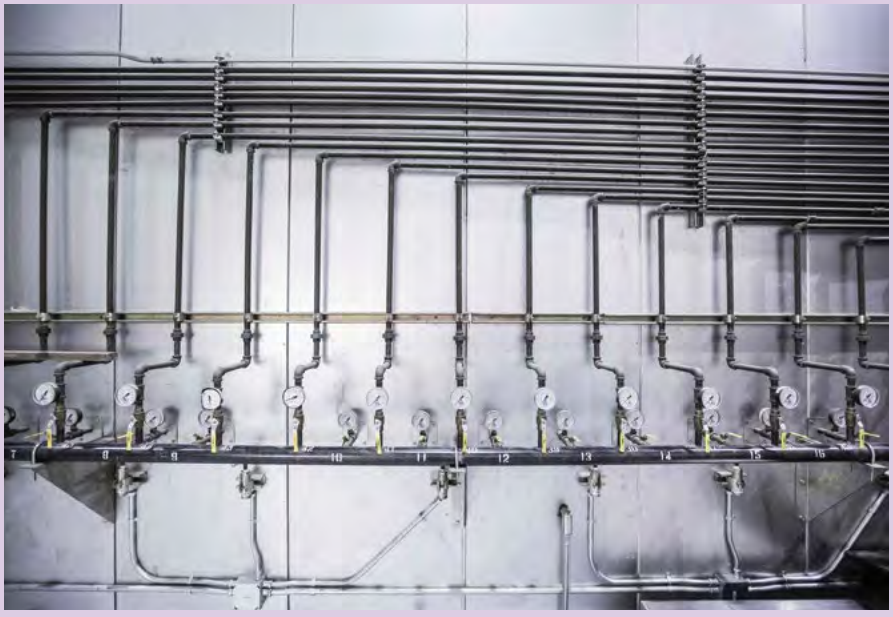
States, supported by industry, environmental groups, and broader campaigns, can:

- Put in place important regulations and/or permitting programs to manage methane emissions from oil and gas facilities.
- Collaborate to develop and scale up new technologies and approaches to detecting and repairing methane leaks. The Methane Detectors Challenge (MDC) is a partnership between the Environmental Defense Fund, oil and gas companies, technology developers, and other experts with the goal of accelerating the development and commercialization of methane detection technologies. The collaboration has developed several new technologies, has performed field testing, and is now working to pilot them at scale.
- Commit through regional initiatives to address methane emissions. Recently, the Western Governors' Association—made up of governors from 19 Western states—announced a policy resolution recognizing the benefits of taking action to address methane pollution from oil and gas facilities. State collaborations can encourage additional action and help apply existing policies and programs to a broader set of actors.

Example of This Approach at Work

Last June, Pennsylvania Governor Tom Wolf delivered on a key promise, enacting general permit conditions for new well sites and major emissions sources in the midstream sector. Pennsylvania plays a critical role as the second-largest gas-producing state in the nation. This move is vital not only for the tons of pollution it will prevent from escaping into the atmosphere but also for its value in demonstrating that methane solutions are both cost-effective and politically feasible. Governor Wolf has also committed to proposing new rules for existing sources in 2018, protections that are sorely needed to ensure that pollution from the roughly 70,000 wells already operating in the Commonwealth does not go unaddressed.

CLIMATE ACTION STRATEGY #8



Reduce methane leaks in cities

Methane leaks not only at the wellhead, but from pipes throughout communities. Between 173,000 and 519,000 Mt CO_2e leaks from natural gas distribution systems each year. Much of this infrastructure exists underground in large cities and is controlled by local utilities supplying natural gas for heating, cooking, and other energy uses. Detecting and repairing leaks in this vast system can be difficult and costly. But through the use of innovative technologies, improved partnerships, and advanced analytic methods, including leak quantification, real economy actors can revolutionize the way utilities repair and abate leaks—driving down the cost of detection and repair while achieving greater reductions.

By using innovative, data-driven approaches to identify and prioritize the repair of the top 20 percent of leaks in the eight states with the highest leakage, we estimate that this Climate Action Strategy could cut nationwide distribution system emissions by 30 percent by 2025. This would equate to 3 Mt CO_2e in avoided urban methane emissions each year.

The Opportunity

Working with urban gas distribution utilities in the eight states that account for 85 percent of leak-prone pipe (California, Michigan, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, and Texas), cities, utilities, and commercial service providers can develop and implement plans to use advanced leak detection and data analytics (ALD+) to identify and abate the largest leaks. The ALD+ approach provides benefits to ratepayers, utilities, regulators, and the environment by allowing smarter and more cost-effective utility leak abatement programs. It also improves the rationale for utility expenditures and state approvals for utility leak-prone pipe replacement programs. This approach has been piloted with several utilities, with proven results, and is now being offered by commercial utility leak service providers.

Example of This Approach at Work

EDF developed and piloted this approach working in collaboration with New Jersey's largest natural gas utility, Public Service Electric & Gas (PSE&G). Using leak data collected by EDF and Google Street View vehicles equipped with advanced leak detection sensors, PSE&G was able to prioritize leakage repairs as part of a large-scale $905 million pipe replacement program. PSE&G achieved an 83 percent reduction in leakage and replaced one-third fewer miles of gas lines than would have been needed to achieve the same result using industry standard approaches for leak detection.

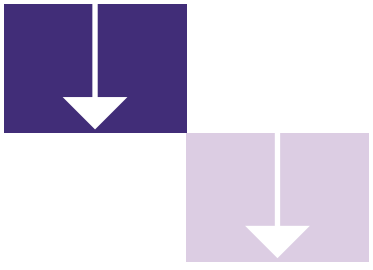
Natural and Working Lands

Maintaining and enhancing a strong land-sector sink is essential to cost-effectively achieving long-term climate goals. Yet the role of the land sector to serve as a carbon sink is increasingly threatened by drought, disease, wildfire, invasive species, and urban development. This challenge is compounded by the fact that land uses vary across ecosystems and are owned and managed by millions of individual farmers, ranchers, foresters, and public and private institutions. Furthermore, land-sector monitoring and measurement tools are grossly inadequate to provide the precision necessary to track changes in this sector with confidence.

Land-sector strategies offer mitigation, adaptation, and sequestration benefits in the same low-cost investment. These mitigation opportunities provide added benefits to farmers and rural communities by improving productivity and cutting down on waste while also improving environmental conditions, including enhancing biodiversity, water quality, and air quality. For these reasons, these opportunities may be attractive to states, cities, and businesses for climate as well as non-climate purposes. However, this sector also illustrates the urgency of bringing the federal government back as a positive partner in curbing climate change; federal farm policy, particularly poorly managed disbursement of agricultural subsidies, significantly impedes improvements in landscape carbon storage.

In total, we estimate that through state, city, and business actions, it is possible to bolster the land carbon sink by 60 Mt CO_2e through implementing the *Climate Action Strategies* scenario and 100 Mt CO_2e by 2025 through the *Enhanced Engagement* scenario. Realizing the full sequestration potential of the land sector is a long-term endeavor requiring immediate scale-up to allow forests and soil carbon sequestration the decades needed to mature and to allow land managers the opportunity to learn and adopt new strategies. In addition, roughly tripling the number of farmers and ranchers who have installed methane digesters from nearly 300 to 1,000 could realize an additional reduction of 10 MT CO_2e by 2025.

ACCELERATING PROGRESS



We estimate that through state, city, and business actions, it is possible to bolster the land carbon sink by

60-100 Mt CO_2e

and reduce emissions from farms and feedlots by

0-10 Mt CO_2e

through implementing the *Climate Action Strategies* and *Enhanced Engagement*

Levers of Change

To date, few actions have focused on this sector, resulting in a significant amount of untapped potential—in part owing to challenges associated with measuring and monitoring carbon flux in the land sector. Achieving land-sector targets requires building strong coalitions across local, state, and regional levels. These levers include:

- Establishing state-level programs that engage state and local governments, businesses, and communities in improving forest management, tree cover expansion, and soil health;
- Preserving forestland by increasing conservation designations and pursuing smart-growth development policies aimed at addressing development pressure;
- Investing in natural and working lands' GHG inventories and other measuring and monitoring programs, including remote sensing, to track progress;
- Collaborating with city officials and residents to preserve and expand urban forests through planting and tree-retention ordinances;
- Enhancing opportunities for land-use and natural resources management at the landscape and watershed level by enabling multi-jurisdictional planning and regulation; and
- Working with farmers by providing incentives and education to promote emissions reductions and sequestration through fertilizer management, crop changes, conservation tillage, and waste reduction.

Much of the potential for impact lies in innovative forest-based interventions, which provide significant carbon storage both above and below ground. States can provide incentives and tools to cities and landowners to help them improve forest management—increasing the carbon productivity of existing forests by managing them for forest health and resilience in the face of inevitable climate change, increasing rotation age in timberlands, actively replanting with resilient, native species after harvest, changing species composition, and other measures. Reforestation of lands threatened by conversion could provide similar increases in carbon sequestration.

Improved agricultural practices such as planting cover crops, converting marginal croplands to grasslands, adopting no-till policies, and improving the productivity of rangelands can

increase the carbon stored in soils (with a technical potential of 200-300 Mt CO_2e of incremental storage per year).[182] Additional measures such as planting higher-residue crops and perennials, adding manure or compost to soils, avoiding burning agricultural slash, and planting legumes in pastures can support GHG reduction goals and sequester carbon. Integrating trees into agricultural systems by establishing forested riparian buffers and wind breaks could sequester several hundred million tons of carbon dioxide per year without significant displacement of food production. Finally, actions by farmers and livestock managers involving better application of fertilizer and treatment of livestock manure can curtail nitrous oxide and methane emissions.

