ACCELERATING AMERICA'S PLEDGE

GOING ALL-IN TO BUILD A PROSPEROUS, LOW-CARBON ECONOMY FOR THE UNITED STATES

Bloomberg Philanthropies

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About America's Pledge

An unprecedented coalition of U.S. states, cities, businesses, communities of faith, universities, health care and cultural institutions, and other organizations are now acting to fulfill America's climate pledge to the world. This commitment is reflected in the large number of American actors continuing to back the Paris Agreement, including members of the We Are Still In network, U.S. Climate Alliance, Climate Mayors, We Mean Business, and many others.

In July 2017, former New York City Mayor and United Nations Secretary-General's Special Envoy for Climate Action Michael R. Bloomberg and then-California Governor Edmund G. Brown Jr., launched an initiative known as America's Pledge. The initiative seeks to analyze, catalyze, and showcase climate action leadership by U.S. governors, mayors, business leaders, and others. America's Pledge serves these efforts as a voice of U.S. action to the international community—and also to domestic actors, helping them better understand their significant impact as activity broadens and deepens across the country.

In November 2017, at the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change, America's Pledge released a comprehensive survey of U.S. climate action led by states, cities, businesses, and other non-federal actors. At the Global Climate Action Summit in San Francisco in September 2018, America's Pledge released *Fulfilling America's Pledge*, providing at that point the most comprehensive and robust assessment of the impact of action by U.S. states, cities, businesses, and others.

With this report, released in December 2019 at the 25th Conference of the Parties in Spain, America's Pledge looks further out—toward 2030. It assesses what would be delivered from expanded actions by states, cities, businesses, and citizens and then layers on a robust, complementary, and ambitious federal policy program after 2020 to form an "All-In" comprehensive American climate strategy.

Acknowledgements

America's Pledge is co-chaired by Michael R. Bloomberg and Edmund G. Brown Jr. The America's Pledge Vice-Chairs are Carl Pope, former Executive Director of the Sierra Club, and Mary Nichols, Chair of the California Air Resources Board. The America's Pledge report is the product of a collaborative effort between the leadership of the America's Pledge initiative and a core project team. The America's Pledge project team responsible for this report is co-led by the University of Maryland Center for Global Sustainability and Rocky Mountain Institute. Significant contributions to this year's report were also made by the World Resources Institute and CDP. Support for America's Pledge is provided by Bloomberg Philanthropies.

The America's Pledge initiative and project team would like to thank the over 100 stakeholders and reviewers that met with us and/or made suggestions for improving the framing and analysis of this report. Our conversations with stakeholders were valuable and essential to improving the focus, the vision, and the final product of this report. Special thanks also to significant and sustained input and helpful comments from Carl Pope, Co-Vice Chair of America's Pledge.

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Introduction Letter from Michael R. Bloomberg and Edmund G. Brown Jr.

In the two years since President Trump announced his intention to withdraw the United States from the Paris Agreement, nearly 4,000 U.S. cities, states, businesses, and universities have reaffirmed their commitment to helping America drive down emissions and answer the call of the international community to continue leading the global fight against the climate crisis.

We formed America's Pledge to quantify and communicate the successes of this unprecedented climate mobilization—and to show the international community that, despite federal inaction, *we are still in*. Since 2017, America's Pledge has published yearly, comprehensive assessments of non-federal action to reduce national emissions and show that these were not just empty words—that we have and will continue to take action on climate.

This year's report, *Accelerating America's Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States*, is the culmination of a year of dedicated engagement and analysis by researchers, climate scientists, and public policy experts. The University of Maryland Center for Global Sustainability and the Rocky Mountain Institute, with the World Resources Institute and CDP, led this work and have enabled America's Pledge to provide the most comprehensive analysis of ongoing and projected U.S. emissions.

The resulting report from this new analysis previews three potential futures for this country and the world. Informed by the ambitious climate policies already underway in dedicated states, localities, and businesses, it offers a roadmap to reaching the nation's climate goals and sets the groundwork for a clean energy future for decades to come. It is a best-in-class deep-dive into America's climate prospects—and what we need to do to get there.

Accelerating America's Pledge's evidence is encouraging. The current coalition of U.S. cities, states, and businesses committed to the Paris agreement is globally significant – and only continues to grow. Expanding current commitments by these leading actors in the U.S. economy will take us further, and even if late, federal reengagement can enable the United States to get back on track for full decarbonization by 2050.

There is no greater threat facing humanity today than the climate crisis. *Accelerating America's Pledge* reminds citizens across the country—and the world—that we have the tools necessary to fight climate change, but we need our political leaders to do more, faster. By building on the commitments already made by local governments and businesses—and encouraging bolder action from our nation's leaders—we can forge a powerful national climate strategy that lays the foundation for a sustainable future.

Michael R. Bloomberg
Former Mayor of New York

Edmund G. Brown Jr.
Former Governor of California

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Highlights

Leading U.S. states, cities, and businesses are forging a powerful approach to climate action that builds support and implementation from the ground up. By setting their sights higher and generating clean economies through innovative policies, these leaders are today laying the foundation for a comprehensive national climate strategy.

American coalitions of states, cities, businesses, and others committed to climate action in support of the Paris Agreement are massive and globally significant. They now represent 68 percent of U.S. GDP, 65 percent of U.S. population, and 51 percent of U.S. emissions. If they were a country, these U.S. coalitions would have the world's second largest economy—second only to the entire United States itself.

This report illuminates a pathway to a comprehensive and ambitious American climate strategy for 2030, using expanded bottom-up leadership as the foundation of a comprehensive "All-In" climate strategy. This comes at a time when nations around the world are considering how to strengthen their climate targets and raise global ambition.

- Ambitious and rapidly expanded bottom-up action alone, drawing on the policies of the most successful states, cities, and businesses, could reduce U.S. greenhouse gas emissions up to 37 percent below 2005 levels by 2030.
- A comprehensive All-In climate strategy that combines these bottom-up efforts with aggressive new federal engagement could reduce U.S. greenhouse gas emissions 49 percent below 2005 levels by 2030. This new congressional and executive action would lay the foundation for a net-zero emissions economy by mid-century, in line with the goals of the Paris Agreement and the recent IPCC report *Global Warming of 1.5°C*.

Achieving this ambitious level of emissions reductions will require political prioritization of climate action and accelerated market transformation. Since many clean energy technologies are already cost-competitive with their fossil-fuel competitors, the economics are compelling. Nonetheless, a massive effort will be needed to deploy these and other technologies at the speed and scale envisioned in our scenarios. Transforming our politics and our energy economy will require broad citizen mobilization, increased energy productivity, disruptive innovation, new market structures, and forward-thinking investment.

If well-planned and implemented, the required rapid change could bring broad-based economic gain. In part because almost all clean energy technologies will cost consumers less than their current fossil-fuel competitors well before 2030, and many are already cheaper today, the transition to a low-carbon economy will enhance prosperity and lower costs. The United States can re-establish and solidify its position as a leader in the clean industries of the 21st century, improve the health of citizens and ecosystems, and provide a fairer transition for workers and communities in fossil fuel industries.

We are already on our way to this future. Across key economic sectors, states, cities, and businesses are adopting concrete actions that can drive down U.S. emissions at scale. We calculate that full achievement of already on-the-books policies from state and local actors—paired with rapidly shifting economics in the power sector—would reduce emissions 19 percent below 2005 levels by 2025 and 25 percent below 2005 levels by 2030.

Executive Summary

The United States is an economic engine of the world, a leader in innovation, and a cradle of global creativity. Even with rollbacks to federal climate policies, U.S. states, cities, and businesses are emerging as leaders in the global green economy. Growing public concern about climate change has the potential to dramatically shift national politics towards action. With renewed federal leadership, these efforts can complement each other and contribute to an "All-In" national climate strategy to drive U.S. emissions to net-zero while bolstering our economy.

Since 2017, the America's Pledge initiative has demonstrated the resolve and power of U.S. states, cities, and businesses to pursue decarbonization during a period of federal inaction. New policies are being tested in our nation's "laboratories of democracy," as states, cities, and businesses deploy new and cost-competitive clean technologies. These efforts have become even more crucial as the IPCC special report *Global Warming of 1.5°C* has highlighted the urgent need to avert the worst effects of climate change, and as nations around the world are considering how to strengthen their climate targets and raise global ambition.

To illustrate the opportunities for American climate action, this report develops two high-ambition scenarios for 2030—the year many countries will plan for when ratcheting their climate commitments and an important milestone on the path to net zero emissions by mid-century.

1. **The Bottom-Up scenario** projects how much a significant expansion of state, city, and business climate action could reduce greenhouse gas emissions, even without federal interventions. In this scenario, first-mover states and cities strengthen their climate policies and a growing wave of fast-follower jurisdictions join their efforts due to growing citizen activism and the economic benefits and consumer savings from decarbonization. Businesses pioneer and lead market innovations. However, many holdout states remain largely inactive on climate and federal policy remains frozen.

   We find that significantly expanded bottom-up action alone could reduce U.S. emissions up to 37 percent below 2005 levels by 2030.

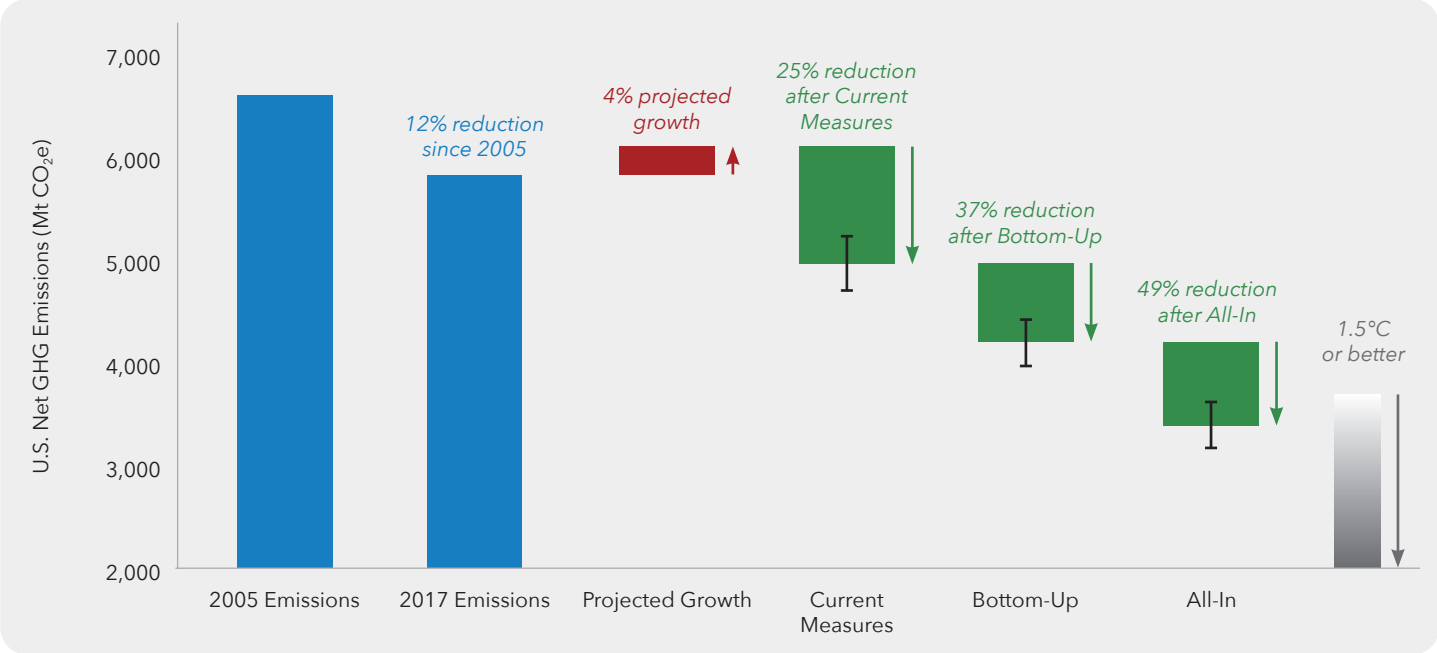
2. **The All-In scenario** projects how much a comprehensive national climate strategy could reduce greenhouse gas emissions, when layered on top of the expanded state, city, and business actions included in the Bottom-Up scenario. New executive branch and congressional actions after 2020 complement the continuing efforts of states, cities, and businesses and fill in the gaps where federal policy is needed or more effective.

   We find that combining bottom-up efforts with aggressive federal engagement and legislation after 2020 in a comprehensive All-In strategy could reduce U.S. emissions by 49 percent below 2005 levels by 2030.

Both of these scenarios offer encouraging news on the potential for U.S. decarbonization in the coming decade. Figure ES-1 shows how these scenarios build on each other to drive U.S. emissions rapidly lower. According to our analysis, the policies and technological progress driven by the policies in these scenarios reduce emissions enough by 2030 to lay a foundation for a fully decarbonized economy by mid-century, in line with the goals of the Paris Agreement and the recent IPCC report *Global Warming of 1.5°C*. They would put the United States into a renewed position of global leadership that could add to international efforts to reduce emissions across the world.

The strategies outlined in this report are organized around three simple principles that will empower action from the smallest business or town to large states, companies, and the federal government: 1) **Accelerate toward 100% clean electricity** and other energy supplies; 2) **Decarbonize energy end-uses** in our transportation, buildings, and industry, primarily through electrification and efficiency; and 3) **Enhance the carbon storage potential** of forests, farms, and coastal wetlands to address remaining emissions (see Figure ES-2). Across all of these principles, it will be essential to limit both carbon dioxide (CO_2) and other non-CO_2 greenhouse gases. These steps take advantage of high-impact opportunities that are available today, while also laying the necessary groundwork for long-term continued emissions reductions after 2030 to achieve a carbon-neutral future.

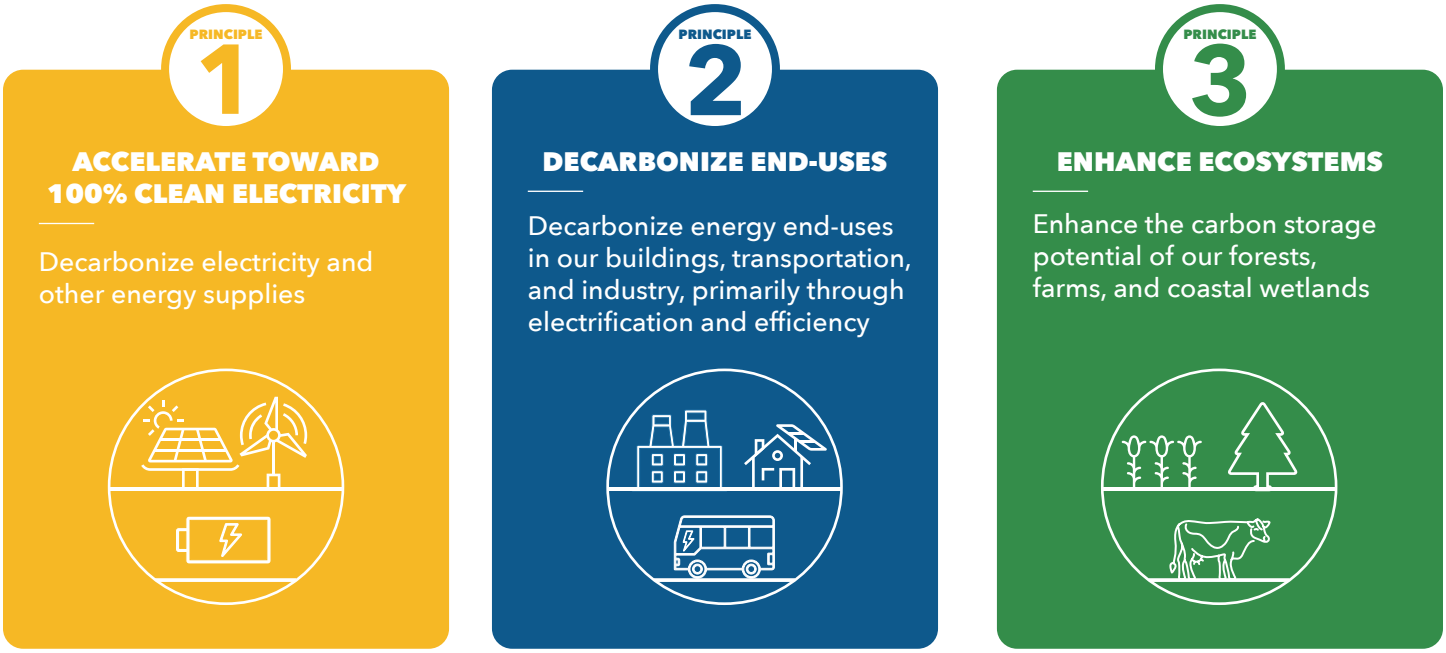
Figure ES-1 | **America's Pledge U.S. Emissions Analysis for 2030**



▲ **Rapidly expanded bottom-up action could reduce emissions 2,435 Mt CO_2e, 37% below 2005 levels by 2030. An All-In climate strategy that combines bottom-up action with federal reengagement could reduce emissions 3,245 Mt CO_2e, 49% below 2005 levels by 2030. This is in line with the Paris Agreement's mid-century goals.**

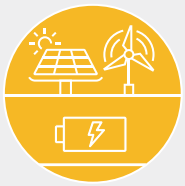
By following the strategies we outline across these principles, a leading state would undergo significant economic transformation. By 2030 it would have at least 60 percent renewable electricity, zero coal plants, 100 percent electric new buildings, electric vehicles as two-thirds of all new car sales, and an enhanced land carbon sink, among other improvements. And it would have set a firm policy framework to move rapidly towards 100 percent zero-emission power, road transport, and buildings as soon as feasible between 2030 and 2050. Table ES-1 presents the other essential ingredients that were modeled in our high-ambition scenarios and can serve as a policy platform for leader states, cities, and businesses. The report and technical appendix describe the modeling assumptions in more detail.

Figure ES-2 | **Three Principles of All-In Climate Action**



▲ **An All-In American climate strategy will be built on actions taken across three principles: accelerate toward 100% clean electricity and energy supply, use that clean electricity in buildings, transportation, and industry (end-uses) while improving the energy productivity of our economy, and utilize nature-based solutions across our diverse American ecosystems.**

Table ES-1 | Key Policies and Actions Included in this Analysis

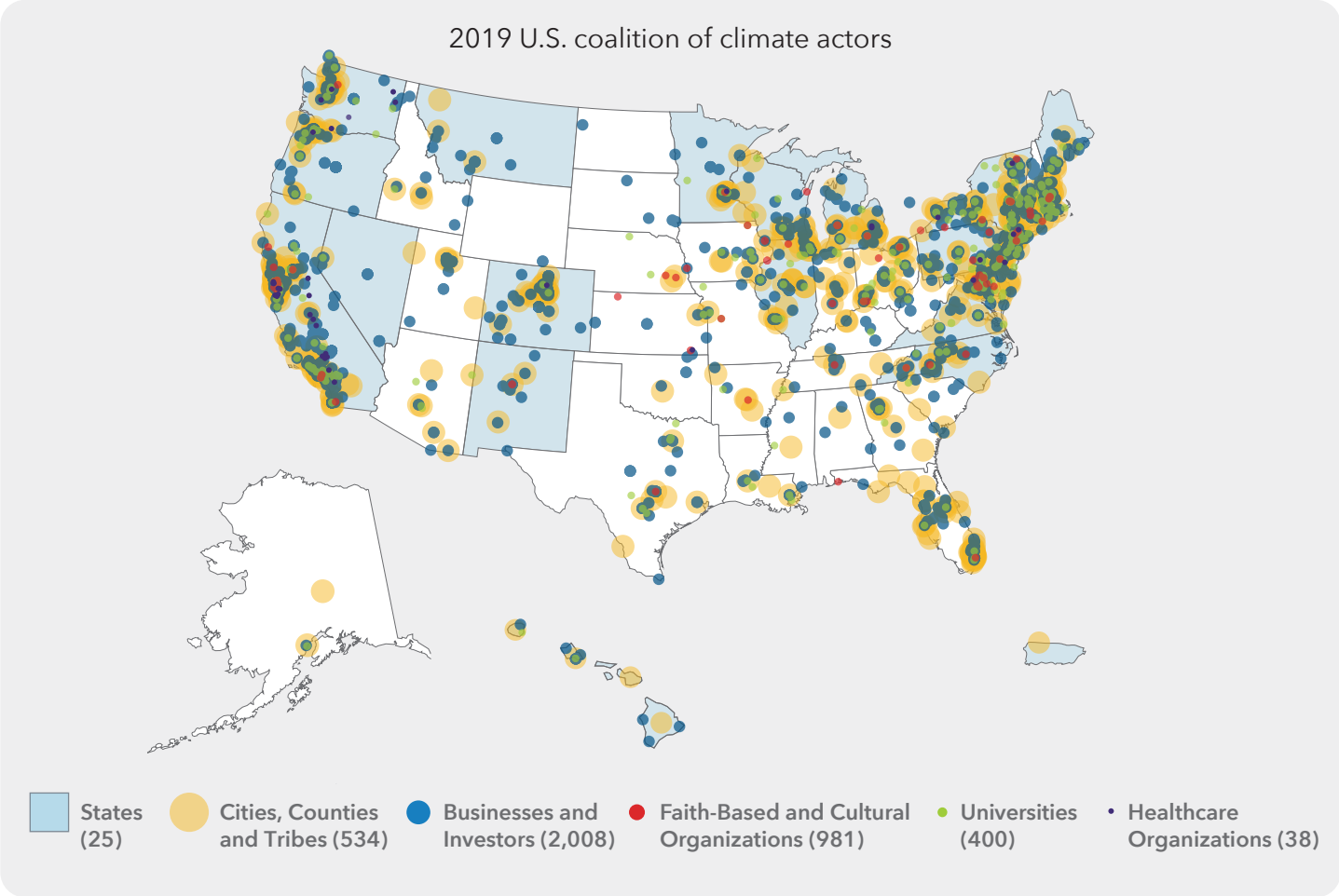
	BOTTOM-UP SCENARIO IN 2030	ALL-IN SCENARIO IN 2030
Principle 1: Accelerate toward 100% clean electricity and other energy supplies 	Leader states: • Reach 60% renewable electricity with clean electricity standards and other policies. • Shut down all coal plants. Peak and then reduce reliance on gas. • Reduce fugitive methane from oil and gas facilities by 60%. Remaining states make less policy progress, though market trends and advocacy reduce coal generation and increase renewables nationally. Overall coal generation decreases to just 7% of generation nationally in 2030, while renewable electricity increases to 42% and clean electricity to 61%.	• Federal clean electricity standard and tax incentives complement state efforts and lead to approximately 50% renewable electricity and more than 75% clean electricity nationwide. • Federal policies complete the phase-out of coal generation by 2030 and ensure that gas generation is below current levels by 2030 and declining. • Methane regulations and associated emissions reductions are extended to all states.
Principle 2: Decarbonize end-uses: buildings, transportation, and industry 	Leader states: • Improve energy efficiency in buildings 2% annually with updated Energy Efficiency Resource Standards. • Ensure all new buildings are 100% electric by 2030 and existing buildings install electric appliances at end-of-life. • Improve performance of light-duty vehicle internal combustion engines by 4% annually. • Ensure electric vehicles reach two-thirds of new car sales and more than half of light-duty truck sales through zero-emissions vehicle mandates and other supporting policies. • Incentivize industrial facilities to adopt best-in-class energy management practices and adopt electric technology, and promote CCUS for industrial uses. • Adopt policies to phase down HFCs consistent with the global Kigali Amendment and to reduce leaks from existing stock. Fast-follower states go about half as far. Remaining states make little progress.	All states follow the policies of leader states described in the Bottom-Up scenario with the help of federal policies, standards, and financing. • All new buildings in all states are 100% electric by 2030 and existing buildings install electric appliances at end-of-life. • Federal policies and standards ensure electric vehicles reach two-thirds of new car sales, more than half of light-duty truck sales, 20% of medium-duty truck sales, and 100% of transit bus sales, while continuing progress on conventional vehicle GHG emissions from 2021 to 2030. • Federal policy extends industrial efficiency, electrification, carbon capture, utilization, and storage (CCUS), and procurement policies to facilities in all 50 states.
Principle 3: Enhance ecosystems 	• Leader states incentivize low-cost natural climate solutions such as natural forest management, optimal nutrient application, and the use of cover crops to increase capacity of the land carbon sink 11% compared to today. • All states mitigate agricultural methane and nitrous oxide emissions where it is cost effective.	• Low-cost natural climate solutions pursued in all states increase the land carbon sink by 23% compared to today. • Strong federal incentives promote methane biodigesters to reduce methane from livestock by 29% compared to reference case.
Economy-wide	Leader states meet their legislated economy-wide emissions reduction goals and partially meet their aspirational goals.	In addition to meeting legislated economy-wide emissions reduction goals, all leader states fully meet their aspirational goals.

Additional assumptions are described in the report and further details are in the technical appendix.

Achieving this ambitious level of greenhouse gas reductions will require profound changes across our economy and politics at a pace matching or exceeding that of other rapid technological transitions. While many clean energy technologies are already cheaper than their fossil-fuel competitors, and the remainder will be competitive by 2030, deploying these technologies at the speed and scale envisioned in our scenarios will require comprehensive, forceful policies and significant investments. Increased energy productivity and innovation can help smooth the path to these changes. Such rapid transitions are not unprecedented. For example, in the United States, automobiles went from less than 1 percent penetration in 1900 to 75 percent in 1930.[1] Fundamentally, this transition will depend on a transformation of our politics that both draws from and supports higher climate action across all levels of government.

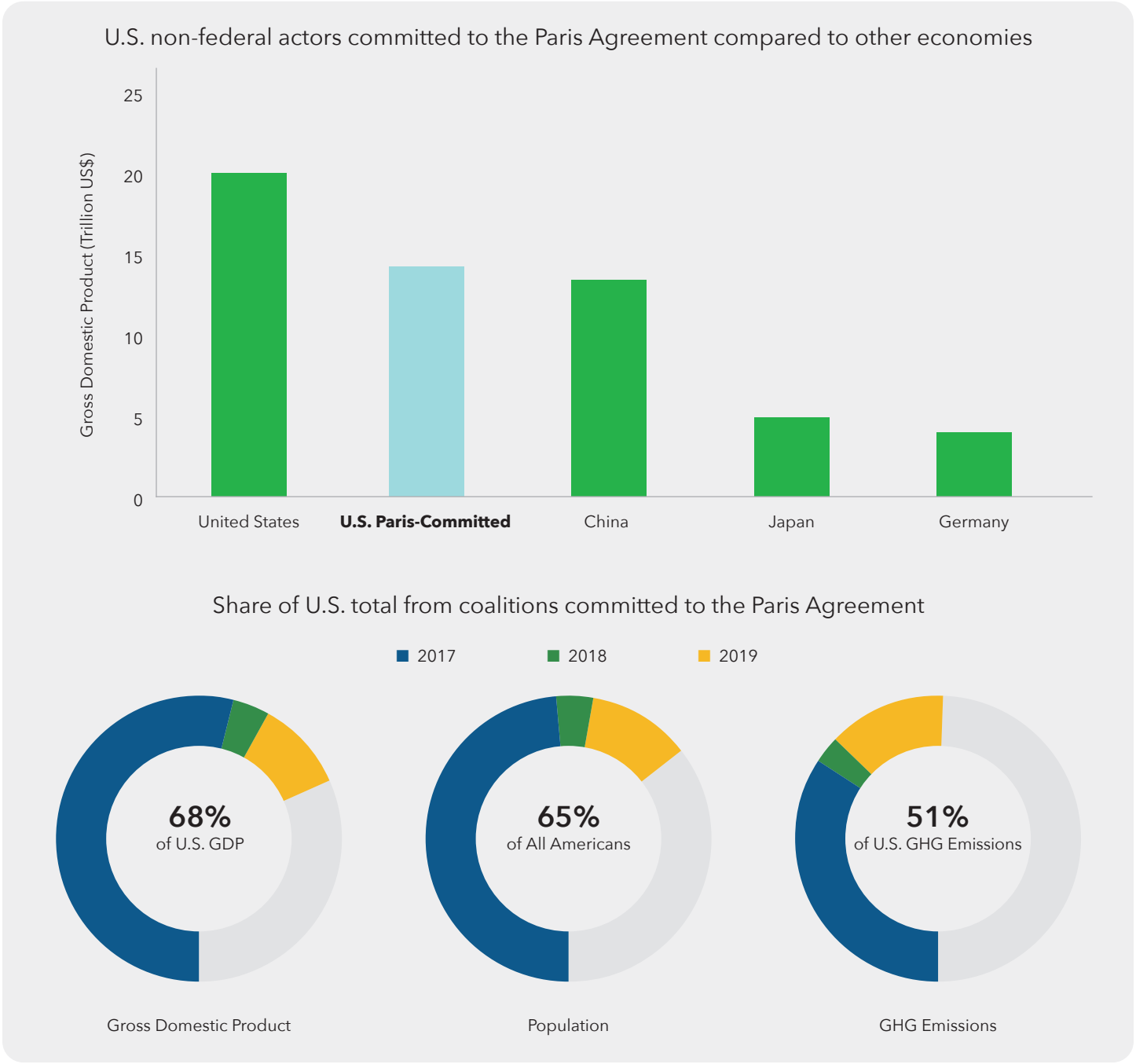
Fortunately, we are already moving rapidly toward this future. In the past year, states, cities, and businesses have raised the bar on climate leadership and are making up for some of the lost ground from the federal government's climate policy rollbacks. The coalition of these American actors committed to climate action has continued to grow, particularly after the 2018 midterm election (Figure ES-3, ES-4). These coalitions now represent 68 percent of U.S. GDP, 65 percent of the U.S. population, and 51 percent of U.S. emissions. If they were a country, these American leaders, jurisdictions, and organizations would be equivalent to the world's second largest economy—after the United States itself (Figure ES-4). This means that if America was broken into two economies, one climate forward and one climate laggard, the largest economy in the world would be U.S. climate-forward states, cities, and counties.

Figure ES-3 | **Actors Supporting the Paris Agreement**



▲ **Thousands of leaders, with real policy and financial power across our federal system in the United States, have committed to climate action in their jurisdictions or within their organizations.**

Figure ES-4 | **The Growing Footprint of U.S. States, Cities, and Counties committed to Climate Action in Support of the Paris Agreement**



▲ **Coalitions of states, cities, businesses, and counties committed to climate action in support of the Paris Agreement continue to grow, particularly after the U.S. mid-term elections. They now represent 68% of GDP, 65% of the population, and 51% of GHG emissions. If these U.S. non-federal actors were a country, they would be the world's largest economy besides the United States itself.**

The continued growth of coalitions supporting ambitious climate policy and action demonstrates the potential to rapidly drive down emissions in the United States. Significant reductions will be achieved by translating this momentum into concrete, sector-specific policies and actions which move the United States towards mid-century achievement of 100 percent clean energy. In addition to the Bottom-Up and All-In scenarios, which demonstrate this potential, this report also includes a Current Measures scenario focused solely on what state and local actors are already achieving.

- **The Current Measures scenario** projects how much greenhouse gas emissions would be reduced by the full achievement of existing policies from state and local actors, combined with market forces—measuring only concrete policies and actions rather than aspirational goals. This scenario also reflects shifting economics in the power sector, leading to greater levels of coal retirements than those currently announced, and updated assumptions for non-CO_2 emissions and agriculture. Overall, the results show an improvement from the Current Measures scenario in our 2018 report, *Fulfilling America's Pledge*, and demonstrate the vital role that state and local actions are already playing in decarbonizing our economy.

  We find that full implementation of Current Measures, including those adopted within the last year, will reduce emissions 19 percent below 2005 levels by 2025 and 25 percent below 2005 levels by 2030.