CLIMATE ACTION STRATEGY #9

Develop regional strategies for carbon sequestration on natural and working lands

States and businesses, nurtured with support from coalitions of philanthropies and NGOs, can spark regional initiatives appropriate to the variety of ecosystems that span the American continent. If successful, these regional initiatives could become a focal point for future federal policy, while providing significant benefits for rural economies, agricultural productivity, water resources, habitat, and recreation.

California's existing natural and working lands policy goals are designed to increase carbon abatement within the state's forests, crops, other lands, and soils, resulting in an additional emissions reduction of 15–20 Mt CO_2 by 2030.[183] Through additional action as outlined in this strategy, we conservatively estimate that actions on natural and working lands by California and other states could reasonably drive additional carbon sequestration of 60 Mt CO_2 by 2025. This is an ambitious, but achievable, estimate of this strategy's potential, based on focused studies: In 2005, the EPA's nationwide modeling found that afforestation, reforestation, and forest and agricultural soil carbon management could increase sequestration in 2025 by nearly 90 Mt CO_2 at a nominal carbon price of $1 per ton, and approximately 260 Mt CO_2 at a price of $5 per ton; in addition, a 2016 study found that land management strategies in California alone could bolster carbon sequestration by an incremental 40 Mt CO_2 by 2030.[184]

The Opportunity

Deploying carbon-beneficial practices across a large majority of U.S. forestlands, croplands, and grazing lands will require improved data, new monitoring systems, and scalable incentive mechanisms to elevate deployment from one-off transactions at the farm level or forest level to efficient landscape-level programs. States, local governments, and businesses can lay the foundations for this vision by:

- Establishing state-level programs for forest management, tree cover expansion, and soil health;
- Committing to science-based targets for GHG emissions and removals in agricultural for forest product supply chains; and
- Investing in measurement and monitoring systems to target efforts and track progress.

These actions have the potential to force policy transformations that extend beyond state boundaries. For instance, by increasing the availability of agricultural products meeting climate-related corporate purchasing standards, first-mover states can enable broader adoption of such standards while boosting the competitiveness of in-state producers.

Philanthropies and NGOs can catalyze and support these efforts by conducting outreach and providing technical assistance for policy and program development, engaging landowner groups, developing public–private partnerships for incentive delivery mechanisms, and seed-funding innovative incentive programs with grants and program-related investments.

Example of This Approach at Work

Forests present the largest opportunity for carbon sequestration in the North American land sector, and currently absorb and sequester roughly 10–15 percent of total U.S. carbon emissions each year. Of the 750 million acres of forest in the United States, over half is privately owned; 61 percent of private ownership (265 million acres) is in the hands of individuals and families in tracts over 10 acres in size. Unfortunately, the United States is slowly losing its forests, and many remaining forests are in a degraded state due to unsustainable harvesting, forest health issues including fires, and expanding development.

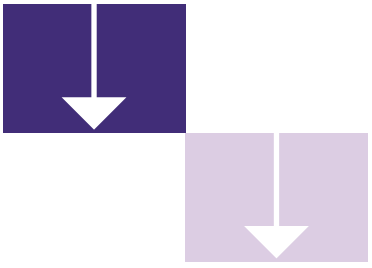
In partnership with a wide range of private landowners, The Nature Conservancy (TNC) of Pennsylvania launched a new program, Working Woodlands, in 2009 to accelerate large-scale forest protection and sustainable management by offering a new value proposition to forest landowners through forest certification and carbon markets. The program targets key landowner segments with a value proposition to protect forests through a working forest easement and agreement, Forest Stewardship Council (FSC) certification, and access to carbon markets. This model can help landowners achieve higher-performing forests, with better growth rates that produce higher-value wood products. Meanwhile, the forest is able to capture and store more carbon through improved forest practices. The additional carbon is quantified, verified, and sold to organizations or companies that wish to offset their carbon footprint, and the majority of the benefits flow to the landowner.

To date, in Pennsylvania alone, over 62,000 acres have been protected, restoration has been accelerated on 5,000 acres, and almost 3.5 Mt CO_2e of carbon will be sequestered over the life of the projects. Now, the model has been implemented in Tennessee, Michigan, and New York; eight other states are in early stages of project development. TNC aims to have 1 million acres in the program by 2025, sequestering an estimated 50 million tons over the life of the projects.

Emissions Limits and Market-Based Policy Frameworks

In concert with other policies and actions described above, states and other real economy actors, where appropriate, should seek to establish comprehensive and binding carbon pricing policies. Not only are such pricing-based frameworks the most comprehensive way to reduce emissions across an entire economy, but they can also ensure that major industrial sectors not otherwise covered by specific |policies contribute meaningfully to climate progress. If optimally designed, these frameworks can constitute effective complements to other, more targeted climate and energy policies. Evaluating existing emissions limitation policies, aspirational targets, and the potential for additional states to take action in the coming years, we estimate that establishing state caps on GHGs could reduce emissions 350 Mt CO_2e under the *Climate Action Strategies* scenario, and 390 Mt CO_2e in our *Enhanced Engagement* scenario by 2025.

ACCELERATING PROGRESS



We estimate that establishing state caps on GHGs could

reduce emissions 350-390 Mt CO_2e

by 2025 (through implementation of the *Climate Action Strategies* and *Enhanced Engagement*).

Levers for Change

A nationwide GHG emissions limit and pricing system would ultimately be more efficient than a patchwork of separate market-based mechanisms, but states can and must step up in the near term to create and scale carbon markets that could grow to encompass additional sectors and larger geographic regions over time. By helping to achieve near-term reductions with the maximum flexibility and the greatest coverage, programs such as emissions caps and trading can demonstrate their effectiveness and value, building political support for economy-wide pollution limits. Real economy actors can:

- Establish statewide, city-wide, or business-wide science-based emissions reduction targets with concrete plans of action for how to deliver on these goals;
- Develop "trading ready" programs that can link up with programs in other states and provide for broader and more cost-effective reduction opportunities;
- Put a price on GHG emissions within specific sectors or across multiple sectors of the economy; and
- Account for the social cost of carbon when making policy and investment decisions.

Photo by Dennis Schroeder / NREL

Market-based policies with enforceable limits on pollution offer the assurance that emissions targets will be met. Failure to accurately and fully account for the costs of carbon pollution is the single broadest market failure contributing to climate disruption. Many other market failures will need to be directly resolved to enable the effective decarbonization of the economy. GHG pricing is not a silver bullet—and in many cases it may be of greatest value when used in conjunction with other policies, for instance, to advance research and development, particularly for relatively costly-to-deploy important early-state technologies. The distribution of revenues generated from GHG pricing also represents a politically and economically efficient tool to accelerate other reforms that reduce emissions and yield co-benefits, as California's experience with its AB 32 program revenues demonstrates.

CLIMATE ACTION STRATEGY #10

Photo by Anthony Zboralski

Form state coalitions for carbon pricing

We estimate that through this Climate Action Strategy, if a set of politically plausible states put into place a binding limit and implementation plan for GHG pollution consistent with U.S. targets under the Paris Agreement, the United States could reduce emissions by more than 350 Mt CO_2e by 2025.[185]

The Opportunity

States, cities, and businesses can aim to establish legally enforceable economy-wide limits on carbon pollution in geographically diverse states, with emissions targets consistent with the near- and long-term reductions necessary to achieve the goals of the Paris Agreement. These policies may be implemented through caps with emissions trading or tax and should look to existing successful policy frameworks such as California's cap-and-trade and Regional Greenhouse Gas Initiative (RGGI) as model policies to replicate. Today eight states have mandatory economy-wide GHG targets, and another eight states and the District of Columbia have aspirational GHG targets (e.g., set by executive order).

Additionally, regions with existing GHG markets can link with new emerging markets or broaden their markets to cover new sectors. For instance, RGGI covers only emissions from electric utilities, but some policymakers are looking at opportunities to expand the protocol to include transportation or establish a cap on transportation emissions under another program.

Finally, these real economy actors have the opportunity to increase the stringency of their existing emissions limits and pricing policies. As a result of the low price of natural gas and the declining costs of renewable energy, as well as policy drivers including federal clean air standards, power companies are on a much lower carbon trajectory than they were even five years ago. That reality creates new opportunities for utilities to make the transition from coal to clean energy while providing cost savings to their customers and setting even more ambitious targets than could have been imagined just a few years ago.

Example of This Approach at Work

Demonstrating how quickly a state can advance ambitious executive action, then Virginia Governor Terry McAuliffe deployed available air pollution control tools and issued an executive directive (on May 16, 2017) to the Department of Environmental Quality (VADEQ) requesting the development of a "trading-ready" regulation to limit carbon pollution from the power sector. After broad stakeholder outreach, a draft regulation awas formally proposed to the state's Air Pollution Control Board (APCB) in the fall of 2017. Governor Ralph Northam continued this climate leadership, shepherding the regulatory process along through his first year in office. A final regulation is expected to be compatible with the successful RGGI program and completed in time to facilitate compliance beginning in 2020.

Summary

As demonstrated in this chapter, states, cities, and businesses have only begun to approach the opportunities to cut emissions while growing the economy. Ambitious actions aimed at cleaning the energy system, restoring natural lands, and targeting non-CO_2 emissions have the potential to put the United States within range of its near- and long-term climate targets. And specific strategies oriented around discrete objectives can help lay the groundwork for increasingly ambitious targets over time.

Ultimately, meeting the goals of the Paris Agreement will require new investment in innovative technologies; rapid deployment of wind, solar, and electric vehicles; expanded policies covering all sectors of the economy; and a broadening of coalitions in support of ambitious climate action. It will require transformations of major sectors, such as the U.S. electric grid, urban buildings, and transportation infrastructure at an unprecedented pace. Leaders must challenge conventional wisdom and identify new strategies that will allow the United States to go farther faster while also inspiring others to heed the call to action. Actions such as those discussed in this section can enable the coalition-building necessary to begin to address the climate challenge.

Photo by Ken Oltmann/CoServ | U.S. Department of Energy, 431 024 010

Chapter 4

Pathways to America's Low-Carbon Future

As detailed in Chapter 2 of this report, on metric after metric (whether electric vehicle sales, coal plant closures, renewable energy deployment, or methane leaks), more actors than ever in the real economy are taking innovative, ambitious, and replicable steps to cut greenhouse gas emissions.

Impressive as these efforts are, it has always been clear that commitments to date will neither ensure that the United States meets its 2025 Paris target nor establish a sufficient foundation for long-term deeper decarbonization. Holding global warming to well below 2 degrees Celsius will require renewed engagement from all stakeholders and across all sectors, including the U.S. federal government. It is equally clear that actors in the real economy have a wide range of opportunities to greatly accelerate decarbonization in ways that will drive U.S. emissions steadily toward meeting both the country's 2025 pledge under the Paris Agreement and the long-term, science-based decarbonization goals. Most of these *Climate Action Strategies* and opportunities for enhanced ambition also deliver substantial public health and economic benefits, such that pursuing them is not only vital for climate security, but beneficial for the organizations that lead the way to a low-carbon future. But change is always difficult; incumbent players with substantial equity in fossil fuel supply chains will resist those assets being stranded and seek to influence national politics to defend their interests.

This puts the United States at a critical juncture. Dedicated leadership from

citizens, governors, mayors, and businesses, combined with the cumulative impact of previous and remaining federal policies, has helped achieve significant emissions reductions to date and set the stage for even greater ambition in the years ahead. Using a novel method to estimate the emissions reductions from real economy actors, we project that through sustained state, city, and business leadership, the United States could come within striking range of meeting the U.S. climate target under the Paris Agreement. Central projections find that the 10 *Climate Action Strategies* and the broader *Enhanced Engagement* scenarios would drive emissions 21 and 24 percent, respectively, below 2005 levels by 2025 (see Figure 4-1). Given the uncertainty that attends all projections of future emissions, the actual potential from real economy actors could be either higher or lower than these central estimates, and these uncertainties are discussed in more detail in this chapter. Moreover, the scenarios indicate that these real economy actions would accelerate the decarbonization of the U.S. economy between 2025 and 2030.

Photo by Dennis Schroeder/ NREL

Discussion of Results

The analysis for this report modeled three scenarios reflecting different pathways of climate ambition and broadly aligned with the levels of ambition discussed throughout this report: *Current Measures, Climate Action Strategies,* and *Enhanced Engagement*. In this analysis, we generated central estimates for these three pathways (or scenarios) that reflect the outcome of one plausible set of core assumptions. We also generated a range of outcomes for each scenario reflecting plausible alternative assumptions about many key uncertainties that could influence future emissions—energy prices, technology costs, economic growth, and land sector sinks.

Modeling of the three scenarios yields central estimates of emissions reductions as follows (see Figures 4-1 and 4-2):

- *Current Measures:* 17 percent below 2005 levels by 2025 (range of 12–22 percent) and 20 percent by 2030 (range of 13–27 percent)
- *Climate Action Strategies:* 21 percent below 2005 levels by 2025 (range of 16–26 percent) and 26 percent by 2030 (range of 18–32 percent)
- *Enhanced Engagement:* 24 percent below 2005 levels by 2025 (range of 20–30 percent) and 32 percent by 2030 (range of 23–38 percent)

Note that economy-wide emission reduction estimates throughout this report have been rounded to the nearest percentage point.

2016 Emissions

Between 2005 and 2016—the latest EPA U.S. GHG inventory—U.S. emissions declined by 12 percent, or nearly halfway to the lower bound of the emissions target under the Paris Agreement.[186] This emissions reduction occurred in tandem with overall economic growth of more than 18 percent during that same period.[187]

Economic Growth 2016–25

Between 2016 and 2025, overall emissions would be expected to grow by some range, with the center of the band at roughly 200 Mt CO_2e, driven by economic expansion and population growth. As discussed in detail below, we assume 1.9 percent annual economic growth and 0.8 percent annual population growth, in line with the April 2018 U.S. Congressional Budget Office (CBO) analysis.

Between 2005 and 2016

U.S. emissions declined by 12%

nearly halfway to the U.S. NDC

Current Measures:

17% below

2005 levels by 2025

Climate Action Strategies:

21% below

2005 levels by 2025

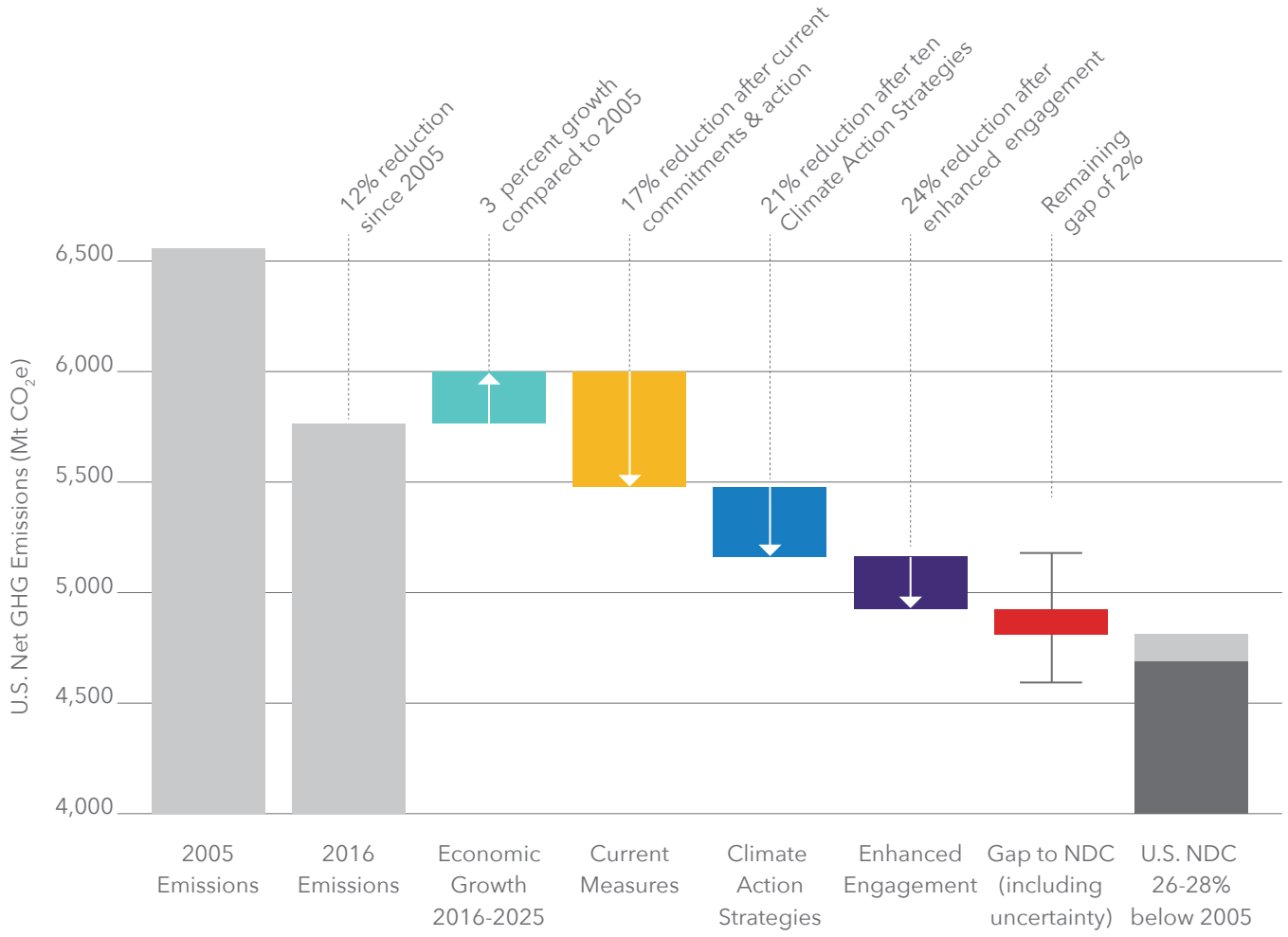
Enhanced Engagement:

24% below

2005 levels by 2025

Photo by Sameer Halai, Co-Founder of SunFunder Solar Company: Gigawatt Global

Figure 4-1: America's Pledge Analysis Demonstrates that States, Cities, and Businesses Can Significantly Cut U.S. Emissions in 2025 (Mt CO_2e)



Climate Action Strategies:

#1: Double down on renewable energy targets

#2: Accelerate the retirement of coal power

#3: Encourage residential and commercial building efficiency retrofits

#4: Electrify building energy use

#5: Accelerate electric vehicle (EV) adoption

#6: Phase down super-polluting hydrofluorocarbons (HFCs)

#7: Stop methane leaks at the wellhead

#8: Reduce methane leaks in cities

#9: Develop regional strategies for carbon sequestration on natural and working lands

#10: Form state coalitions for carbon pricing

Source: Historical emissions data is from the U.S. EPA "Inventory of GHG Emissions and Sinks: 1990-2016"; projected emissions based on modeling from the America's Pledge research team

Current Measures

The *Current Measures* scenario reflects state, city, and business commitments announced as of June 2018. Factoring in this future economic and population growth, current federal, state, city, and business climate actions are projected to result in a 17 percent reduction in U.S. GHG emissions by 2025 compared with 2005, or an additional 5 percent reduction beyond 2016. This outcome would be roughly two-thirds of the way to the Paris Agreement pledge, but would fall short by roughly 600 Mt CO_2e. Plausible alternative assumptions about key factors such as future energy prices, technology costs, economic growth, and land sector sinks create uncertainty in the projections. Considering many of these key uncertainties, we find a broader range of possible reductions in the *Current Measures* scenario, from 12 percent to 22 percent.