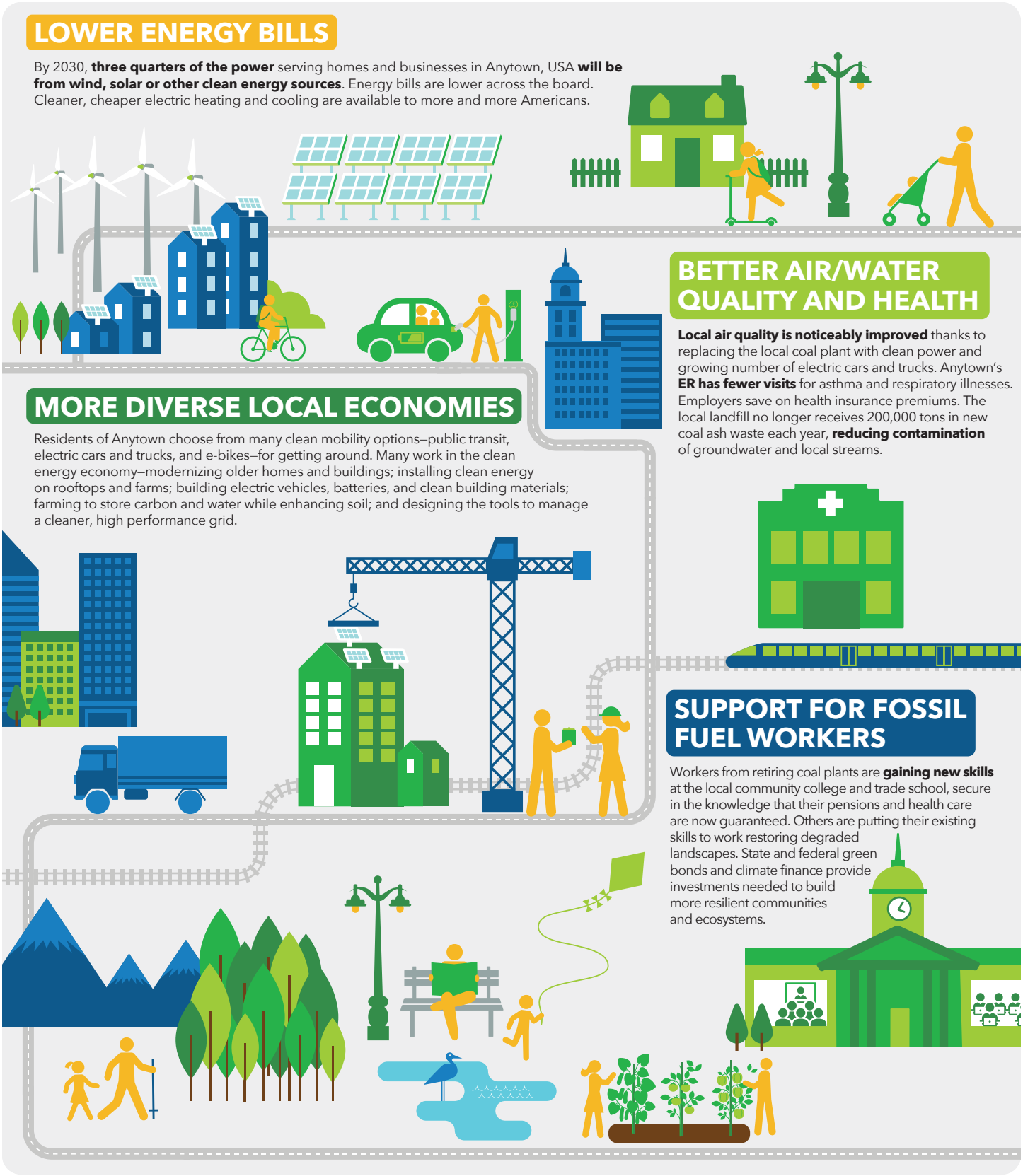
An All-In climate strategy will catalyze a fundamental transformation of the U.S. economy. If planned well and done right, it will reinvigorate American communities, industries, and landscapes; create jobs; and lower energy costs for consumers and businesses. It will also improve public health and reduce the economic costs and risks from unmitigated climate change (Figure ES-5).

Technology and Cost: By 2030, the transformation can deliver better or equal performance in electric power, vehicles, and buildings compared to fossil fuel technologies—and at a smaller price tag. Building and operating new clean energy generation combined with storage and load management is already cheaper than keeping existing coal plants online. Such clean energy portfolios are also cheaper than 90 percent of proposed new gas-fired power plants. Plug-in electric cars are delivering substantial savings on a lifetime basis now and are expected to be at or very close to purchasing price parity with gasoline vehicles within three to five years. Buildings with electric heat pumps increasingly save money compared with gas heating systems in homes and offices. Continued innovation will be necessary for all sectors, but especially for hard-to-decarbonize areas like industry, aviation, and shipping.

Jobs: The transition will create new opportunities in the industries and careers of the future, including renewable energy, energy storage, electric vehicle manufacturing, green building construction and efficiency retrofits, sustainable forestry, and regenerative agriculture. Already, clean energy generation employs 1.3 million workers across over 300 occupations, and energy efficiency employs an additional 2.35 million. The two fastest growing occupational categories in the United States are wind turbine technician and photovoltaic installer, both with average salaries well above the median wage. These jobs are located in both urban and rural areas, and across the geographic span of the United States.

The transformation will also create benefits to air and water quality, human health, and ecosystems that improve quality of life for all Americans. Since 2010, the retirement of 270 coal plants has already helped avoid 7,000 premature deaths from air pollution. In the All-In scenario, the health benefits of improving air quality just by lowering coal and gas electricity generation compared to current levels would

Figure ES-5 | **Life in Anytown, USA with the All-In Climate Strategy**



result in an additional 5,700 avoided premature deaths annually and have an economic benefit of $26 to $58 billion. These numbers from conventional pollutants capture just one portion of the benefits possible in the All-In scenario. Lower levels of ground-level ozone will also occur, reducing incidences of asthma and other illnesses. After 2030, the decarbonization of transport and buildings will lead to even greater benefits to air quality and health.

Achieving these many benefits will require innovative public and private investments in low-carbon infrastructure such as smart grid technologies, high-voltage transmission lines, energy storage, and electric vehicle charging stations. The government will need to phase out fossil fuel subsidies and both the public and private sectors we also need to expand investment in deploying emerging low-carbon technologies while developing new advanced emissions-reducing solutions through research and development. This will continue the trend of driving down technology costs through economies of scale and learning-by-doing. And to achieve a zero-carbon economy that works for all Americans, we also need to begin planning immediately to ensure economic diversification and compelling employment opportunities for workers and communities highly dependent upon fossil fuel industries. Public policies and investments must anticipate needs and be tailored to the local context to reorient communities and workers toward new industries, careers, and sources of municipal revenues.

◂ If we have 100% commitment across government, business, and citizens to execute the vision of the All-In climate strategy, daily life in the average American town will have improved substantially by 2030. By protecting the climate, we can achieve cheaper energy, cleaner air and water, and better-performing buildings and vehicles.

While the road ahead is not easy, it is possible—and state, local, and private sector efforts are already moving us in the right direction. It will require rapid deployment of diverse climate strategies from the bottom up and will require the skills of all leaders and organizations to envision and act on the ways in which these opportunities can transform their own economies for the better. Long delayed reforms and deferred maintenance of infrastructure and ecosystems will need to be addressed. It will require grassroots and broad organizational efforts to elect leaders that embrace, regardless of partisan affiliation, the vision of a clean, climate-friendly, and robust American economy. It will require that policies and strategies are pursued that help ensure all communities share in the benefits of the transition to a clean economy. It will require us to bring renewed American leadership to the international stage.

Events of the past few years demonstrate that America can and will step up, not only to carry the torch forward in this period of federal inaction on climate, but also to build the basis for a real, robust, and comprehensive American approach to building a thriving, clean economy. We are close, and the next few years will be critical to our success. We can, and must be, all in.

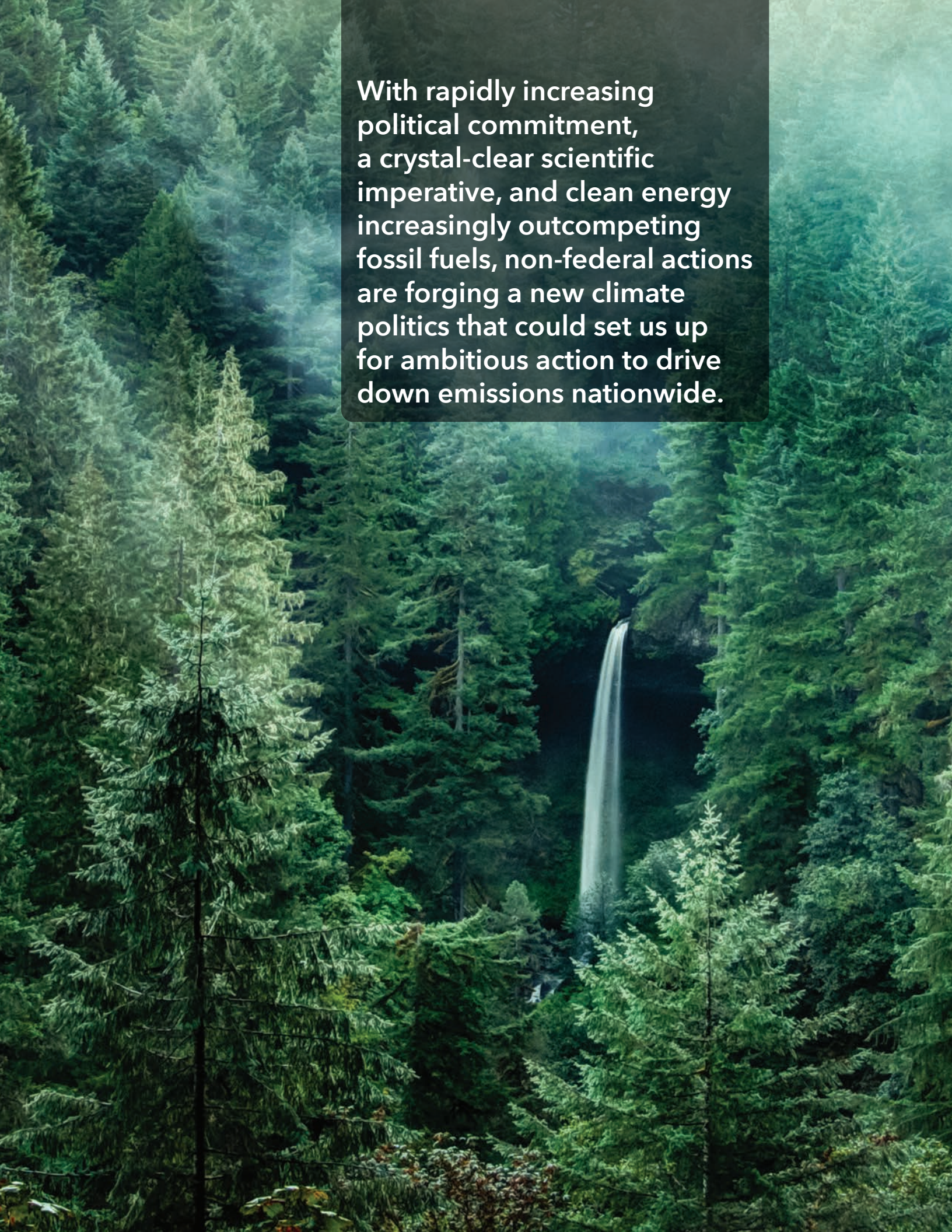
1

Introduction:
The New American Climate Landscape

The United States is an economic engine of the world, a leader in innovation, and a cradle of global creativity. It is well positioned to confront the challenge of climate change and deliver new technologies that will improve lives at home and globally. As U.S. states, cities, businesses, investors, universities, and other institutions are emerging as leaders in the global green economy, the U.S. is building a new bottom-up approach to national climate action based on robust, expanding, and durable state and local policies and other actions. Growing public concern about climate change creates additional pressure to shift national politics toward rapid action. With renewed federal leadership, an "All-In" national climate strategy can drive U.S. emissions to net zero while bolstering our economy.

America's Pledge was established in 2017 to understand and communicate the impact of the states, cities, and businesses taking climate action today. Last year our report, *Fulfilling America's Pledge*, provided the most comprehensive estimate of what states, cities, businesses and others could deliver by 2025, based on what was currently on the books and what was identifiably possible with near-term, high-impact steps available to those actors. We built a new, data-driven and comprehensive analytical approach, and showed that these actions were already making a major difference, and with further effort had the potential to drive U.S. emissions closer to our Paris Agreement target despite opposition from the current U.S. administration.

Since last year's report, the window of possibility for bold climate breakthroughs by states, cities, and the private sector has opened even wider. Ambitious new legislation by California and New York has set the standard, and other states like Colorado and New Mexico are becoming leaders. Governors, CEOs, mayors, state



With rapidly increasing political commitment, a crystal-clear scientific imperative, and clean energy increasingly outcompeting fossil fuels, non-federal actions are forging a new climate politics that could set us up for ambitious action to drive down emissions nationwide.

The comprehensive All-In strategy described in this report could get the U.S. back on track for long-term decarbonization.

legislatures, county governments, tribal groups, universities, health organizations, and citizens are taking bold steps that even a few years ago may have been considered out of the realm of possibility. With rapidly increasing political commitment, a crystal-clear scientific imperative, and clean energy increasingly outcompeting fossil fuels, these non-federal actions are forging a new climate politics that could set us up for ambitious action to drive down emissions nationwide after 2020.

Given accelerating bottom-up momentum on climate action, it is now time to analyze what these transformational changes could enable in terms of new, ambitious combined bottom-up and federal action after 2020. What does such an all-in approach signal for overall U.S. decarbonization potential in 2030?

This year's report demonstrates our path to success. It presents a vision of what a globally-leading, "All-In" American climate transformation would look like. It envisions a world of continued positive market trends and rapidly expanding ambitious bottom-up climate policies, accelerated by community mobilization strategies like Beyond Carbon and other citizen movements. Layered into that environment, it shows the impact of ambitious and comprehensive federal leadership including full implementation of existing statutory obligations and authorities combined with increasingly ambitious new legislation from Congress after 2020. The comprehensive All-In strategy described in this report could get us back on track for long-term decarbonization. It will not be easy to achieve—requiring a massive mobilization effort to deploy technologies and policies at accelerated speed and scale—but if we do, the benefits will be immense, not just for the climate but for our society, our health, and our economy.

The remainder of this report includes the following:

Chapter 2 describes how the United States could achieve a comprehensive, national climate policy by building on the foundation of the most ambitious bottom-up efforts. It introduces two scenarios for U.S. climate action and explains the scale and pace of change necessary to achieve them, as well as their projected results in terms of emissions reductions in 2030.

- The Bottom-Up scenario includes aggressive emissions reduction efforts from U.S. states, cities, businesses, and other actors, bolstered by growing citizen activism.
- The All-In scenario is a comprehensive American climate strategy that integrates aggressive bottom-up action with renewed and expanded federal engagement after 2020.

The scenarios are organized around three principles that outline a pathway to success: 1) accelerating toward 100 percent clean electricity and other energy supplies; 2) decarbonizing energy end-uses in our transportation, buildings, and industry, primarily through electrification and efficiency; and 3) addressing remaining emissions by enhancing the carbon storage potential of our farms, forests, and coastal wetlands.

Chapter 3 provides an update on new state, city, and business leadership from the past year and presents a footprint analysis to show how much of the U.S. economy is acting on climate. It gives the results of the Current Measures scenario, which shows the emissions reductions that can be delivered based on currently enacted policies by state and local actors through 2030.

Chapter 4 presents a vision for a new American economy in line with the All-In scenario and deep decarbonization. This includes affordability benefits for consumers, economic development and jobs benefits for workers and communities, investment opportunities in new clean industries, and plans for a fair transition for all Americans.

Chapter 5 concludes the report.

As shorthand, this report refers to the many U.S. entities taking action on climate change outside the federal government as **states, cities, and businesses**. These are not the only important actors, however. States, cities, tribes, counties, businesses, investors, regional associations, faith-based groups, cultural institutions, universities, citizen groups, and others are all making efforts to address climate change. 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."

2

Building Our American Future: Bottom-Up Pathways to an All-In Climate Strategy

The comprehensive approach to an American climate policy rests on a strategy of combining an ambitious set of state and local policies and actions with a set of strong and complementary federal policies. This report details how such a strategy might be constructed and what it can deliver. To do so, this chapter introduces two ambitious scenarios and provides an in-depth look at the specific policy pathways by which they could be implemented. It also presents the results of each scenario in terms of emissions reductions. The Bottom-Up scenario explores the implications of significantly expanded state, city, and business-level action. The All-In scenario tests the results of ambitious and comprehensive federal engagement, building on the bottom-up actions from the first scenario.