Previous modeling exercises have already (and usefully) attempted to project the impact of U.S. actions to date on emissions through 2025 and 2030.[188] Our approach goes one step further. In creating the *Current Measures* scenario, the modeling team incorporated the policies, incentives, and public commitments listed in Chapter 2 as well as several additional existing policies. Because the *Current Measures* scenario assumes full compliance with all existing policies and concrete city and business commitments (including pledged targets), this underscores the importance of ensuring that real economy actors hold true to their pledge, continuing to implement on these policies and targets.

Falling GHG emissions in the power sector have been the primary factor in the reductions to date. Existing policies, such as federal incentives, the Regional Greenhouse Gas Initiative (RGGI), California's cap-and-trade, state renewable portfolio standards (RPS), and technology-based factors (such as growth in natural gas and renewables) continue to drive a substantial reduction (7 percent) from the power sector through 2025 in the *Current Measures* scenario. Owing to the relatively slow pace of fleet turnover, current policies will have a relatively small impact in transportation emissions by 2025. *Current Measures* also deliver modest levels of emissions reductions from non-CO_2 sources (e.g., methane, hydrofluorocarbons), which currently account for 21 percent of net emissions in the United States.

Climate Action Strategies

The *Climate Action Strategies* represent early-start actions that could be readily adopted by already motivated and engaged actors. The *Climate Action Strategies* alone would cut emissions by an additional 4 percent below 2005 levels compared with the *Current Measures* scenario, reaching 21 percent below 2005 levels in 2025 (16–26 percent range). This analysis assumes fully successful implementation of the *Climate Action Strategies* laid out in Chapter 3 while also assuming continuing full implementation of the policies in the *Current Measures* scenario. These actions could lay the groundwork for greater ambition (consistent with *Enhanced Engagement*) in the coming years.

Enhanced Engagement

Expanding from the *Climate Action Strategies* in terms of both the number of engaged real economy actors and the range of their interventions, the *Enhanced Engagement* scenario presents a top-end estimate of what can plausibly be achieved within realistic political and legal limits through state, city, and business actions in the 2025 time frame. Modeling the overall opportunity in the *Enhanced Engagement* scenario, including the broader set of actions defined in Chapter 3, indicates that real economy actors can put the United States within striking range of achieving the original Paris Agreement target. The central projection for the *Enhanced Engagement* scenario leads to a reduction of more than 24 percent below 2005 levels in 2025.

Current federal and real economy commitments, combined with market forces, will

drive U.S. emissions to 17% below 2005 levels by 2025, roughly 2/3 of the way to the original U.S. target

Gap to NDC

The gap between the *Current Measures* scenario and the lower bound of the U.S. nationally determined contribution (26 percent) would be substantial—9 percent of total U.S. emissions, or approximately 600 Mt CO_2e. The actions led by real economy actors in the *Enhanced Engagement* scenario narrow that gap substantially, to 100 Mt CO_2e (see Figure 4-2). This would be within striking distance of the Paris pledge, making the 26 percent threshold achievable shortly thereafter. Any number of combinations of federal actions could resolve the remaining gap, though time is short to 2025 and national political outcomes are difficult to predict. One significant finding of the modeling is that these actions will continue (and even accelerate) emissions reductions through 2030.

This result is compatible with the emissions projections presented by the Obama Administration to the global community in its 2016 Biennial Report to the United Nations Framework Convention on Climate Change (UNFCCC). They demonstrate that the U.S. target for 2025 is a stretch goal, but achievable with concerted effort. But whereas the Obama Administration's 2025 projections assumed continued, and indeed enhanced, federal engagement in the period from 2017 through 2025, our analysis demonstrates that during the current hiatus in federal leadership, real economy actors can maintain the momentum of the nation's decarbonization trajectory for 2025 and beyond.

Furthermore, the annual rate of decarbonization in the *Enhanced Engagement* scenario is 1.6 percent between 2016 and 2025, accelerating to 2.1 percent for 2025–30. This is substantially higher than the historical 1.1 percent rate for the period 2005–2016.

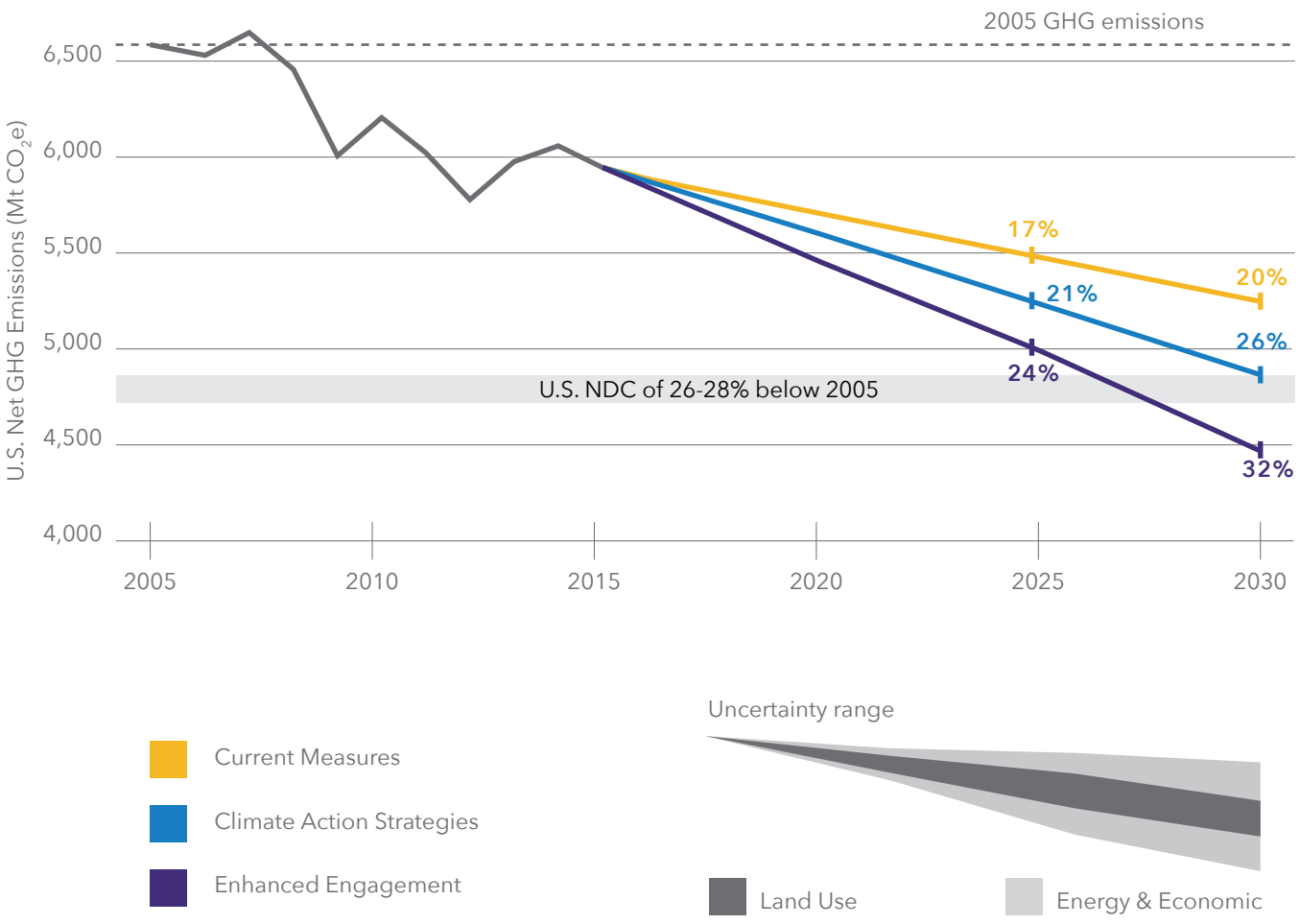
Photo by Michael Nothum

The post-2025 trajectory approaches the rate of decarbonization needed to hit 80 percent below 2005 levels by 2050 (2.3 percent).[189] This accelerated rate of decarbonization is attributed to the fact that several sectors of the economy—transportation and buildings, for example—have long lead times for capital turnover. Policies put in place between now and 2025 will deliver the bulk of their emissions reduction benefits only after 2025, and will continue to have an effect after 2030 as buildings, fleets, industrial processes, and other infrastructure components are modernized.

Federal reengagement undertaken as rapidly as possible will be essential in sustaining and accelerating the needed breadth and depth of emissions reductions across all sectors of the U.S. economy, both to close any remaining gap in 2025 and for long-term decarbonization.