States: America's Laboratories of Democracy

States, cities, businesses, and other actors across the United States have been leading the way when it comes to addressing climate change. Because the American governance system delegates decision-making across levels of government, leaders at all levels have been able to step up and make a meaningful difference. For example, the majority of utility regulatory and siting decisions, transportation planning, building codes, and other important aspects of energy and transportation decision-making take place at the state and regional level. By advancing climate-friendly technologies and policies within their jurisdictions, these actors are not only reducing U.S. emissions at a local level but are also offering tried-and-tested models for how other entities should replicate and scale similar efforts. Indeed, this "laboratory of democracy" model—with one state leading the way via an innovative policy that others then tailor to their own contexts and adopt—has been used frequently throughout U.S. history.

For example, in 1973, Arizona became the first state to restrict smoking in several public places. While a controversial policy at the time, additional states and cities passed similar and then more stringent smoking bans in the decades that followed. In 2019, almost all the U.S. population is covered by 100 percent smoke-free provisions for workplaces, restaurants, and/or bars by a state or local law, including those who work in federal buildings.[2, 3]

Policies around same-sex marriage offer another example. In 2000, Vermont became the first state to grant the full benefits of marriage to same-sex couples. The fifteen years following saw a heated battle over the issue in many states, with numerous states passing pro-same-sex marriage legislation and others issuing bans (which were later ruled unconstitutional). Between 2011 and 2014, 15 states legalized same-sex marriage. Finally, in 2015, a U.S. Supreme Court ruling made same-sex marriage legal in all 50 states.[4]

In the realm of energy policy, energy efficiency standards are one area where states have led the charge and federal policy has followed suit. Appliance standards were first established in California in 1974, followed quickly by Florida, New York, and Massachusetts. In 1978, federal standards were proposed, though national efficiency standards did not become mandatory until 1987, when the National Appliance Energy Conservation Act was enacted.[5]

Thanks to today's interconnected world, actions and ideas by state and local actors need not take decades to extend across the country. The spread of increased ambition is further supported by the work of organizations like We Are Still In, the U.S. Climate Alliance, Climate Mayors, Urban Sustainability Directors Network, and others who exist to help share and scale strong climate policies and programs.

Figure 2-1 | **A Virtuous Cycle of Climate Action**

▲ **Bottom-up actions from states, cities, businesses, and other entities are mutually reinforcing with top-down federal action.**

SCENARIOS

As the United States and other countries continue to take high-impact climate actions at the non-federal and federal level, the results reinforce the benefits of higher ambition and support growing that ambition across all countries. The vision for ambitious climate action presented here rests on a foundation of rapidly scaling proven measures and continued technological advancements. For the Bottom-Up scenario, we assume that states, cities, and businesses learn from and expand on cutting-edge decarbonization actions their peers are taking. In addition, we assume growing citizen activism pushes for ambitious action and a rapid shift away from fossil fuels.

While these bottom-up initiatives provide the basis for significant progress, federal action is essential to achieve the pace needed for nationwide progress. For the All-In scenario, we therefore assume that post-2020 the federal government responds to the increased citizen mobilization and proof points provided by state and local actors and reengages on climate action by further scaling up existing, state-tested climate policies and programs as well as passing new nationwide policies, including in areas that the federal government is uniquely tasked with overseeing. It is through this complementary federal reengagement that the United States can develop a comprehensive national climate strategy (Figure 2-1).

The Bottom-Up Scenario: States, Cities, and Businesses as the Foundation of Ambitious Action

Even with the U.S. executive branch working to roll back climate regulations, states, cities, and businesses have steadily increased their ambition. They are driven by a combination of economic developments, compelling public health benefits, and increased demand from their citizens, customers, and shareholders to address climate change. As this enhanced ambition is now translating into real impact—not just on climate, but also for the economy, public health, and quality of life—more states, cities, and businesses are beginning to follow suit. Yet current progress is insufficient. To avert the most damaging impacts of climate change, states, cities, and businesses must do more. The Bottom-Up scenario identifies opportunities for these actors to step up—modeling a future where this momentum accelerates.

This scenario assumes federal policy remains frozen through the 2020s—no additional rollbacks and no new climate-friendly federal policies—and that public support for climate action prompts significant new action from both current leader states and new leaders. **Specifically, we assume that an increasing number of states, cities, and businesses adopt current, cutting-edge decarbonization policies and actions to reduce economy-wide emissions.**

For instance, as the economic benefits of clean energy are demonstrated by first-mover states like New York and California, an increasing number of states join the movement and match their ambition. This momentum helps to further improve the economics of clean energy, which leads to significant inroads even in states not focused on addressing climate. The Bottom-Up scenario assumes that some states do not prioritize climate action; state-wide measures are limited in these resistant states. However, the Bottom-Up scenario recognizes that local advocacy still has the potential to reduce emissions, as has happened in states as diverse as Oklahoma and Indiana**.** And it assumes local advocacy will continue to be effective at reducing uneconomic coal and gas generation, even in many states with governments indifferent to climate risk.

Tiered Approach to Building the Bottom-Up Scenario

Although the U.S. may be broadly advancing toward a tipping point for national climate action, states will inevitably remain diverse at any point in time. For this reason, to facilitate our scenario analysis, we grouped states into three different tiers depending on their historical willingness to lead on climate.

Tier 1 first-mover states have historically and recently embraced ambitious

climate action. We anticipate they will continue to lead the way, adopting the most–and most ambitious– climate targets and policies. We identified these states by attributes such as membership in climate leadership coalitions (e.g., USCA), vocal leadership in support of climate action, ambitious emissions reduction targets, and on-the-books climate policies. Tier 1 states represent roughly 45 percent of the U.S. population, half of the GDP, and one-third of emissions.

Tier 2 fast-follower states are adopting some climate measures, but not as quickly as Tier 1 states. Our Bottom-Up scenario assumes that fast-follower states will implement some of the policies developed by the Tier 1 leader states but to a lesser extent. These states account for roughly one-fifth of the U.S. population, GDP, and emissions.

Finally, Tier 3 slow-follower states have thus far done little with respect to passing climate-friendly policies. We anticipate these states will continue, for the most part, to follow the status quo, even if embracing new policies would be more cost effective. However, even Tier 3 states are impacted by the increasingly favorable economics of clean energy technologies. Slow-follower states represent the remaining population and GDP of the U.S. and, most importantly, are currently responsible for roughly half of U.S. emissions

These tiers are used for modeling purposes and intended to be illustrative, as there is no bright line between states in actuality. Some states defined as Tier 2 or Tier 3 may take leadership-level actions in some sectors, and not all Tier 1 states will adopt the most ambitious actions across all sectors of the economy. Our tiered approach is intended to approximate the scale of action across all 50 states. The policies that were modeled for each tier depends on the sector and are explained below and in the technical appendix in more detail.

City and business activities are also included in the Bottom-Up scenario modeling. In order to avoid double-counting in areas where state, city, and business-level policies target the same emissions sectors or policy areas, the modeling factors out overlapping ambition, particularly where cities and businesses taking action are located inside a Tier 1 state.

The All-In Scenario: Federal Leadership Expands on Bottom-Up Efforts

Bottom-up initiatives deliver a strong foundation, but achieving emissions reductions that align with the Paris Agreement's goals will require even more ambitious steps across all levels of society and all sectors—including, most notably, the federal government. This fact rings particularly true because Tier 3 states are responsible for such a large fraction of U.S. emissions. Our All-In scenario reflects this, layering new federal policies from both the executive branch and Congress onto the state, city, and business actions modeled in the Bottom-Up scenario.

The All-In scenario assumes ambitious policy interventions, including broad, sector-based federal climate investment, regulation, and legislation; maximal implementation of existing federal statutory obligations; and authorities to complement and build on bottom-up actions. Importantly, many of the modeled reductions are not possible without new congressional action across many sectors.

In light of the current administration's opposition to climate action, efforts to dismantle environmental protections, and lack of a current congressional pathway for comprehensive legislation, fully renewed federal leadership will require both a major shift in congressional dynamics and a reversal by the current administration or a new administration with a different approach. Increasing political demand for action and evermore powerful economic drivers for clean energy add pressure for such renewed politics over the course of a decade.

The ambition modeled in the All-In scenario relies on full implementation of

the actions modeled in the Bottom-Up scenario and assumes economy-wide interventions comparable to those implemented in Tier 1 states. It thus expands the measures taken by first-mover states, cities, and businesses to the entire country. Many of the modeled policies are a logical outgrowth of those implemented by the "laboratories of democracy," demonstrating that strong state leadership and policy development has the potential to serve as a model for national interventions, allowing federal policies to be complementary.

Ambitious state and local policy remains essential because federal interventions have their limits. For instance, the federal government has virtually no say in state and local zoning decisions, yet smart growth and urban densification policies are critical for cost-effectively reducing transportation-related emissions and maintaining our terrestrial carbon sink.

Similarly, federal interventions are necessary because states, cities, and businesses are limited in what they can accomplish alone. Given political dynamics, some regions are unlikely to enact policies to decarbonize rapidly enough without top-down federal policy frameworks. Some federal authorities, including those relating to appliance standards, preempt or limit states and cities.

Furthermore, the federal government oversees interstate electricity transmission, aviation, shipping, interstate pipelines, and coal and gas leasing on public lands. The federal government also owns and manages 28 percent of U.S. land area. Key regulatory requirements, such as those for the power sector and for energy intensive industries like cement and steel, are difficult to implement at the state level because of interstate competitiveness and leakage concerns. Moreover, as demonstrated by their resistance to the current administration's efforts to roll back automobile GHG standards, automakers benefit from a single, clear, national policy framework as they transition toward zero-emissions vehicles. Finally, the federal government is well-suited to invest in the research, development, and deployment needed to improve clean energy technology performance and reduce costs.

For the All-In scenario, we model a suite of potential policies across each sector. These options provide one potential method of realizing the high-ambition outcomes. At the same time, they are not intended to be prescriptive; in fact, there are numerous policy options for each of the sectors that, if designed correctly, could deliver equivalent end results.

For instance, an ambitious clean electricity standard, a carbon tax, or an emissions cap could theoretically result in equivalent power sector emissions reductions. This is particularly true in the early stages of the decarbonization process; markets for clean energy technologies can be expanded with a variety of incentive programs (e.g., government purchase programs, consumer incentives). And the needed EV recharging infrastructure could be built with more or less engagement by public utilities

The All-In scenario does not model an economy-wide carbon price. Carbon pricing has been studied in-depth and is widely seen as a particularly efficient way of reducing emissions in some sectors if not all. While carbon pricing can helpfully reflect the costs of climate change into investment and purchase decisions throughout the economy, it is not a standalone solution. To ensure sufficiently rapid and cost-effective emissions reductions, additional policies would still be needed to address other market barriers and provide incentives to develop and deploy processes and technologies needed to achieve deep emissions reductions in the decades ahead.[6] Such policies largely overlap with the bottom-up and complementary federal policies that are the focus of this report.

Both state and local policy and federal interventions will be essential.

By focusing on a broader set of solutions, we hope to provide additional nuance to the existing literature. What is important to note is that this study demonstrates that the first half of deep decarbonization—through efforts that reduce energy bills—is feasible even without economy-wide carbon pricing, so progress does not need to wait for a change in the perceived politics of carbon pricing.

While new legislation from Congress will be necessary to put the United States fully on track to achieve the goals of the Paris Agreement, the federal government already has strong obligations to act on climate under existing statutory authorities to drive substantial progress across many sectors. In addition to pushing for congressional action, a climate-focused administration should fully implement regulations under these existing authorities.

For instance, a new administration should implement ambitious emissions standards applicable to new and existing sources in the power sector; finalize the next round of vehicle standards to accelerate progress towards vehicle electrification; finalize a new round of appliance and building equipment standards, which ensure that polluting fossil-based furnaces are replaced with electricity; and impose standards for methane and volatile organic compound emissions from new and existing oil and gas wells and landfills, among other actions.

New legislation would both allow for faster action across a greater share of the economy and facilitate positive impacts of this transition. For example, new laws could renew tax incentives for electric vehicles, promote accelerated scrappage of inefficient vehicles, and provide incentives to reduce vehicle miles traveled through urban densification and public transit. Legislation aimed at industrial decarbonization would help advance deployment of innovative industrial technologies while protecting domestic jobs and industries. Future Farm Bills and other legislation could encourage climate-smart sustainable agriculture while bolstering the terrestrial carbon sink.

A PATHWAY TO SUCCESS: THREE PRINCIPLES OF ACTION

Climate change's unique complexity creates a decision-making challenge for states, cities, and businesses. However, numerous governmental, nongovernmental, industrial, and scientific analyses have coalesced around three main strategies for achieving significant emissions reductions. Amid an often bewildering number of possible solutions, a simple approach built on three principles can support efficient decision-making:

1) Accelerate toward 100% clean electricity and other energy supplies
2) Decarbonize energy end-uses in our buildings, transportation, and industry, primarily through electrification and efficiency
3) Enhance the carbon storage potential of our forests, farms, and coastal wetlands (Figure 2-2, 2-3)

Although the term "decarbonize" is used to describe this entire process, these principles cover emissions of both carbon dioxide and non-CO_2 greenhouse gases, such as methane (CH_4), hydrofluorocarbons (HFCs), and nitrous oxides (N_2O), depending on the particular strategy. These three principles expand on the climate action strategies from our 2018 report, *Fulfilling America's Pledge*. Best of all, states, cities, and businesses are already working on each principle.

As described above, the Bottom-Up and All-In scenarios build upon the cutting-edge climate policies and programs first-movers are implementing today. (See Chapter 3 for more information on these existing policies.)

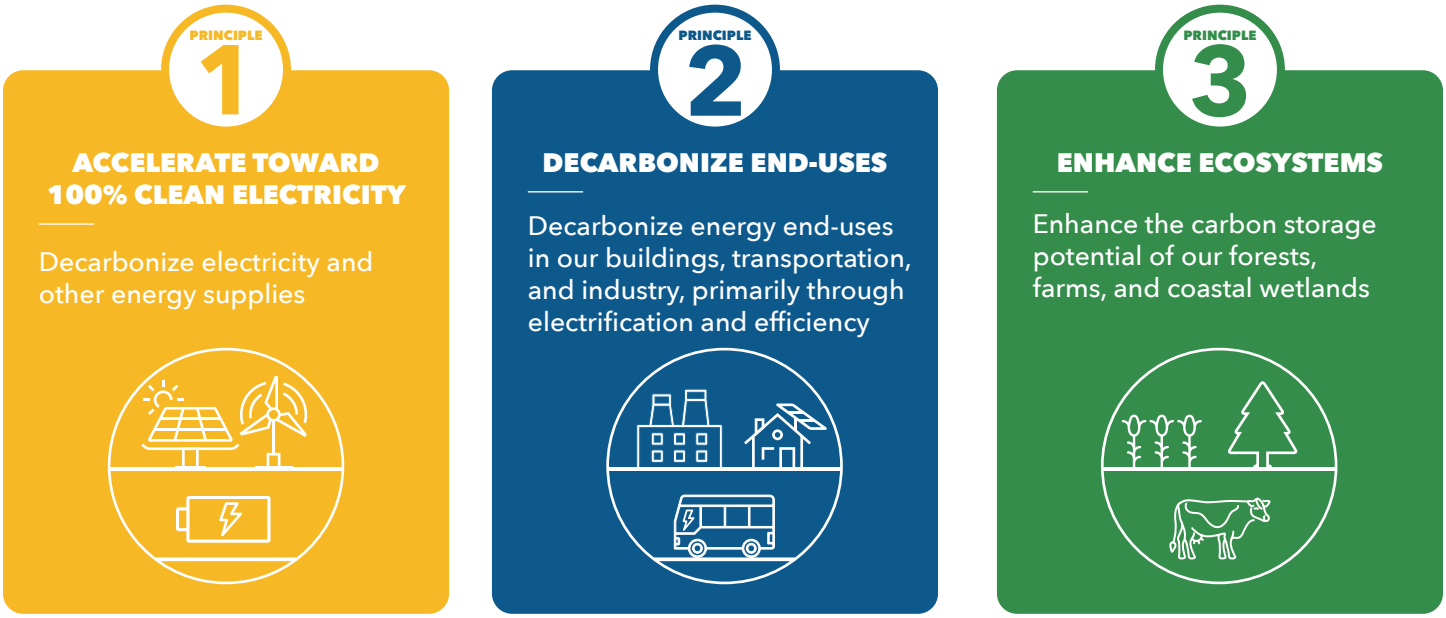
This section outlines our scenario assumptions for each principle—the policies and strategies we assume will be implemented.