As we move onward from the Paris pledge, this momentum in turn sets the stage for more rapid decarbonization between 2025-30

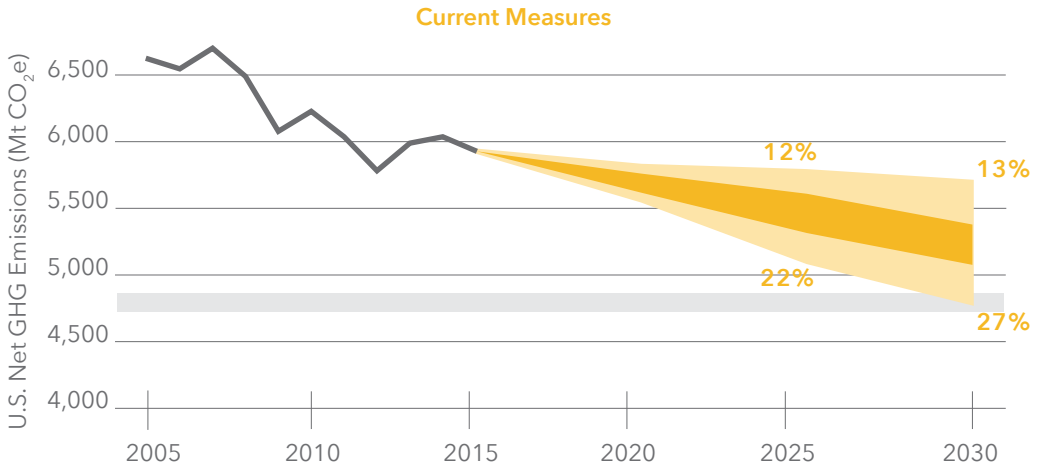
Figure 4-2: Progress Toward Near- and Long-term Climate Goals Varies Across the Three Scenarios (Mt CO_2e)

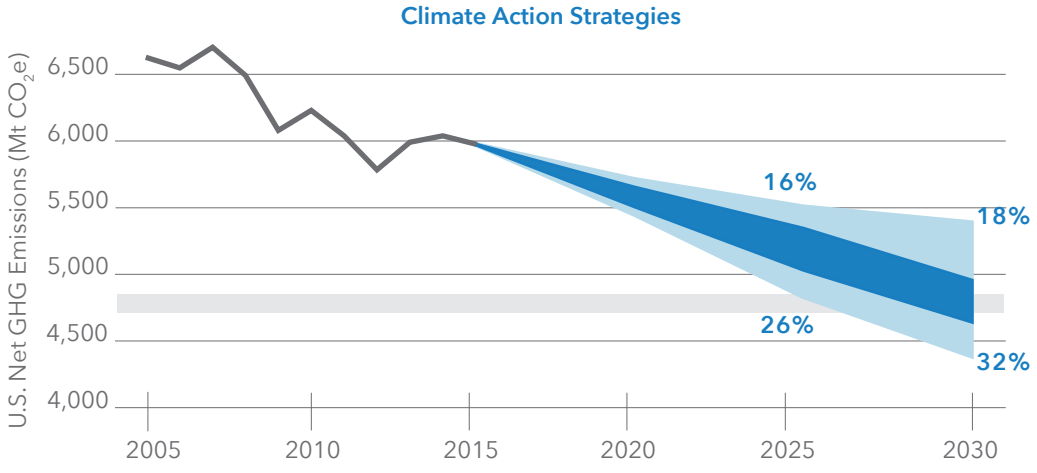


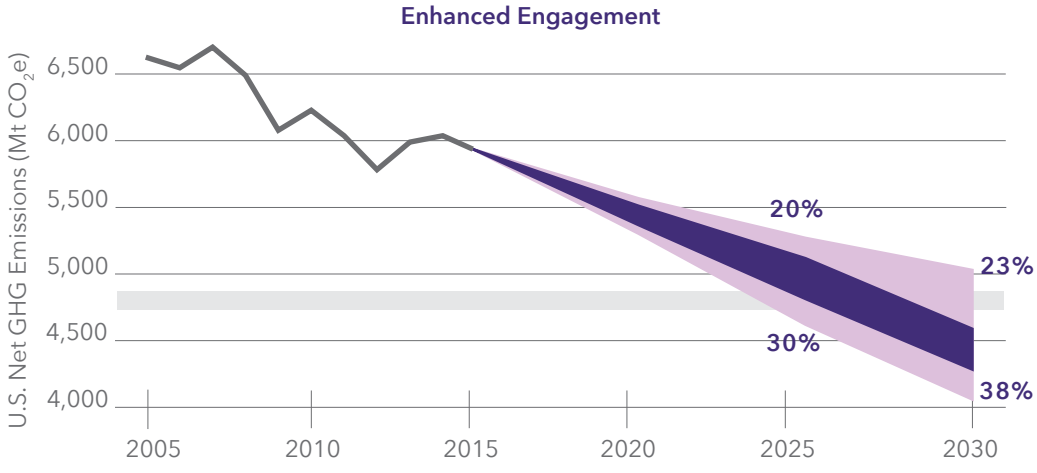
Source: America's Pledge modeling results

Comprehensive Cross-Sector Approach

This analysis demonstrates the potential for reductions across all sectors of the economy (see Figure 4-3). Although some sectors realize only modest emissions reductions by 2025 under the *Enhanced Engagement* scenarios, action across all areas is an important component of a comprehensive emissions reduction strategy. While some actions have relatively modest gains in early years, they help lay the groundwork for deep decarbonization by building cumulatively. For example, due to the slow turnover time of vehicles and the interaction between state policies and federal vehicle standards, investments in electric vehicle infrastructure may be slow to generate immediate emissions reduction benefits. However, investment today will help ensure that these vehicles proliferate in the decades to come. Building codes and land sector activities, which are available and rapidly scalable now, also deliver increasing impacts over time. Therefore, readers should not interpret the quantitative results presented here in isolation but should also take into consideration the complementary suite of enabling policies and programs that will help achieve deep decarbonization.


Current Measures
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
12%
13%
22%
27%


Climate Action Strategies
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
16%
18%
26%
32%


Enhanced Engagement
U.S. Net GHG Emissions (Mt CO_2e)
6,500
6,000
5,500
5,000
4,500
4,000
2005
2010
2015
2020
2025
2030
20%
23%
30%
38%

Modeling the Scenarios: Approach, Assumptions, and Uncertainty

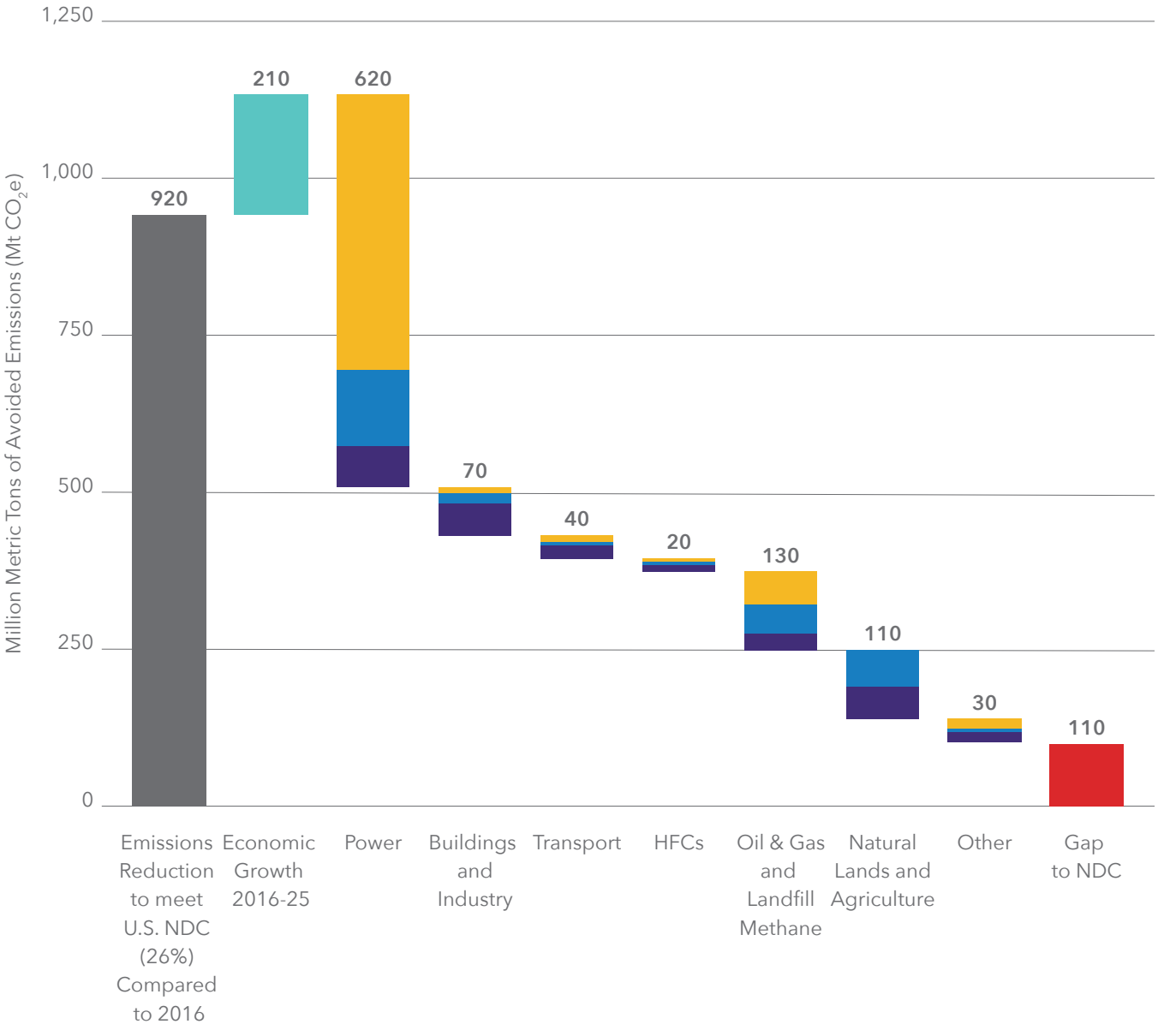
Modeling State, City, Business, and Other Real Economy Climate Action

Quantifying the overall implications of state, city, and business action presents a methodological challenge. Actions take place across different scales, from cities with narrow or broad impacts across their metropolitan area footprints to states with regional power imports and exports to businesses that themselves may operate across multiple U.S. jurisdictions and with globally integrated supply chains. Many of the measures estimated in our analysis interact with one another, in some cases complementing each other, and in other cases overlapping or even counteracting each other. Impacts of one action may completely subsume the impacts of another action.

To address these challenges, this report uses a novel approach for understanding the implications of city, state, and business actions (as outlined on Page 44 and detailed in the *Technical Appendix*). It combines bottom-up, granular accounting of the multiplicity of real economy actions across the United States (using the Aggregation Tool for modeling Historic and Enhanced Non-federal Actions [ATHENA] model) with top-down analysis (using the Global Change Assessment Model for the United States of America [GCAM-USA] model) to understand the cross-linkages across the U.S. and global economy and energy systems, enabling an estimate of the overall implications for all six GHGs. The report controls for double-counting and cross-sectoral interactions by employing the ATHENA and GCAM-USA tools designed—in part—to address explicitly address those challenges. Integrating aggregated, bottom-up inputs from ATHENA into the comprehensive, energy-economic integrated assessment modeling framework of GCAM also allows for an analysis of how complementary actions, such as increasing the use of electric vehicles and simultaneously promoting the use of low-carbon electricity, intersect and interact in the real world.

As with any other modeling analysis, the results of this exercise should be interpreted carefully. Importantly, models are themselves simplifications of a complex reality and can therefore never precisely incorporate or represent all the actors and interactions that influence how the future might unfold. The key is to select a modeling approach that best addresses the need, and to discuss the assumptions and uncertainties clearly. This is the approach we take in this *Fulfilling America's Pledge* report.

Figure 4-3: Achieving Full Potential Entails Actions Across All Major Economic Sectors and GHG Gases (Mt CO_2e in 2025)



Source: America's Pledge modeling results

Scenario Assumptions and Uncertainty

To aid readers in interpreting the modeling outcomes described in this chapter, Figure 4-3 provides a detailed breakdown of assumed emissions reduction potential by sector and by scenario. Table 4-1 complements Figure 4-3 by providing an overview of the key assumptions used to define each of the scenarios in this chapter. More information is provided in the *Technical Appendix*.

Table 4-1: Key Climate Action Levers and Associated Potential

Sector	2005 Emissions ($MtCO_2e$)[1]	Change in Sector Emissions in 2016 relative 2005 ($MtCO_2e$)[2]	Percent Change in Sectoral Emissions 2016 Compared to 2005[3]	Scenario	Change in Sector Emissions in 2025 by Scenario($Mt CO_2e$)[4]	Total Feasible In-Sector Emissions Reductions 2005-25 as % of 2005[5]
 Power	2,439	-593	-24%	Current	-440	-50%
				Strategies	-120	
				Enhanced	-60	
				Total	-620	
 Buildings	1,696	-160	-9%	Current	-10	-14%
				Strategies	-10	
				Enhanced	-50	
				Total	-70	
 Transportation	1,904	-99	-5%	Current	-10	-7%
				Strategies	-10	
				Enhanced	-20	
				Total	-40	
 HFCs	103	+56	+54%	Current	-5	+35%
				Strategies	-5	
				Enhanced	-10	
				Total	-20	

Oil & Gas and Landfill Methane[7]	469	-20	-4%	Current	-50	-32%
				Strategies	-50	
				Enhanced	-30	
				Total	-130	
Natural & Working Lands and Agricultural Emissions[8]	-211	+57	+26%	Current	0	-25%
				Strategies	-60	
				Enhanced	-50	
				Total	-110	
Total Net GHG Emissions	6,589	-795	-12%	Current	-530	-24%
				Strategies	-250	
				Enhanced	-240	
				Economic Growth[9]	+210	
				Total	-810	

Notes:

1. Sector emissions based on 2016 U.S. EPA GHG inventory estimates. Some small sectors are omitted and therefore sum does not add to total net GHG emissions. As some sectors are estimated and calculated, values may differ slightly from EPA GHG inventory.
2. Change in sector emissions between 2005 and 2016 calculated based on 2016 U.S. EPA GHG inventory estimates.
3. Percent sectoral emissions reductions between 2005 and 2016 as % of 2005 sectoral emissions (based on 2016 U.S. EPA GHG inventory)
4. Total sector emissions reductions across three scenarios modeled by America's Pledge relative to a 2025 reference scenario.
5. Total feasible in-sector emissions reductions quantified as the total emissions reductions between 2005 and 2016 (based on U.S. EPA GHG inventory) and modeled emissions reduction between 2017 and 2025 (based on America's Pledge analysis), compared to the 2005 baseline.
6. Direct emissions from residential, commercial and industrial sectors. Does not include indirect emissions associated with electricity consumption which is included in power sector. Does not include industrial-related methane and HFCs included in other sectors.
7. GCAM assumes significant growth in methane emissions between 2005 and 2025. While total emissions grow, actions taken by real economy actors has the potential to cut emissions by over 30% against below 2005 levels. Agricultural methane included in Natural and Working Lands
8. Net change in emissions inclusive of land-sector sink and agricultural emissions. Both land-sector sink diminished in magnitude and agricultural emissions increased between 2005 and 2016, resulting in net increase in emissions of 26%.
9. Total GHG emission increases by 210 Mt CO2e in the GCAM reference scenario from 2016 to 2025. Emission reductions are measured relative to this scenario.

Table 4-2: Achieving Full Potential Entails Actions Across All Major Economic Sectors and GHG Gases (Mt CO_2e in 2025)

Sector	Scenario	Scenario Assumptions
 **Power**	Current	Federal wind and solar incentives through 2020/2022; state RPS targets; 104 cities with RE goals; all announced coal and uneconomic coal units retire (69 GW by 2025).
	Strategies	Extend state RPS targets through 2025/2030, while states with voluntary targets achieve and modestly expand targets; Additional cities in open markets achieve 50% RE targets by 2030; Additional uneconomic coal plants close, including plants in traditionally regulated markets (94 GW by 2025)
	Enhanced	States with an RPS set ambitious new targets; States without an RPS adopt a conservative mandate; A greater number of uneconomic plants close (128 GW by 2025)
 **Buildings**	Current	All 26 states and 56 cities with stated efficiency targets meet the target
	Strategies	40 additional cities with a population over 100,000 and that are engaged in a city energy or climate action network adopt efficiency targets; Scaling building electrification in the Northeast and Midwest regions
	Enhanced	States with existing EERS adopt more stringent targets and states without an EERS adopt modest targets; Building electrification occurs across the U.S. in line with economic and market potential studies
 **Transportation**	Current	EPA and NHTSA GHG and fuel-economy standards through model year 2025; CA and 9 other states implement 2025 ZEVR targets; 34 cities with EV procurement goals achieve target; States and cities (CA, VT, and WA and 32 cities) achieve stated VMT targets
	Strategies	States, cities, and businesses implement programs and policies that result in EVs comprising 11% of new sales in 2025 (in line with BNEF EV forecasts)
	Enhanced	EV sales exceed forecasts achieving 13% of new car sales; State, city, and business policies and programs support a reduction in nationwide passenger vehicle kilometers traveled by 2% by 2025 and 3.25% by 2030; modeling of additional freight targets

HFCs	Current	California achieves its goals under its March 2018 target, SNAP program, and Refrigerant Management Program; Businesses maintain commitments under EPA's GreenChill program
	Strategies	States representing approximately 50% of HFC emissions adopt California's SNAP program
	Enhanced	States achieve additional reductions equivalent to a 40% reduction from 2013 levels by 2030
Methane	Current	Existing federal standards remain intact; 6 states achieve reduction targets consistent with existing policy; 5 states achieve distribution-system methane reduction targets; Voluntary NaturalGas STAR program continues apace
	Strategies	Aspirational policies beyond current standards are achieved in California, Colorado, New Mexico, Ohio, Pennsylvania, Utah, and Wyoming; Eight states implement distribution-system policies that would cut emissions 50% by 2025
	Enhanced	Sufficient voluntary action and engagement with stakeholders occurs such that reductions are achieved in three high-emitting states with no current standards in place, inline with achievable source-specific best practices.
Natural Lands and Agriculture	Current	Land sector sink remains constant through 2030
	Strategies	California meets and slightly exceed existing NWL policy to reach additional sequestration of 30 Mt CO_2 by 2025; other states begin to implement policies that scale sequestration to achieve an additional 30 Mt CO_2 by 2025
	Enhanced	States scale sequestration opportunities even further, such than nationally, total sequestration reaches 100 Mt CO_2 by 2025. Roughly tripling the number of farmers and ranchers who have installed methane digesters could realize an additional reduction of 10 Mt CO_2e by 2025.
Carbon Pricing / GHG Targets	Current	Emissions cuts consistent with existing caps: CA with AB-32 and Northeast states with RGGI
	Strategies	16 states achieve mandatory or stated aspirational GHG targets and projected reductions
	Enhanced	Additional states achieve reductions in line with RGGI for power sector and Paris Agreement for transportation sector

** Economy-wide actions cut across all major sectors of the economy and therefore are not modeled or quantified separately from sector-specific policies, commitments, and other actions.*

This report uses a novel approach for understanding the implications of city, state, and business actions, combining a bottom-up, granular accounting of real economy actions with a top-down analysis to understand the cross-linkages across the U.S. and global economy and energy systems.