Principle 1: Accelerate toward 100 percent Clean Electricity and other Energy Supplies

Over the past decade, the U.S. electricity system has become significantly cleaner. From 2005 to 2017, the system, while generating more electricity overall, decreased the carbon dioxide emissions associated with electricity generation by 28 percent through burning less coal and oil and using more natural gas, renewable energy, and energy efficient processes.[7] And a pathway to continued progress in clean electricity deployment, with lower electricity costs, has already been established as commercially and technically viable.[8,9,10] The private, public, and philanthropic sectors have propelled significant progress in decreasing the power sector's carbon intensity through policy and investment. While nuances remain around storage (particularly seasonal) and grid stability for deep decarbonization targets beyond 2030, storage and demand management technologies are offering promising solutions for continued progress.

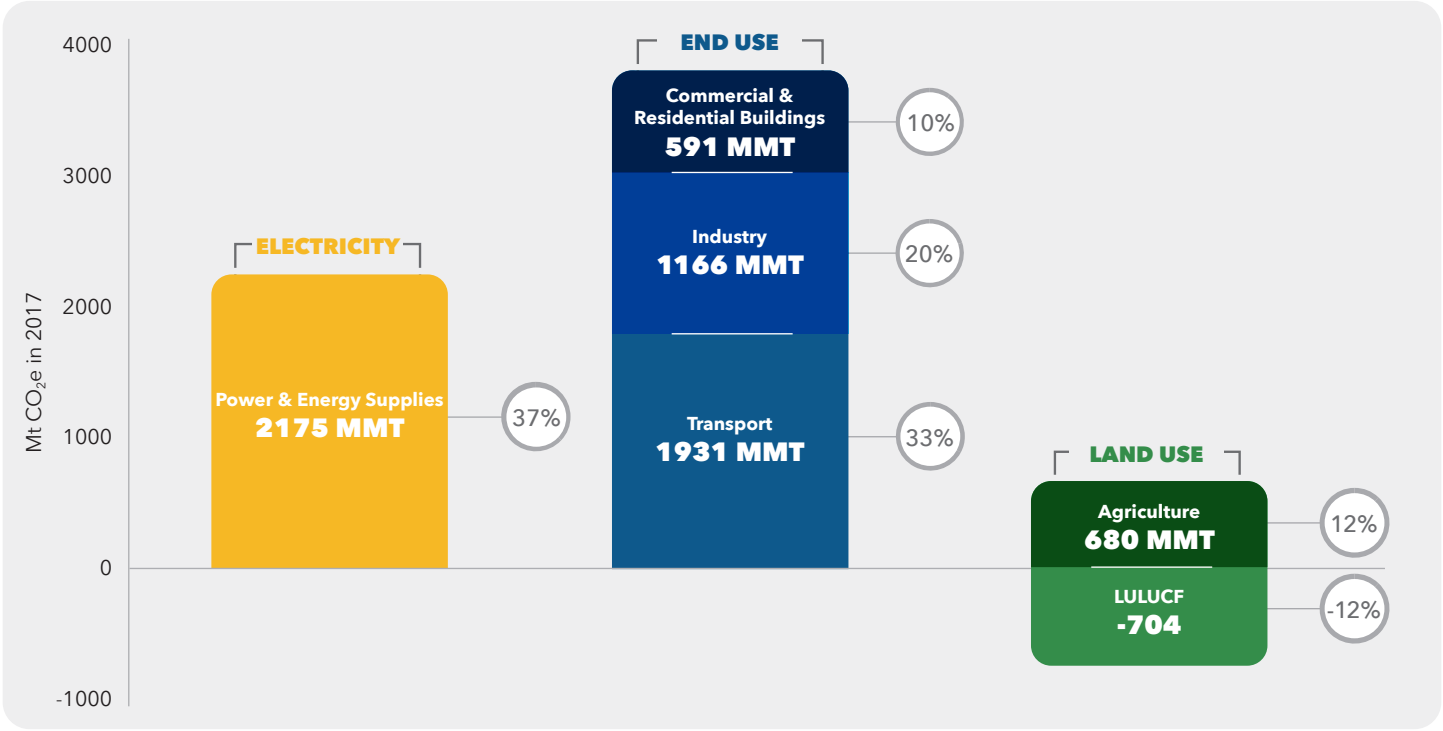
Furthermore, the economics support the energy transition. Building new renewables is cheaper than building new coal, and in most cases building and operating new renewables is cheaper than keeping existing coal plants open. Replacing 74 percent of coal plants nationally with wind and solar power would immediately reduce electricity costs and make coal plants increasingly uneconomical as time goes on.[11] New analysis also indicates that clean energy portfolios of wind, solar, and storage coupled with demand-side management cost less than 90 percent of the proposed gas-fired power plants across the country. These plants, if built, would put customers, shareholders, and society at risk for stranded costs.[12]

Figure 2-2 | **Three Principles of Action**



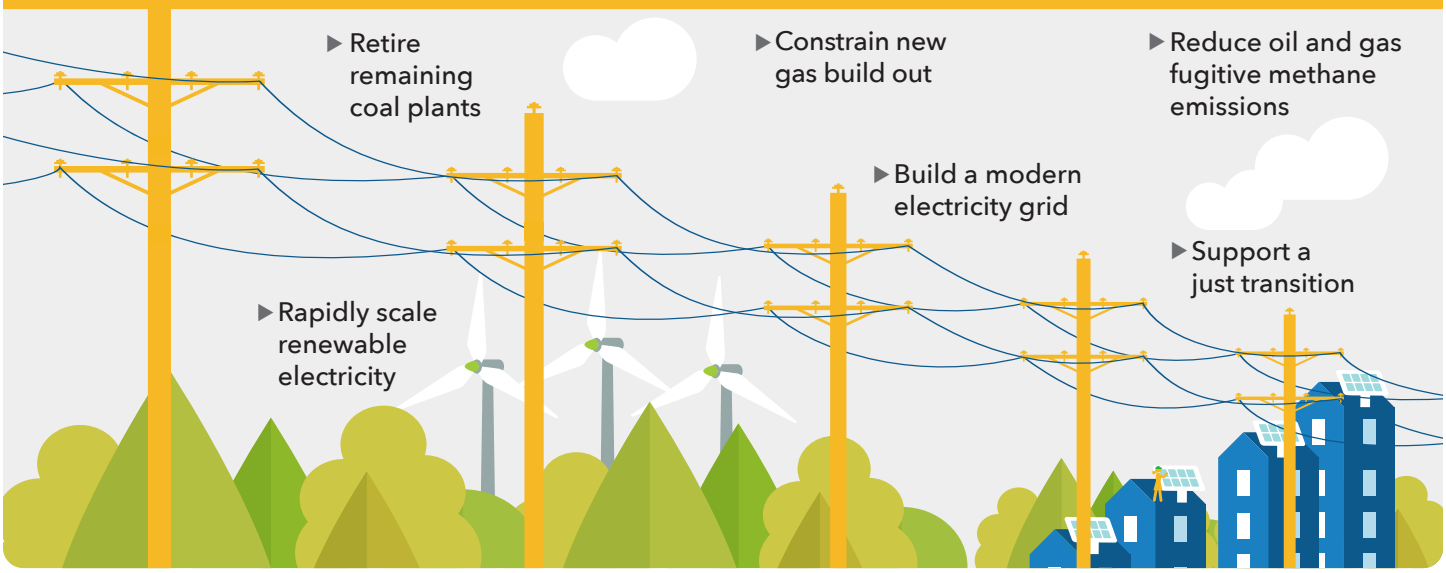
▲ The scenarios in this report are organized around a simple 3-principle framework.

Figure 2-3 | **2017 U.S. Greenhouse Gas Footprint by Principle**



▲ Greenhouse gas emissions are distributed across the three principles of our analysis. Electricity and energy end-uses from transportation, buildings, and industry make up the bulk of current emissions. Agricultural emissions and net carbon storage from land use, land-use change, and forestry are also important.

Figure 2-4 | **Key Energy Actions (Principle 1)**



▲ **Key actions that states, cities, and businesses can take to reduce emissions from power.**

Electricity in the Scenarios

In the Bottom-Up scenario, a robust, active citizen and political movement supports the transition away from fossil fuels, strengthened by the increasing cost advantage of renewables over existing coal. States, cities, and businesses continue to adopt clean energy policies as ambitious as current policies in New York and California. Tier 1 states reach at least 60 percent renewable electricity by 2030 and efficiency gains partially offset the increased demand for electricity due to end-use electrification.

Economics, policy, customer demand, and community pressure accelerate the pace of coal retirements beyond the rate witnessed over the last decade. With most coal plants uneconomic, bottom-up actions result in the coal fleet shrinking dramatically by 2030. For political reasons, a few states continue to use uneconomic generation, and a few other plants are occasionally used for grid stability. Only 7 percent of U.S. power comes from coal.

Updated utility business models and ratemaking approaches enable the private sector to successfully support continued and expanded deployment of clean generation technologies. This allows the country to predominantly replace retiring coal plants with clean energy portfolios rather than trigger significant investments in gas plants, which will become stranded assets as the cost of renewables continues to decrease.[13] Continued reductions in wind and solar costs, plus citizen action and new policies, put downward pressure on existing gas generation. In addition to age-related retirements, some gas plants are retired early due to the relative cost-effectiveness of clean energy portfolios or to meet updated clean electricity standards and renewable portfolio standards.[14] Overall, gas retirements or decreased utilization offset any increased gas generation in Tier 3 states and gas generation remains at roughly 2020 levels.

In the All-In scenario, a federal clean electricity standard or comparably effective policy, in conjunction with cost declines, achieves 77 percent clean electricity, including 49 percent of total generation coming from renewables by 2030. This puts the U.S. on a pathway to full decarbonization of electricity well before 2050. The national policy acts as a signal to utilities and investors, halting new construction of gas generation. Replacement of remaining gas and residual coal with clean energy is well underway by 2030 and is completed before 2050. Almost all of today's nuclear capacity is retained, providing 17 percent of generation in 2030.

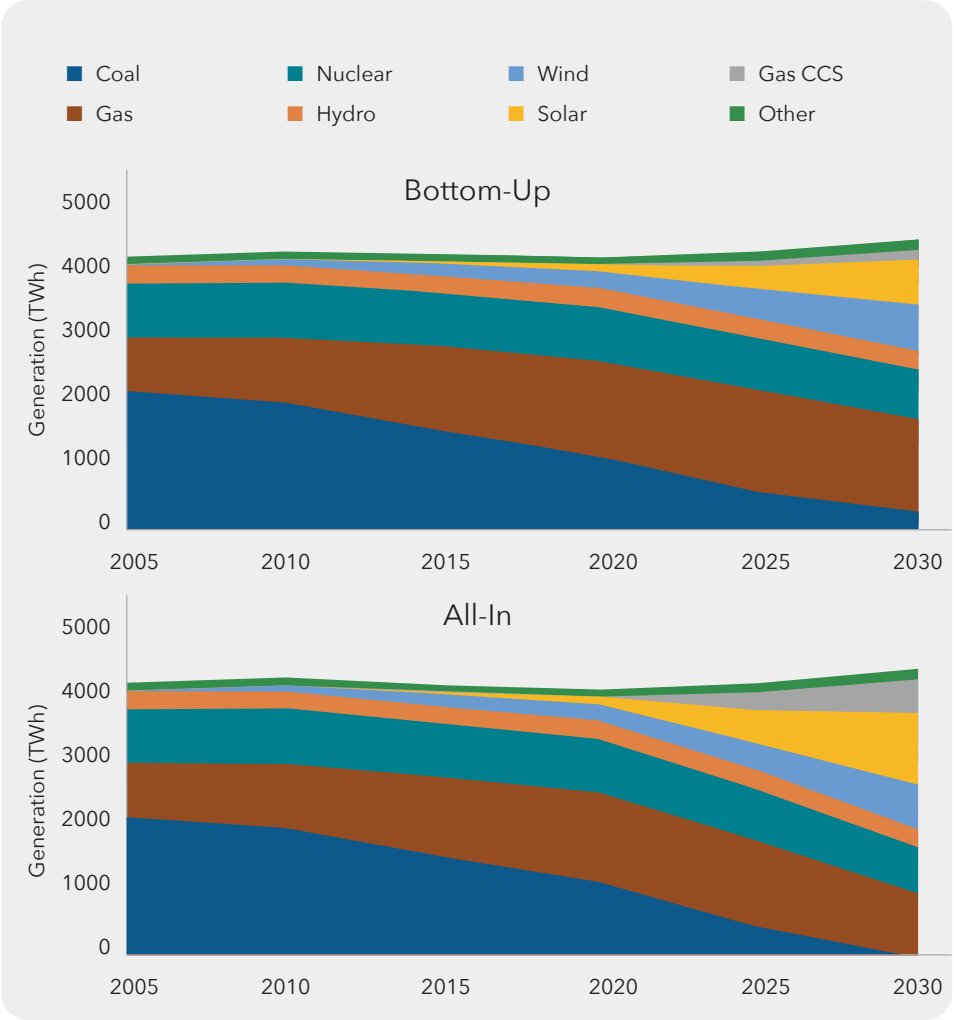
Greenhouse gas emissions from oil and gas drilling are addressed on an accelerated schedule to phase out venting and flaring, with all upstream leaks captured through the regulation of both new and existing facilities.

The scenarios assume leader states, cities, and businesses employ a combination of the following electricity-sector strategies:

- Scale to at least 60 percent renewable electricity by 2030 and full decarbonization of electricity well before 2050 through a combination of policies (e.g., clean electricity or renewable portfolio standards) and financial incentives (e.g., tax incentives)

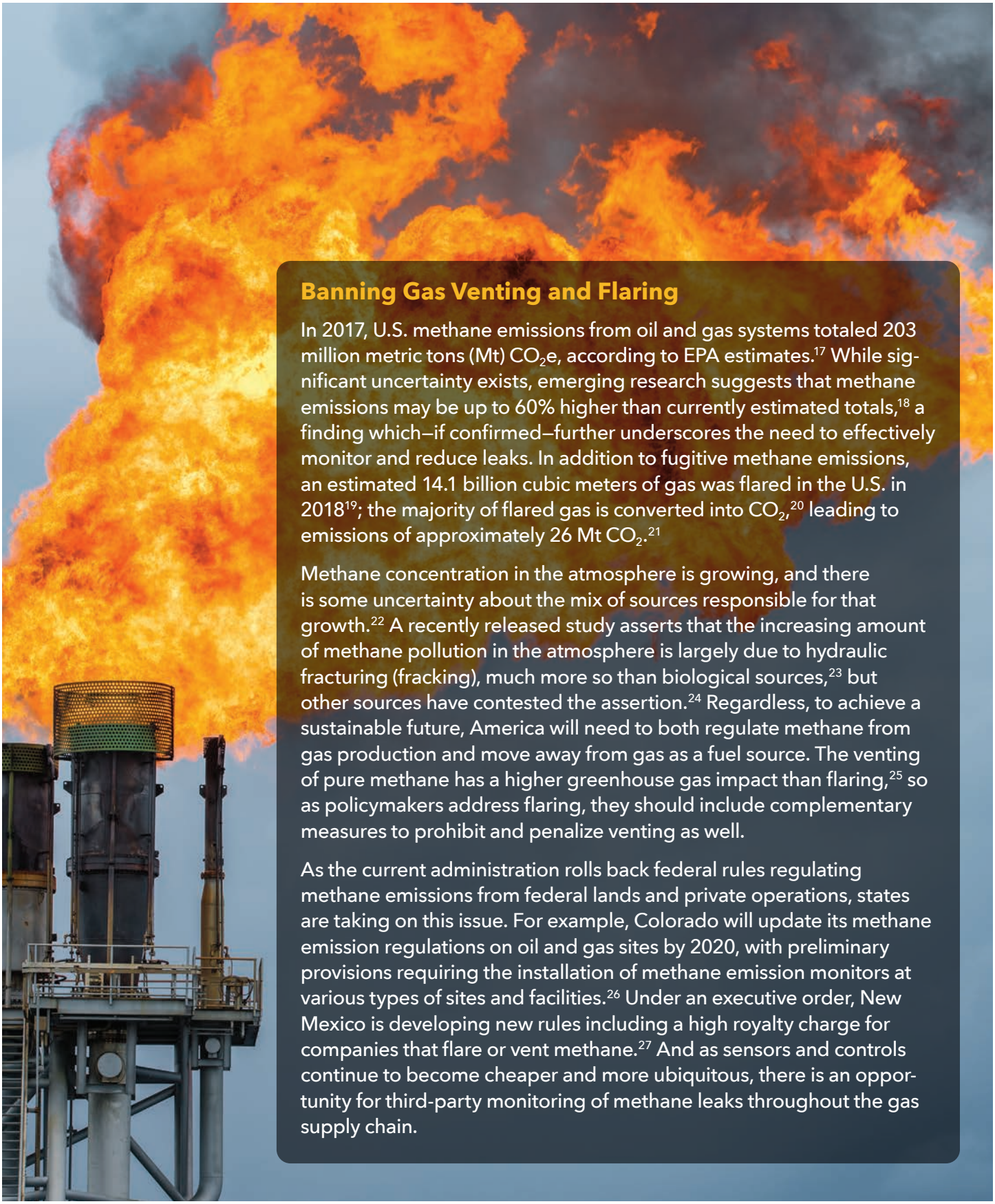
- Replace coal with clean power as rapidly as system planning permits wherever coal is no longer competitive
- Plan for a staged transition away from coal and gas by deploying innovative financing approaches like debt securitization and by requiring stranded asset evaluations for proposed fossil fuel infrastructure
- Particularly in states and localities with fossil fuel-dependent communities, direct resources toward a just transition through approaches including workforce programs and hiring preferences
- Work with public utility commissions and regional planning organizations to modernize assessments of proposed projects, prioritize climate considerations, and support cross-jurisdiction planning
- Remove barriers to renewable energy and distributed resource deployment (e.g. simplifying requirements for solar PV and storage permitting and installation)
- Invest in modernizing grid transmission and distribution and deploy R&D resources into next-generation storage and other flexible technologies