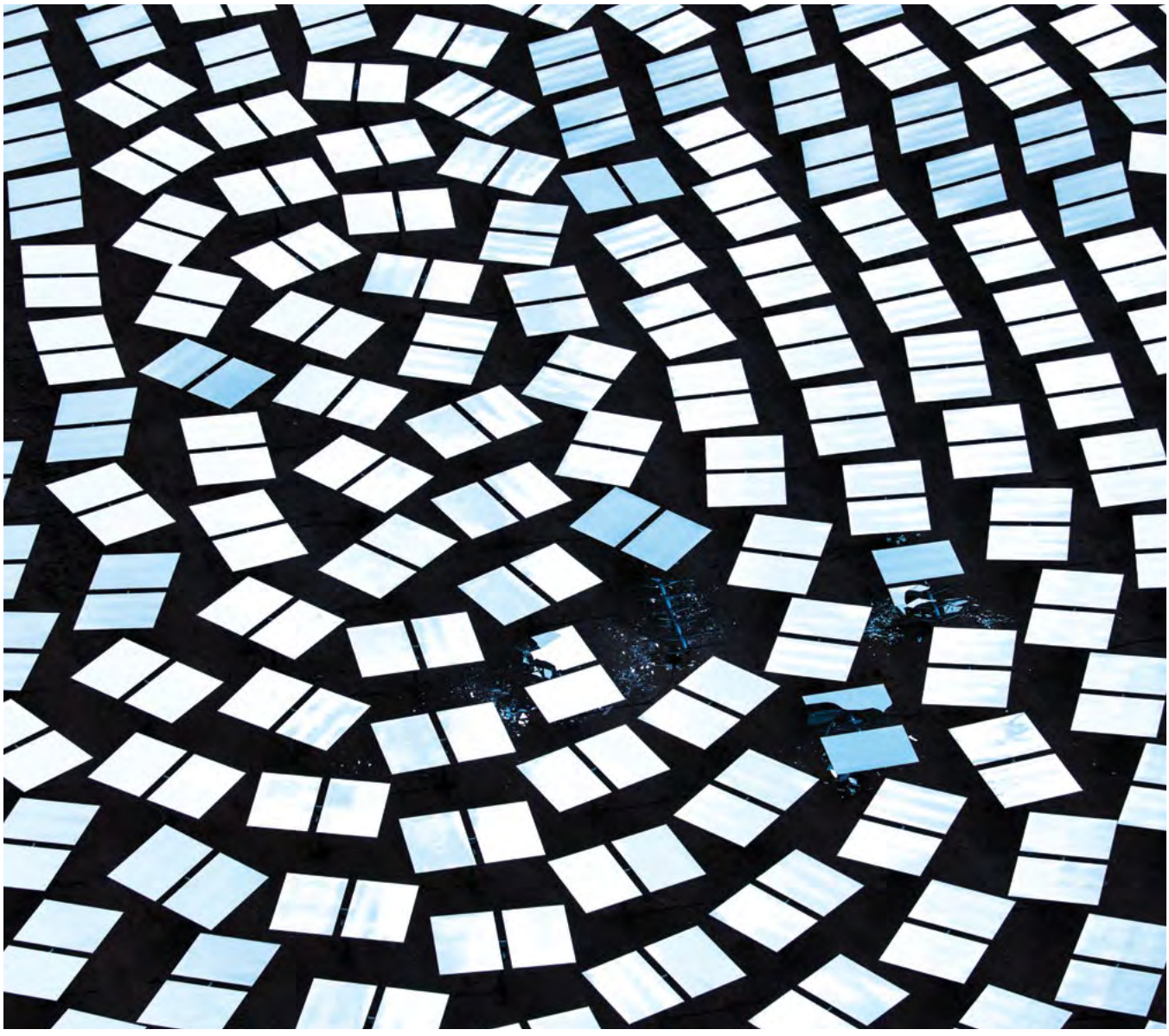


Photo by Dennis Schroeder / NREL

Economic and Energy System Assumptions and Uncertainty

The modeled outcomes in this analysis are strongly influenced by forces and factors that are independent of the real economy actions described in the scenarios. These include broad demographic and economic trends, technology trends, and the prices of key energy commodities. The assumptions used to define the central estimates for the scenarios in this study are provided in Table 4-2.

Although these assumptions were chosen to be plausible central estimates given what we know today, actual outcomes will likely vary. For example, in the future, GDP might grow at a higher or lower rate, or fossil fuel prices might trend higher or lower. In order to allow others to understand the implications of different plausible future pathways, different assumptions for such variables were tested using what is called a sensitivity analysis, which is also summarized in Table 4-2. This sensitivity analysis explores a range of uncertainties in the inputs for these primary technology, demographic, and macroeconomic assumptions. Four sources of uncertainty were taken as the focus of this exercise: economic growth, fossil energy prices, clean energy technology costs, and the nature of the U.S. land use sink.

Table 4-3: Economic and Model Assumptions and Sensitivities

Scenario	Current Measures Scenario	Sensitivity	AEO 2018 Comparison[21]	BNEF NEO 2018 Comparison
Economic Growth	Overall GDP[1] growth at 1.9%/yr	1.4%/yr (low growth) 2.4%/yr (high growth)	2.1% (reference) 1.4%/yr (low economic) 2.4%/yr (high economic)[12]	2.0% (median) 1.7% (low) 2.3% (high)
Population Growth	Overall population[2] growth at 0.8%/yr	No sensitivity	0.7%/yr (reference) 0.6%/yr (low economic)[13] 0.8%/yr (high economic)[13]	0.7% (Med) 0.6% (Low) 0.7% (High)
Fuel Prices	Oil prices[3] grow at 2.5%/yr	1.6%/yr (high resources) 3.3%/yr (low resources)	4.7%/yr (reference) 3.3%/yr (high resources) 5.4%/yr (low resources)[14]	Expect Brent crude oil price to decline out to 2030
	Gas prices[4] grow at 0.8%/yr	-4.3%/yr (high resources) 4.4%/yr (low resources)	4.2%/yr (reference) 0.9%/yr (high resources) 9.1%/yr (low resources)[15]	Gas prices grow at 2.8%/yr in the reference
Land Use	Terrestrial carbon sink assumed to be largely unchanged relative to today[5]	Uncertainty[6] set at +150 $MtCO_2e$ and -150 $MtCO_2e$	-	-
Electric Vehicles	Electric LDVs are price competitive with internal combustion engines by 2030[7]	Modeled as explicit policy measures	Sales of electric vehicles grow 11 times by 2030, with decreasing prices[16]	-
Solar Power	Solar PV costs[8] drop to $737/kW by 2025	Modeled as explicit policy measures	Average capacity-weighted LCOE is $59.1 /MWh by 2022[17]	Solar PV costs drop to $737/kW by 2025
Wind Power	Wind Turbine (class 5)[9] costs drop to $1357/kW by 2025	Modeled as explicit policy measures	Average capacity-weighted LCOE is $48 /MWh by 2022[18]	Wind Turbine (class 5) costs drop to $1357/kW by 2025
Power Plant Retirements	Coal[10]: 3.4%/yr	Modeled as explicit policy measures	Coal[19]: 3.3%/yr	See power sector assumptions
	Nuclear[11]: 0.7%/yr	Modeled as explicit policy measures	Nuclear[20]: 0.9%/yr	See power sector assumptions

Data Sources for Table 4-2:

All data, unless otherwise noted, is from 2015 to 2025.

1. GDP is from Congressional Budget Office (CBO)'s April 2018 report The Budget and Economic Outlook: 2018 to 2028. www.cbo.gov/publication/53651.
2. Population is from Congressional Budget Office (CBO)'s April 2018 report The Budget and Economic Outlook: 2018 to 2028. www.cbo.gov/publication/53651.
3. Oil prices are based on AEO 2018; the growth rate is between three-year average of 2014, 2015, and 2016, and three-year average of 2024, 2025, and 2026.
4. Gas prices are based on BNEF New Energy Outlook 2018; the growth rate is between three-year average of 2014, 2015, and 2016, and three-year average of 2024, 2025, and 2026.
5. Land use: Data: U.S. Inventory of Greenhouse Gas Emissions and Sinks. 1990-2016.
6. Uncertainty range: from the Second Biennial Report of the United States.
7. Electric Vehicles are from the United States Mid-Century Strategy.
8. Solar: 2015 based on NREL 2017 ATB Medium Case; 2025 and 2030 from BNEF; 2020 interpolated—UMD research team.
9. Wind: 2015 based on NREL 2017 ATB Medium Case; 2025 and 2030 from BNEF; 2020 interpolated—UMD research team.
10. Coal is based on EIA and BNEF, retirement trajectory by UMD research team.
11. Nuclear data is from the Nuclear Regulatory Commission.
12. GDP: AEO 2018, Appendix B, Table B4. Macroeconomic indicators.
13. Population: AEO 2018, Appendix A, Table A20. Macroeconomic indicators.
14. Oil prices: AEO 2018, Appendix D, Table D1. Total energy supply, disposition, and price summary.
15. Gas prices: AEO 2018, Appendix D, Table D1. Total energy supply, disposition, and price summary.
16. Electric Vehicles: AEO 2018, Data, Reference case.
17. Solar: Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018, March 2018, Table 1a, Table A1a, Table B1a.
18. Wind: Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018, March 2018, Table 1a, Table A1a, Table B1a.
19. Coal: AEO 2018, Data, Reference case, Table 9. Electricity Generating Capacity.
20. Nuclear: AEO 2018, Data, Reference case, Table 9. Electricity Generating Capacity.
21. All 2015 data is from AEO 2017, https://www.eia.gov/outlooks/archive/aeo17/tables_ref.php.

These uncertainties capture some, but not the full range, of the potential outcomes. One reason for this is the large possible range of all forces that could affect future emissions. For example, there could be different relationships between energy demand and economic growth, levels of end-use electrification, and nuclear power plant retirements, all of which could affect the results. Lower energy demand would generally lower emissions; less electrification would reduce emissions from electricity but would increase emissions from end-uses; faster nuclear retirements would increase emissions. Higher prices for oil would encourage the sale of electric vehicles but increased production of associated gas could also have repercussions for natural gas prices and hence the relative pricing and deployment of gas-fired power, coal, and renewables.

A second consideration when interpreting these scenarios is that they are dependent on two models—ATHENA and GCAM-USA—that are simplified representations of a complex reality. The simplifications inherent in modeling necessarily lead to differences between projections of the future and the future that actually comes to pass. Moreover, in aggregating city, state, and business actions to be incorporated into the models, a number of assumptions must be made, many of which can have important implications for the results. These caveats should be taken seriously in interpreting the precise numerical estimates and uncertainty ranges in this chapter. The best way to balance these considerations is to note that although a study such as this one cannot provide a precise view of the future, it can provide insight into the range of possibilities that might emerge from real economy actions and the potentially substantial value and impact of those actions.

A Note on Future National and International Ambition

This report focuses primarily on the impact of real economy actors on the near-term emissions trajectory of the United States over roughly the next decade. However, we know that in the medium to long term, in embracing the opportunities for a cleaner, economically vibrant, and climate-safe future, emissions reductions must continue to decline at a rapid rate by 2050 and beyond. As this report demonstrates, states, cities, businesses, and other actors are taking significant actions today that are building a cleaner and healthier economy and also driving down the overall emissions trajectory in the United States. But the speed and scale of the transition required to address climate change will require all levels of government, as well as broader civil society, to fully participate. The positive economic and health benefits from accelerating the clean energy transition will increasingly be attractive to an ever-broader set of American constituents and voters. Federal reengagement with climate change, driven by such political forces, would build on progress by states, cities, and businesses, enabling the United States to more effectively and quickly track toward a long-term, accelerated decarbonization trajectory.

Moreover, greater ambition in the future that goes beyond even the three core scenarios of this report is possible and ultimately necessary if countries are to meet the long-term targets of the Paris Agreement. Such shifts include the aforementioned changes in the national political landscape leading to renewed federal leadership, but also faster-than-expected technological advancement, or international impacts on U.S. technology advancement and decarbonization. Alternatively, continued investment in renewables and clean vehicles by international actors such as China could lead to lower-than-expected technology costs, making these resources more economically attractive to consumers. Other policies and programs enacted by international actors could benefit U.S. abatement, including helping U.S. real economy actors replicate initiatives domestically. In addition to creating new, real climate action as outlined in the three core scenarios of this report, states, cities, and businesses can help demonstrate proof of concept for policy interventions that could be replicated at a national level. And real economy actors can help build a broader umbrella of support for climate policies that will build momentum for federal intervention.

Finally, although the analysis developed and presented in this report focuses on the United States, the concepts and methods are applicable in other country contexts. Of course, such analysis is predicated on sufficiently detailed data and assessments of the commitments of such actors, as well as national inventories and other elements important to the global community as the pledge and review process of Paris is implemented more fully. As countries embrace the potential of their domestic actors to help raise ambition and implement real actions, the analytical approach developed here can be used to support the efforts of this increasingly diverse set of actors and may have relevance for countries considering how best to understand and account for national actions and potential impact driven by the real economy.


THIS IS A SILENT ENERGY SYSTEM
ALWAYS ASSUME LIVE VOLTAGE IS PRESENT
THIS IS A SILENT ENERGY SYSTEM
ALWAYS ASSUME LIVE VOLTAGE IS PRESENT

Chapter 5

Conclusions and Implications

The vision of the Paris Agreement—as informed by the best science and analysis—calls for broad, rapid, and significant engagement across all parts of society to reap the benefits of an advanced, innovative, low-carbon, climate-resilient future, one fueled by clean jobs and economic growth.

And in the United States, states, cities, businesses, and other real economy actors have embraced this future—helping drive better outcomes for their own citizens and business operations. Although they are being driven in part by necessity, in light of the lack of national-level leadership on climate change, these real economy actors have embraced action for the benefit of their own economies while helping bend the emissions curve downward. This renewed climate leadership of states, cities, and businesses has already made an impact, and this impact will only grow as additional action is taken—in three ways:

Inspiring through Demonstration

First, the emphatic embrace of climate action opportunities from real economy actors continues to inform and inspire broader action across the United States economy. These initiatives reflect enthusiasm from constituents, businesses, and governments for the opportunities provided by climate and energy leadership, and their example provides additional evidence of the broad-based economic, health, and environmental benefits of taking action.

Deploying Real Solutions to Change the World Today

Second, the commitments and actions taken by states, cities, and businesses are already making a significant impact on the U.S. emissions trajectory, and expanding the set of actors and actions can drive emissions down even further. Although the long-run trajectory of decarbonization in the United States will require participation by all actors and all levels of government, the U.S. democracy has enabled and encouraged climate action to continue during this period of disengagement at the national level.

Building the Groundwork for Future Progress

Third, the implementation of commitments and ambition by real economy actors allows for more significant reductions over time. This report has demonstrated that essential deep decarbonization (80 percent or more by 2050) can be led by the bottom-up efforts of real economy actors—but only with deep collaboration and engagement. The groundswell of action will set the tone for the future of climate ambition and will make possible more ambitious future efforts. Indeed, because of the important work that can be carried out in the near term by states, cities, and businesses, a new administration that understands the significance of the Paris Agreement as a global climate governance mechanism would find supportive and ready partners on climate policy.

Photo by Abbie Trayler-Smith / Panos Pictures / Department for International Development

Our success will ultimately depend on the commitment of these leaders to implement their pledges and adopt more ambitious policies in the coming years. Importantly, while the current political situation in the United States is unique, the approach we are developing, based on bottom-up and diversified actions across the economy, can serve as a blueprint for implementing climate action in other places—for example, as countries identify opportunities to engage the real economy and deliver greater climate ambition. This is critical as the world seeks to dramatically bend the curve on the current trajectory of GHG emissions and close the emissions gap.

America's Pledge is just the beginning of a new phase of America's climate action, a moment that not only reflects the work and potential of real economy actors in the United States, but is also a way of inspiring and integrating climate action across all sectors of society as the world moves to a cleaner, healthier, more economically vibrant, and more climate-friendly future.

America's Pledge is just the beginning of a new phase of U.S. climate leadership

Endnotes

[1] United Nations, "United Nations Framework Convention on Climate Change," Article 2, 1992, https://unfccc.int/resource/docs/convkp/conveng.pdf.

[2] America's Pledge analysis. Simple rate of reduction based on U.S. emissions in 2016 compared to 2005 and an 80 percent reduction by 2050. Emissions data based on the U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 19902016," April 2018, https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf.

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[7] U.S. Department of Energy, State and Local Energy Data resource; America's Pledge analysis.

[8] This study focuses on action in the United States. For an assessment of impacts of non-state actions in other countries and globally, see Data Driven Yale, NewClimate Institute, PBL 2018: Global climate action of regions, states and businesses. Research report published by Data Driven Yale, NewClimate Institute, PBL Netherlands Environmental Assessment Agency, forthcoming, prepared by project team of Angel Hsu, Amy Weinfurter, Andrew Feierman, Yihao Xie, Zhi Yi Yeo, Katharina Lütkehermöller, Takeshi Kuramochi, Swithin Lui, Niklas Höhne, Mark Roelfsema.

[9] America's Pledge, "America's Pledge Phase 1 Report: States, Cities, and Businesses in the United States Are Stepping Up on Climate Action," November 2017.

[10] We Are Still In, "Signatories," https://www.wearestillin.com/signatories.

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[12] We Are Still In, "Signatories," https://www.wearestillin.com/signatories.

[13] The U.S. Climate Alliance, https://www.usclimatealliance.org/.

[14] U.S. Climate Mayors, http://climatemayors.org/.

[15] America's Pledge, "America's Pledge Phase 1 Report: States, Cities, and Businesses in the United States Are Stepping Up on Climate Action," November 2017.

[16] We included businesses that report emissions and pledges to CDP and voluntary programs led by EPA. The analysis also relies on activity data and other information from a range of sources like the Energy Information Administration, Lawrence Berkeley National Laboratory, ACEEE, and the University of Maryland's GCAM model.

[17] Center for Climate and Energy Solutions, "Greenhouse Gas Emissions Targets," https://www.c2es.org/document/greenhouse-gas-emissions-targets/.

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[19] Estimate based on Scope 1 & 2 absolute, location-based GHG emissions reduction targets reported to CDP. GHG impacts from businesses achieving these targets were estimated using methods described in Appendix C of the ICAT guidance, http://www.climateactiontransparency.org/wp-content/uploads/2017/07/ICAT-Non-State-and-Subnational-Action-Guidance-26-JUL-2017.pdf. CDP, Corporate GHG and Renewable Energy Targets (internally shared dataset), June 2018.

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[21] Science Based Targets Initiative, http://sciencebasedtargets.org.

[22] World Resources Institute, "CAIT Climate Data Explorer."

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[24] U.S. Energy Information Administration, Table 12.6: Carbon Dioxide Emissions From Energy Consumption: Electric Power Sector, "Monthly Energy Review," May 2018, https://www.eia.gov/totalenergy/data/monthly/pdf/sec12_9.pdf; U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

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[51] These cities were identified from the 51 U.S. cities that represent the largest Metropolitan Statistical Areas (MSA) that ACEEE tracks as part of its State Energy Efficiency Scorecard, including an additional 11 cities that report energy policy information directly to ACEEE.

[52] The 36 quantifiable targets included in this analysis represent top-down, community-wide goals to reduce energy consumption for residential and/or commercial buildings from a specified baseline. Certain more nuanced measures (e.g., targets applying only to municipal operations, building standards, retrofitting measures) were not included; however, these policies may of course contribute to the top-down goals included in the analysis. More information on the rationale and decisions behind the actions included in this analysis can be found in the *Technical Appendix*.

[53] While city targets may expire, utilities have reported that energy efficiency programs they put into place continue to achieve energy savings for an average of 11 years. Therefore, even if city targets expire in 2021, they will continue to reap benefits for a decade into the future.

[54] Arkansas Public Service Commission Docket No. 08-144-U.

[55] Analysis is based on data from American Council for an Energy-Efficient Economy State Energy Efficiency Scorecards 2006-2017, available at: http://aceee.org/state-policy/scorecard; and analysis by American Council for an Energy-Efficient Economy in support of the America's Pledge initiative.

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[67] U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016," April 2018, https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf

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