Figure 2-5 **Electricity Generation in the Bottom-Up and All-In Scenarios**



▲ **Compared to 17% today, renewable electricity market share in the Bottom-Up scenario reaches 39% by 2030 and in the All-In scenario reaches 48% by 2030. In both scenarios, nuclear generation declines only slightly from today.**

When integrating more renewable energy to the grid, it will also be important to reduce losses in electricity transmission and distribution (T&D). Average line losses are 6-10 percent in the United States.[15] Continued investment in expanded transmission and targeted grid modernization, to reduce losses and better integrate renewable resources, can lead to a more efficient grid and lower overall electricity needs. Retiring coal frees up T&D assets to be used by other generation sources. Targeted T&D investments also support clean energy. For example, dedicated above-ground or underground high-voltage direct current lines provide renewables access to new markets, and increased connectivity also helps the electric system better manage wind and solar intermittency. Both will be increasingly important as renewables make up a greater proportion of the grid post-2030. However, new research indicates that flexible approaches, including better planning and forecasting and multiple types of storage, could reduce the need for transmission build out, even in high-electrification future scenarios.[16]



Banning Gas Venting and Flaring

In 2017, U.S. methane emissions from oil and gas systems totaled 203 million metric tons (Mt) CO_2e, according to EPA estimates.[17] While significant uncertainty exists, emerging research suggests that methane emissions may be up to 60% higher than currently estimated totals,[18] a finding which—if confirmed—further underscores the need to effectively monitor and reduce leaks. In addition to fugitive methane emissions, an estimated 14.1 billion cubic meters of gas was flared in the U.S. in 2018[19]; the majority of flared gas is converted into CO_2,[20] leading to emissions of approximately 26 Mt CO_2.[21]

Methane concentration in the atmosphere is growing, and there is some uncertainty about the mix of sources responsible for that growth.[22] A recently released study asserts that the increasing amount of methane pollution in the atmosphere is largely due to hydraulic fracturing (fracking), much more so than biological sources,[23] but other sources have contested the assertion.[24] Regardless, to achieve a sustainable future, America will need to both regulate methane from gas production and move away from gas as a fuel source. The venting of pure methane has a higher greenhouse gas impact than flaring,[25] so as policymakers address flaring, they should include complementary measures to prohibit and penalize venting as well.

As the current administration rolls back federal rules regulating methane emissions from federal lands and private operations, states are taking on this issue. For example, Colorado will update its methane emission regulations on oil and gas sites by 2020, with preliminary provisions requiring the installation of methane emission monitors at various types of sites and facilities.[26] Under an executive order, New Mexico is developing new rules including a high royalty charge for companies that flare or vent methane.[27] And as sensors and controls continue to become cheaper and more ubiquitous, there is an opportunity for third-party monitoring of methane leaks throughout the gas supply chain.

Principle 2: Decarbonize Energy End-Uses in our Transportation, Buildings, and Industry, primarily through Electrification And Efficiency

As the intensity of greenhouse gas emissions in the electricity mix decreases, expanding electrification reduces emissions even further. "Beneficial electrification" replaces fossil-fueled end-uses in buildings, transportation, and industrial facilities with efficient, electrically powered technologies "fueled" with increasingly low-carbon electricity. The switch cuts greenhouse gases, lowers costs, and/or provides other benefits.[28] The technologies to electrify nearly all building and transportation related end-uses already exist and are being deployed. Additionally, electric technologies are typically more energy efficient than fossil-based alternatives, so they can provide the same level of service with less energy.[29]

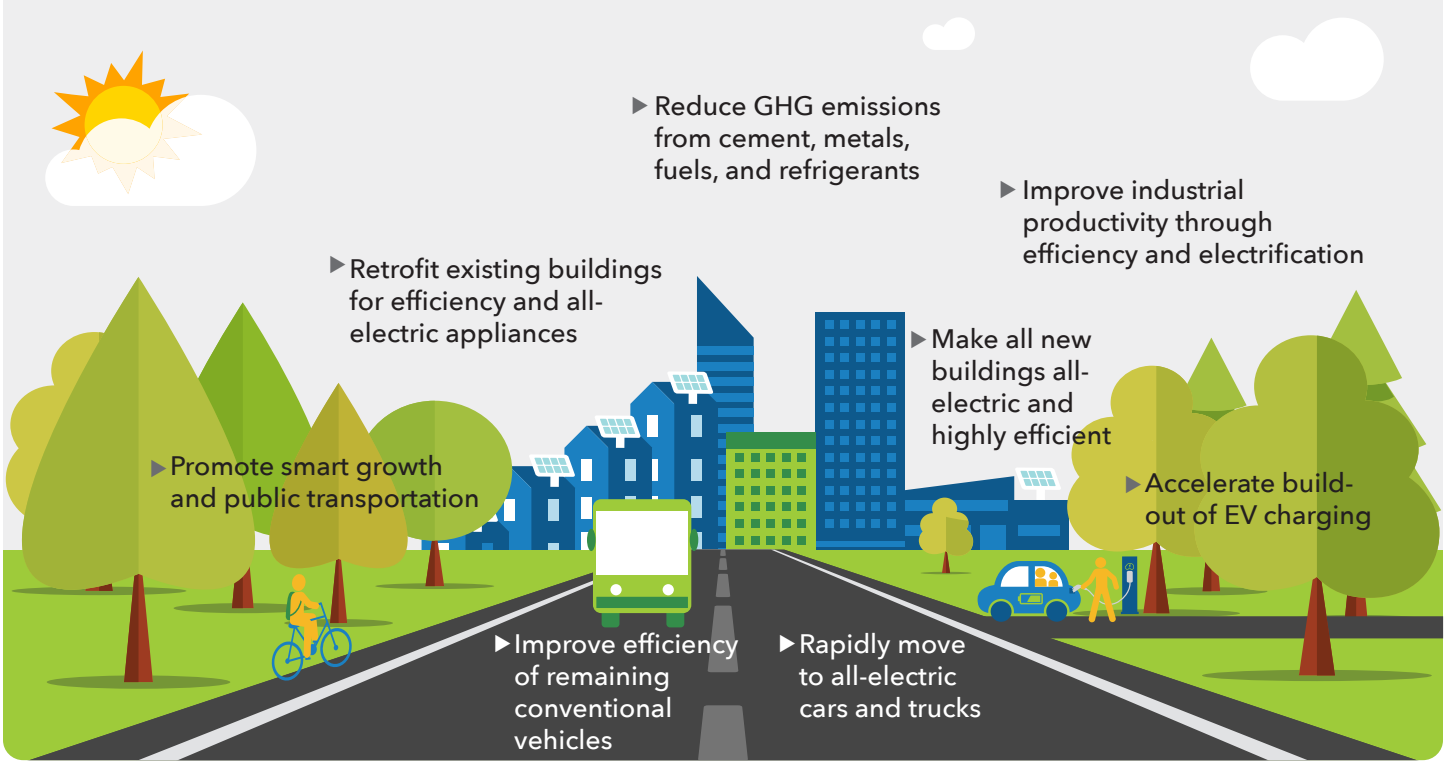
Electrification of end-uses will inherently lead to increased demand for electricity. Therefore, electrification strategies must include strategies that improve energy productivity, ensure that new demand is met with low-carbon generation, and support load management and electricity transmission. As energy efficiency offers significant cost savings and other benefits, both electrification and efficiency are essential and are highly interrelated.

Constraining methane emissions in part starts with electrifying the building, industry, and transportation sectors, given that these sectors consume 60 percent of natural gas. Electrification reduces end-use consumption, which reduces upstream demand for gas as a direct fuel source. Over time, decreasing the scale of gas distribution pipelines helps address methane leaks and costly repairs by removing the source of leaks.

Buildings

One-quarter of residential buildings[30] and over 20 percent of commercial buildings[31] in the United States are already all-electric, and the technologies exist to move to fully electric, highly efficient, and grid-interactive buildings in a much broader range of climate zones. For example, electric heat pumps can cost-effectively replace gas-fired furnaces or boilers in most of the United States if the building is well insulated, efficiently providing both heating and cooling. Heat pump water heaters are also efficient and widely available. Induction cooktops are highly efficient substitutes for gas ranges and improve indoor air quality as well as safety. Integrating demand flexibility into buildings reduces emissions and increases efficiency.

Figure 2-6 | **Key End Use Actions (Principle 2)**



▲ Key actions that states, cities, and businesses can take to reduce emissions from end uses.

Buildings in the Scenarios

In the Bottom-Up scenario, we assume first-mover and fast-follower states emphatically embrace the concept of a pollution-free building stock. Supported by aggressive and updated energy efficiency resource standards (EERS), major investments are made by states, cities, and businesses in retrofitting existing building stocks to reduce energy waste. First-movers achieve 2 percent annual energy savings, a significant gain over current levels. By 2030, leading cities and states have adopted codes and emissions regulations to ensure that all new buildings are fully electrified and thus have zero air pollution emissions. Gas hookups are phased out for new construction. After 2030, as furnaces, air conditioners, water heaters, and stoves wear out, they are replaced by zero-emission electric appliances so existing building stocks move steadily toward zero carbon impact, with very cold climates being the final segment to be electrified. City and state building policy supports densification and equitable access to housing.

In the All-In scenario, we assume that the staggered phaseout of building combustion technology that had been initiated by cities and many Tier 1 states in the Bottom-Up scenario is now extended to all 50 states, with an emphasis on the air pollution benefits of phasing out combustion in uncontrolled heating, cooling, and cooking technologies. Federal banking and housing policy support rapid efficiency retrofits and electrification. These assumptions put the building sector solidly on a pathway to zero pollution and emissions by 2050.

The scenarios assume leader states, cities, and businesses employ a combination of the following building-sector strategies:

- Adopt building codes and practices that encourage or require zero-emission, all-electric buildings so that all new buildings are 100 percent electric by 2030 and retrofits for existing buildings are actively underway.
- Begin the phaseout of combustion building technologies and after 2030 ensure that all replacement furnaces and water heaters are zero-pollution, electrified appliances. Timing of the phaseout will depend on regional cost considerations.
- Reduce costs and emissions and avoid stranded assets by placing a moratorium on gas hookups in new building construction before 2030.
- Divert investments from expanding or subsidizing gas infrastructure toward building electrification and efficiency improvements. These improvements include electrification retrofits and deep-envelope upgrades that include air sealing and insulation.
- Align incentives and programs for building retrofits with state climate goals and begin efficient retrofit of existing buildings. Ensure equity is a key consideration in retrofit efforts.
- Adopt aggressive efficiency targets (e.g., through an Energy Efficiency Resource Standard) to achieve 2 percent annual savings. In new or modified targets, optimize greenhouse gas reductions by not only encouraging efficiency but explicitly allowing electrification. In some cases, this requires increasing electricity consumption to decrease greenhouse gas emissions.
- Encourage the switch from gas to electric appliances at replacement by shifting current tax credits and other incentives. By 2030, establish low- to zero-emission requirements for appliances and HVAC, emphasizing the health, safety, and climate risks associated with indoor gas use and its associated infrastructure.
- Provide financing options that enable building owners to finance deep retrofits, such as utility on-bill financing or via mortgage and property tax instruments, not credit cards and short-term cash flow.
- Develop and implement strategies to integrate demand flexibility (i.e., the ability to adjust load profiles across

Phasing Out Gas Heating in Favor of Cost-Effective Electric Heat Pumps

In the context of both building and industrial electrification, heat pumps offer an all-electric solution to both space and water heating needs. Therefore, heat pump adoption will play an important role in phasing out gas heating in new and existing buildings. Because ground- and air-source heat pumps also function as air conditioners, they offer an attractive economic bonus in climates that require both heating and cooling. Research has found that, across the United States, electric heating is already cost-effective for new home construction, for customers switching away from propane or heating oil, for gas customers switching out both their furnace and air conditioner at the same time, and for customers who bundle rooftop solar with electrification.[32] For a new home in California, using all-electric heating instead of gas heating saves $130 to $540 per year in lifecycle costs.[33]

The scenarios in this report include heat pump adoption assumptions in residential, commercial, and industrial buildings, but due to the time series captured in the analysis and appliance turnover limitations, their emissions impact is not fully recognized by 2030 in the modeling in this report. Further benefits accrue after 2030.

different timescales) into buildings. For example, provide outreach, education, and training for building owners, operators, and occupants; provide incentives for building-provided grid services; integrate demand flexibility into performance standards, energy codes, and appliance standards. [34]

Transportation

Electric vehicles (EVs), including both full battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are available or in late-stage development to replace most forms of on-road transport. Currently, EVs have a higher up-front cost than BEVs, but lower operations and maintenance costs and typically lower fuel costs make them cost-effective over their ownership lifetime.[35] Furthermore, passenger EVs are expected to reach up-front cost parity by the mid-2020s.[36] Electrifying freight vehicles is a newly identified emissions reduction opportunity for America's Pledge in this analysis. It will likely take longer for electric commercial vehicles such as buses and medium- and heavy-duty freight trucks to reach parity with their diesel counterparts, particularly for heavy-duty, long-haul applications,[37] though increases in regional haul,[38] promising developments for long-haul affordability,[39] and newly proposed zero-emissions sales requirements for freight vehicles[40] [41] point toward more electrified ton-miles, even for this challenging weight class. A rapid build-out of charging infrastructure will be necessary to support the anticipated growth in EVs. As more vehicles transition from gas and diesel to electricity, this will reduce not only downstream emissions from combustion, but also upstream emissions from oil and gas flaring, venting, and pipeline leakage. Finally, smart growth, expanded transit, and reduced vehicle-miles traveled are important components of decarbonization pathways. Cities and states are investing in complete streets, public transit infrastructure, and bike lanes, and these actors have the opportunity to do more in this space.

Transportation in the Scenarios

In the Bottom-Up scenario, we assume first-mover and fast-follower states follow California's lead to establish emissions standards for all internal combustion passenger vehicles between 2026 and 2030 and are able to improve efficiency by 4 percent per year through 2030. This assumes that all automakers align with the July 2019 compromise between California and automakers (the "California compromise") on light-duty vehicle standards for model years 2021-2026 and that additional efforts to inhibit state action are unsuccessful. Tier 1 and 2 states also put into place purchase incentives, fee-bates, and zero-emission vehicle mandates such that by 2030, two-thirds of car sales, 20 percent of medium-duty truck sales, 15 percent of heavy-duty sales, and 60 percent of transit bus sales are plug-in—on a pace to transition to all new sales being electric shortly thereafter. Adequate investments in vehicle charging infrastructure accompany the incentives and mandates. States and cities implement land use policies that promote densification, transit-oriented development, and complete streets such that city dwellers are encouraged to walk, bike, or use public transit, as opposed to single-occupant vehicles, for commuting and other trips.

Spurred by the knowledge that emissions from aviation are growing faster than expected, with demand outpacing efficiency gains,[42] airports join existing initiatives like the Airport Council International Airport Carbon Accreditation program[43] to measure and reduce their own emissions, and Tier 1 states and the cities that host their large hub airports work with those airports to source sustainable aviation fuels such that by 2030, airlines refueling on site do so using a 10 percent advanced biofuel blend. Ports also reduce emissions from their operations through efficiency measures, electrification of equipment, and clean truck programs.

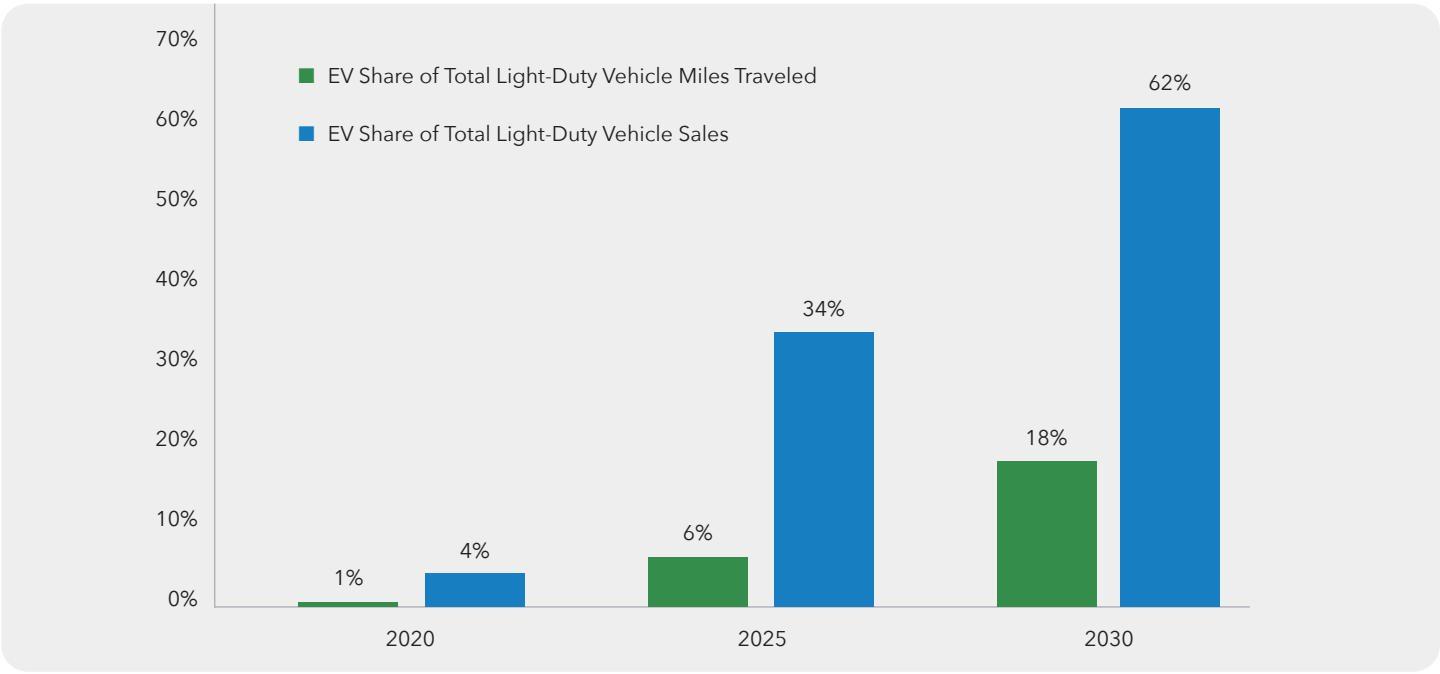
In the All-In scenario, we assume that the federal government builds on the policy package pioneered by first-mover states—steadily improving efficiency standards at 4 percent per year through 2030 while incentivizing a rapid shift to EVs. Federal policies promote removing inefficient and outdated vehicles from the road and replacing them with EVs. Nationally, 67 percent of light duty car sales, 56 percent of light-truck sales, 20 percent of medium-duty truck sales, 15 percent of heavy-duty sales, and 100 percent of transit bus sales are plug-in in 2030. This builds the groundwork

for a transition to 100 percent new EV sales shortly after 2030. National transportation infrastructure, like the Interstate Highway System, is equipped for an all-electric future. Biofuels and hydrogen are utilized by sectors that cannot yet be electrified, spurred in particular by increased research and development by the federal government.

The scenarios assume leader states, cities, and businesses employ a combination of the following transportation-sector strategies:

- Enact state-level vehicle standards and zero-emission vehicle (ZEV) policies. Begin phasing out internal combustion engines for light-, medium-, and heavy-duty on-road vehicles. Start by establishing state- and fleet-level ZEV procurement targets for light-duty vehicles, including those used by transportation network companies and taxicabs, and medium- and heavy-duty vehicles, such as trucks and transit buses.
- Implement EV market enablers that drive adoption such as rebates or tax credits, roadway and parking privileges, special access to urban centers, and specialized utility rates for charging. Develop policies that are inclusive of low-income citizens, for example through tax credits, rebates, or other incentives for used EVs.
- Work with municipal permitting offices and public utility commissions to streamline and accelerate the build-out of charging infrastructure, particularly for public chargers near commercial areas or multifamily residential units. Develop new pricing systems to encourage electric vehicle charging and integrate with the grid's needs.
- Adopt transit-oriented development policies that decrease single occupant vehicle trips and vehicle-miles traveled, such as expanded public transportation options, improved infrastructure for safe walking and biking, and urban mixed-use development.
- Build on and update existing low-carbon fuels standards where they exist. For new policies, work toward the next generation of clean-fuel standards that prioritize clean electricity as a fuel source while aggressively decreasing the carbon intensity of fuels for difficult-to-electrify heavy-duty transport, shipping, and aviation.
- Invest in R&D to reduce cost and improve performance of electric vehicles and fuel cells, battery packs, improved transportation systems, biofuels, and hydrogen.

Figure 2-7 | **Growth in Electric Vehicle Sales & Share of Total Miles Traveled in the All-In Scenario**



▲ **The market share for light-duty EVs in the all in scenario surpasses 60%, though because of slow turnover rates EVs will still only make up 18% of total vehicle miles traveled (VMT) in the same year. EVs' share of total light-duty VMT will continue to increase post-2030 as vehicle stock continues to turn over and older non-electric vehicles are phased out.**

Case Study: California Utilities Offer Charging Infrastructure Support to Drive Heavy-Duty Truck Electrification

To meet California's ambitious goals of reducing statewide emissions 40 percent by 2030[44] and eliminating net emissions altogether by 2045,[45] California will need to rapidly decarbonize its transportation sector, which has increased in both mass and share of total state emissions each of the past four years. With transportation now the number one source of U.S. emissions[46] and electrification of vehicles considered a key strategy for decarbonizing this sector, California is implementing programs to promote electrification of heavy-duty vehicles (HDVs) that will be vital to the state's ability to achieve its ambitious climate goals. These programs also have huge potential to scale to other first-mover and fast-follower states and utilities that are looking for examples of how to design their own medium- and heavy-duty vehicle electrification efforts.

HDVs, such as semi-trucks, buses, and garbage trucks, create 21 percent of California's total transportation greenhouse gas emissions and 41 percent of its nitrous oxide (N_2O) emissions from transportation.[47] HDVs typically run on diesel engines that emit a variety of air pollutants, like particulate matter and black carbon, which are linked to cardiovascular and respiratory illness, and nitrogen oxides (NO_x), which undergo reactions to create ground-level ozone and smog.[48] These vehicle types are commonly used in shipping logistics settings like ports, rail yards, and warehouses, which tend to be located near disadvantaged communities and whose pollution disproportionately impacts people of color.[49] Thus, pursuing HDV electrification has important implications for human health, environmental justice, and emissions reduction goals. However, a lack of adequate charging infrastructure at facilities is currently one of the top barriers to commercial fleet electrification.[50]

Under authorization from the California Public Utilities Commission (CPUC), the state's major utilities are all stepping up to deploy charging infrastructure. For example:

- Southern California Edison's Charge Ready Transport program, launched in May 2019, is putting $343 million toward building infrastructure to support charging stations at 870 commercial sites.[51]
- Pacific Gas & Electric's EV Fleet program has $236 million in funding available to construct charging infrastructure at a minimum of 700 sites.[52]
- In August 2019, the CPUC approved San Diego Gas & Electric's $107 million plan to support make-ready charging infrastructure for medium- and heavy-duty vehicles across 300 sites.[53,54]

In total, the programs are expected to support the deployment of at least 17,990 medium- and heavy-duty vehicles within five years. These programs target commercial fleet owners such as transit agencies, logistics companies, ports and airports, and other industrial customers. The utilities also have the option to either front the costs of installation and ownership themselves or provide generous rebates to customers that want to finance their own installations. Importantly, the California Public Utilities Commission also requires a significant allocation of each program's budget toward supporting customers in disadvantaged communities, a win for environmental justice.[55]

Banning Single-Use Plastics

California, Hawaii, and New York have banned single-use plastic bags in stores, and Seattle and Washington, D.C., have banned plastic straws. According to BP, a worldwide ban on single-use plastics by 2040 would reduce global liquid fuels demand by 6 million barrels per day.[56] The situation is slightly different for the United States because in the United States plastic is made from gas instead of oil like in most of the world, and low gas prices are expected to lead to an increase in U.S. plastic production and exports. While it was not modeled in this report, measures to reduce plastic use could be an effective way to lower gas demand as well as address waste management issues, as long as the alternatives to plastic are low-carbon.

Industry

Efficiency and electrification of industry, primarily heavy manufacturing, can provide competitive advantages to American industry. Both are newly identified emissions reduction opportunities for America's Pledge modeling this year. While industrial processes are heterogeneous, electric technologies to replace many common industrial end-uses exist today. Process heating, the most carbon-intensive portion of industrial emissions, can be electrified in some industrial subsectors by replacing conventional technologies with electric industrial heat pumps, induction ovens, resistance heaters, boilers, and plasma-based technologies.[57,58] The iron, steel, and cement subsectors face challenges due to the high temperatures required by certain process steps and their production of carbon dioxide via chemical processes in the smelting of iron and kilning of limestone. These subsectors (and others) can reduce emissions through electrifying other processes, enhancing efficiency, using carbon-free fuels such as hydrogen, and investing in carbon capture, utilization, and storage technology.[59,60] For optimal economics and performance, industrial electrification must be completed hand in hand with aggressive efficiency strategies.

Industry in the Scenarios

In the Bottom-Up scenario, we assume state and corporate policies aimed at industrial decarbonization and competitiveness are applied across the United States to varying degrees. Industrial facilities take advantage of cost-saving efficiency opportunities supported by mandatory and voluntary programs (e.g., ISO 50001). Tier 1 states initiate programs that reach 75 percent of industrial facilities, which reduce energy use 5 percent in the first year and 1 percent annually thereafter.

Tier 2 programs target 50 percent of industrial facilities in the states and reduce energy use comparably while Tier 3 state programs reach 10 percent of industrial facilities. Likewise, leader states incentivize industrial electrification, fueled by clean and often local electricity. The emerging "Buy Clean" movement for climate-friendly manufacturing of infrastructure materials expands, with a "Buy Clean" performance standard requiring that projects funded by the states gradually shift to more cleanly produced cement, achieving a 22 percent reduction in cement emissions in Tier 1 states by 2030.[i] Industrial carbon capture, utilization, and storage grows, taking advantage of relatively pure streams of carbon dioxide and expanded policy incentives.

In the All-In scenario, we assume national programs steadily improve industrial energy use, mirroring the same performance-based programs supported by states (e.g., ISO 50001) achieving 5 percent improvement for industrial facilities in the first year and 1 percent annually after that. Industrial use of coal and gas as a fuel source and feedstock are phased out incrementally through emission standards that lead to fuel switching to electricity or other technologies such as biofuels where electrification proves unfeasible. The federal government scales R&D and deployment incentives for industrial carbon capture, utilization, and storage and process replacement of fossil fuels in technologies like cement kilns and steel. The United States embraces the fastest possible transition away from hydrofluorocarbons (HFCs), fully complying with its requirements under the Kigali Amendment to the Montreal Protocol to reduce HFC production and consumption while also scaling policies to address HFC stocks.

The scenarios assume leader states, cities, and businesses employ a combination of the following industrial sector strategies:

- Deploy financial incentives and support for industry to adopt efficient, electrified technology for processes where feasible, and defray capital costs related to fuel-switching.
- Work with public utility commissions and utilities to implement or update energy efficiency resource standards (EERS) that specifically target energy-intensive facilities, develop specialized rate approaches for industrial customers, and engage in long-term energy planning that considers infrastructure needs for electrifying industries.
- Allocate R&D investments toward industrial process and product redesign, electric and low-carbon

i "Buy Clean" policies could include steel, but due to modeling constraints, only cement emissions were included out to 2030.

manufacturing process development, and enhanced material efficiency.

- Establish emissions standards that require high-emitting industrial facilities with fewer near-term, low-carbon process substitutes to install carbon capture, utilization, and storage devices.
- Use state and local purchasing power to incentivize low-carbon industrial products, such as iron/steel and cement used in public infrastructure.
- Consider broader carbon pricing mechanisms applied to industrial facilities, as well as other sectors, to incentivize continuous improvement and investment in efficiency and cleaner te chnologies, while accounting for the heterogeneity of industrial actors.

Case Study: Innovative Industrial Efficiency Solutions Provide Opportunities to Reduce Emissions and Save Money

From chemicals that go into life-saving drugs to metals that go into automobiles, industries produce and assemble the raw materials that drive the United States' economic engine. However, the industrial sector is also responsible for 32 percent of U.S. energy consumption[61] and 22 percent of its direct greenhouse gas emissions.[62] And while efficient electrification is an immediate-term strategy for decarbonizing buildings, transportation, and parts of the industrial sector, the high temperatures required by some industrial processes require other near-term options (See Chapter 2, Principle 2). Furthermore, industrial facilities currently have little regulatory incentive to implement energy efficient process changes; utility energy efficiency and resource standards, which target annual reductions in energy use at a building level, often exclude energy-intensive industrial facilities through opt-out provisions. In the near term, however, facilities that pursue energy efficiency strategies significantly decrease their emissions profile and save money in the process.

The U.S. Department of Energy (DOE) manages several programs that work collaboratively with industrial partners to reduce their energy consumption. DOE supports companies through its Better Plants[63] and 50001 Ready initiatives,[64] which support evaluation of facility energy management and energy intensity reduction opportunities. Even companies in difficult-to-decarbonize subsectors have found success with programs of this type. For example, DOE's voluntary Superior Energy Performance program recognizes over 50 facilities[65] that have obtained certifications in ISO 50001, a global, systems-oriented energy management standard that fosters continuous measurement and improvement.[66] One DOE study found that facilities that have adopted these approaches reduce their energy costs by 12 percent within the first 15 months.[67]

American steelmaking companies Charter Steel and ArcelorMittal have each achieved 50001 Ready designations in some of their facilities. In 2017, Charter Steel became the first U.S. heavy industry company to achieve 50001 Ready status by identifying savings at its Saukville, Wisconsin secondary steelmaking mill.[68] In 2018, ArcelorMittal's Cleveland, Ohio, facility became the first primary steelmaking facility to earn the 50001 Ready designation.[69] (Primary steelmaking involves higher temperature processes, such as using blast furnaces to create new steel from iron ore, while secondary steelmaking melts and refines scrap metal to produce recycled steel.[70]) ArcelorMittal's achievement exemplifies that even at high-heat facilities there are still options for reducing emissions and saving money. For example, one of ArcelorMittal Cleveland's process innovations was to automate its cooling tower fans, switching from simple high and low switches to variable frequency drives to control the fan speed based on the water temperature.[71] This switch alone has provided the facility with annual savings of over 3,400 MWh and over $171,000. Having recognized the value of creating energy-efficient facilities, both companies are moving forward to designate other plants. For example, 17 of ArcelorMittal's U.S. facilities currently participate in the Better Plants program, and the steelmaker is hoping to eventually achieve 50001 Ready designation in all of its U.S. plants.[72]

Forests, grasslands, and wetlands currently play a vital role in sequestering 10 to 15 percent of U.S. carbon emissions.

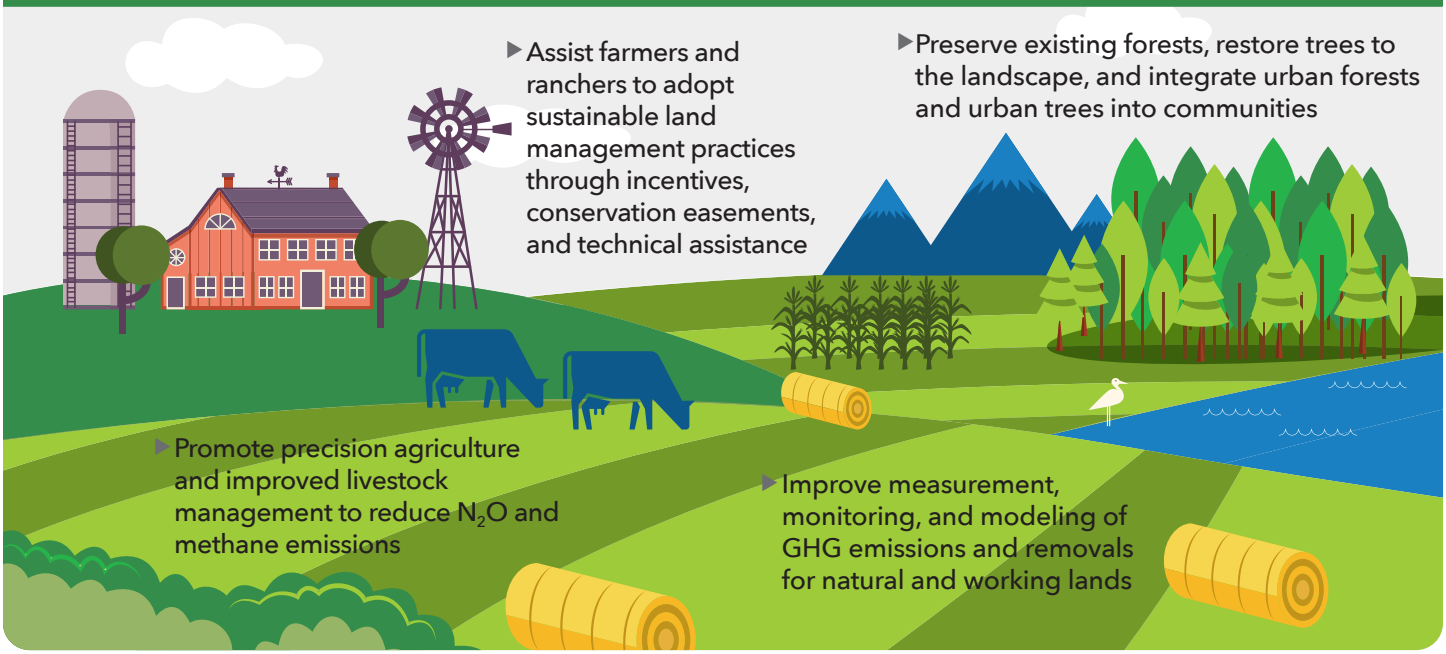
Principle 3: Enhance the Carbon Storage Potential of our Forests, Farms, and Coastal Wetlands

Land use, land use change, and forestry (LULUCF) have the potential to address a significant portion of our greenhouse gas emissions. Forests, grasslands, and wetlands currently play a vital role in sequestering 10 to 15 percent of U.S. carbon emissions. But their status as a carbon sink is not guaranteed because the changing makeup of America's forests and the impacts of climate change, including increased wildfires and pests, could diminish their ability to store carbon.

Improved management of our forests, agricultural lands, grazing lands, and wetlands will ensure that they absorb and store carbon rather than contribute to further carbon emissions. Establishing state-level programs that promote forest preservation, expand reforestation, restore wetlands, improve forest and wildfire management, and optimize land use through smart-growth development and urban densification have the potential to bolster our forest carbon sink. Promoting precision and regenerative agriculture can reduce agricultural emissions while bolstering soil carbon sequestration in agricultural and grazing lands through techniques such as planting cover crops, promoting reduced-till, practicing alley cropping, and implementing rotational grazing practices. These approaches, by increasing soil health and carbon content, also enable these lands to function more effectively as water storage systems, an increasingly important function in a climate-destabilized world.

Solutions also exist for reducing and dealing with the methane emitted from livestock operations. For example, the gas can be readily captured in anaerobic biodigesters and put to use to power farm operations, homes, or electric vehicles. Similar opportunities exist to trap methane from landfills. More direct investments in these sectors could achieve further reductions.

Figure 2-8 | **Key Land Use Actions (Principle 3)**



▲ Key actions that states, cities, and businesses can take to reduce emissions from land use.

Case Study: Less Hugging, More Planting—Urban Forestry Programs Take Root

As the popular proverb goes, "The best time to plant a tree was 20 years ago. The second best time is now." That is certainly true when it comes to removing carbon dioxide from the planet's atmosphere and storing it naturally in our ecosystems. In fact, one tree absorbs as much as 48 pounds of carbon dioxide each year.[73] According to Nature4Climate's U.S. State Mapper tool, urban reforestation initiatives have the potential to mitigate up to 22 million tons of carbon-dioxide equivalent (CO_2e) per year simply by increasing urban tree cover in 3,535 U.S. cities.[74] Because of this carbon sequestration ability of trees, many policymakers across the country have reforestation efforts underway.

Rhode Island, in particular, is investing in its forests in earnest. The state, approximately 55 percent of which is forested, notes in its climate preparedness plan, Resilient Rhody, that Rhode Island's forests "provide numerous economic, recreational, ecological, and human health benefits," including "soil health and conservation, carbon sequestration and improved air quality, and wildlife habitat."[75] The state's Department of Environmental Management has estimated that Rhode Island's forests have the potential to absorb as much as 30 percent of the state's annual greenhouse gas emissions.[76] To take advantage of this potential, Rhode Island includes its Forest Legacy Program, Forest Stewardship Program, and Urban and Community Forestry initiative in its list of major existing state policies for greenhouse gas mitigation.[77]

States are not the only ones investing in urban forestry. Recognizing the many benefits that trees provide, cities themselves are prioritizing tree planting. For example, the District of Columbia's Urban Tree Canopy Plan set a goal of covering 40 percent of the District with a healthy tree canopy by 2032.[78] The District estimates that its existing tree canopy currently "stores 474,000 metric tons of carbon each year (a value of $10.8 million) and captures an additional 14,600 metric tons per year (an additional value of $334,000)," savings that it hopes to increase as it implements its initiative. Cities like the District view urban forestry as not only a climate mitigation strategy but an adaptation one as well, since increasing urban tree canopy is a best practice for mitigating the urban heat island effect and reduces energy demand for cooling.

Cities looking to create or expand their urban forestry initiatives can receive technical assistance, financial guidance, peer-to-peer learnings, and scientific advice through groups like Cities4Forests, an initiative that aims to catalyze political, social, and economic support among city governments and urban residents to integrate forests into city development plans and programs.[79] Cities4Forests has nineteen U.S. members, including Washington, D.C., and 60 members globally.

Land Use in the Scenarios

In the Bottom-Up scenario, we assume that the land carbon sink improves by almost 80 Mt CO_2e from today's levels. California expands its carbon sink by 40 Mt CO_2e, while other first-mover states achieve many of the low-hanging fruit natural climate solutions. Fast-follower states achieve half as much as the first-movers. Slow-follower states do not make any changes. In addition, all states mitigate agricultural methane and nitrous oxide emissions where it is cost effective but do not require any mitigation that has marginal costs.

In the All-In scenario, we assume that federal farm policy is bolstered and reformed so that incentives are increasingly focused on promoting sustainable agriculture while improving yields. Nationwide, about half of the low-hanging fruit natural climate solutions are achieved, including cover crops, cropland nutrient management, avoided forest conversion, and reforestation, which is a total improvement of the land carbon sink of more than 165 Mt CO_2e. All states mitigate methane and nitrous oxide emissions, including by installing biodigesters where the costs are relatively low.

The scenarios assume leader states, cities, and businesses employ a combination of the following land-use strategies:

- Invest in natural and working lands GHG inventories and other measuring and monitoring programs, such as remote sensing, to track progress toward net carbon goals. Improve techniques for measuring, monitoring, and modeling soil and forest carbon.
- Establish state-level programs to promote forest conservation and restoration, agroforestry, and urban forestry. For example, create trusts or funds to help landowners enhance climate-friendly management capabilities, require evaluations of carbon impacts in land use decision-making, and integrate forest-level carbon sequestration into carbon pricing schemes as avoided emissions credits.
- Encourage long-term management and preservation of private forests through state mechanisms such as conservation easements to protect existing forests and promote reforestation, tax and other incentives for

beneficial carbon practices, and fees on deforestation activities.

- Provide technical support and financial incentives to farmers and ranchers to promote GHG emissions reductions and carbon sequestration through fertilizer management, crop rotation, conservation tillage, cover-cropping, silvopasture and other forms of agroforestry, and waste reduction. Target nitrous oxide emissions through fertilizer fees and regenerative agriculture education. Target methane emissions by establishing grant programs for biodigesters.
- Collaborate with city officials and residents to preserve, expand, and integrate urban forests into communities through planting and tree-retention ordinances.
- Reward sustainable agricultural practices that both save money and benefit the climate, including precision and regenerative agriculture.
- Provide technical assistance, for example through the Agricultural Extension Service, to forest owners, farmers, and ranchers to help them transition to more sustainable practices, and integrate carbon considerations into existing conservation practice standards.

Treatment of Economy-Wide Activity in the Scenarios

While this chapter highlights critical climate policies within each of the three principles, certain actions transcend these categories and have more cross-cutting implications. The most obvious of these are state efforts to price carbon emissions or set a formal cap on economy-wide emissions.

In our Bottom-Up scenario, we assume that economy-wide emissions targets are fully achieved in Tier 1 leader states if backed by binding legislation. In our All-In scenario, we assume that federal engagement and support allows economy-wide targets to be fully achieved in Tier 1 states even if the targets are currently more aspirational in nature and not yet backed by binding legislation.

Mandated economy-wide caps do not necessarily lay out the specific measures to be taken to achieve the target, but rather provide state agencies with the legal authority to adopt the most technologically feasible and cost-effective policies across all sectors in order to meet the goal. It is these sector-specific actions—from Renewable Portfolio Standards (RPS) and Energy Efficiency Resource Standard (EERS) mandates to regulations to reduce short-lived climate pollutants such as methane and HFCs—upon which our decarbonization scenarios primarily rely. We recognize that economy-wide measures including carbon pricing can be highly effective in some sectors but have chosen to measure the impact of sector-based policies and strategies.

Key Analysis Assumptions for Priority Sectors

The three principles for action are an organizing structure for our analysis. Analysis assumptions for each of the pillars are summarized in the table below, with extensive additional information available in the technical appendix.

Table 2-1 **Bottom-Up and All-In Scenario 2030 Assumptions**

	Bottom-Up Scenario 2030 Assumptions	All-In Scenario 2030 Assumptions
Principle 1: Accelerate Toward 100% Clean Electricity		
Clean Electricity	States establish ambitious Clean Electricity or Renewable Portfolio Standard requirements. • Tier 1 states reach 60% renewables • Tier 2 states reach 40% renewables • Tier 3 states reach 20% renewables States prevent some at-risk nuclear plants from retiring. *2030 impact:* Clean electricity provides 61% and renewable energy provides 40% of total national generation. Nuclear provides 17% of total national generation.	Federal clean electricity standard and tax incentives. *2030 impact*: Clean electricity is 77% and renewable energy 49% of total generation.
Fossil Fuels	With most coal plants unprofitable, significant coal generation is phased out except in a few holdout states. Market trends and advocacy reduce coal generation nationally. Tier 1 and 2 states constrain new gas plant builds. *2030 impact*: Coal produces 7% and gas without CCUS continues to provide 32% of total generation.	Federal policies result in near complete phase out of coal generation by 2030 and cause gas generation to peak before 2025 and then decline. *2030 impact*: Essentially no remaining coal generation; conventional gas produces only 23% of total generation. Gas with CCUS produces 12% of generation.
Oil and Gas Methane	Tier 1 and 2 states adopt regulations covering new and existing sources, reducing fugitive methane emissions by more than 50%. Tier 3 states achieve reductions where policies are already in place or under development. *2030 impact:* Oil and gas methane emissions reduced by 34%.	Federal methane rules are reinstated and strengthened to cover new and existing sources. Fugitive methane emissions reduced by 60% nationwide. *2030 impact:* Oil and gas methane emissions reduced by 60%.
Principle 2: Decarbonize End-Uses		
Buildings	In Tier 1 and 2 states all new buildings are 100% electrified; policies are in place that ensure that almost all replacements of appliances from 2030 on are electrified. Tier 1 and 2 states enhance Energy Efficiency Resource Standards, with Tier 1 achieving 2% annual savings and Tier 2 states achieving 1.5% annual savings. *2030 impact:* Total direct emissions in buildings sector reduced by 28% compared to 2005.	Due to new federal standards and policies all new buildings are 100% electrified and replacement appliances from 2030 on are electrified. Federal financing for residential and commercial retrofits. All states achieve further economically optimal levels of energy savings. *2030 impact:* Total direct emissions in buildings reduced by 31% compared to 2005.
Transportation	Tier 1 and 2 states implement zero-emissions vehicle mandates and incentives. EVs (BEVs + PHEVs) reach 61% of light-duty vehicle sales. Heavy-duty electric vehicles comprise 15% of new sales in 2030 in Tier 1 and 2 states. In Tier 3 states, adoption is slightly lower. Federal rollbacks of LDV standards prove unsuccessful through 2025. Tier 1 and 2 states set ambitious new vehicle standards post-2026, improving internal combustion engine efficiency by 4% annually. *2030 impact:* Total liquid fuel demand from transportation is down 21% from 2005 levels. Cumulative EV sales (2020-2030) reach 62 million vehicles nationwide.	Federal policies and standards promote zero-emissions vehicles so that nationwide EVs (BEVs + PHEVs) reach 62% of new light-duty vehicle sales and 100% of bus sales. The federal government reinstates the current LDV standards through 2025 and improves internal combustion engine efficiency 4% annually from 2026-2030. Furthermore, the federal government incentivizes the removal of old and inefficient vehicles from the road. *2030 impact:* Total liquid fuel demand from transportation is down 22% from 2005 levels. Cumulative EV sales (2020-2030) reach 64 million vehicles nationwide.

Table 2-1 | Bottom-Up and All-In Scenario 2030 Assumptions (continued)

Industry	Tier 1 states, and to a lesser degree Tier 2 and 3 states, incentivize industrial facilities to adopt best-in-class energy management practices and adopt electrified technology. States promote CCUS for industrial uses. Tier 1 and 2 states adopt policies to phase-down HFCs and reduce leaks as agreed in the global Kigali Amendment Tier 1 states adopt standards targeting cement emissions *2030 impact:* Total direct carbon dioxide emissions in industrial sector reduced 5% below 2005 levels. HFCs and other fluorinated gas emissions reduced 6% below 2005 levels.	Federal incentives lead all industrial facilities nationwide to adopt best-in-class energy management practices, and federal investments increase adoption of electrified technology. Federal policies and incentives promote adoption of CCUS. All states adopt policies to phase-down HFCs and reduce leaks. All states adopt standards targeting cement emissions. *2030 impact:* Total direct carbon dioxide emissions in industrial sector reduced 7.5% below 2005 levels. HFCs and other fluorinated gas emissions reduced 37% below 2005 levels.
Principle 3: Enhance Ecosystems		
Land Use	Tier 1 states and some Tier 2 states incentivize low-cost natural climate solutions such as natural forest management, optimal nutrient application, and the use of cover crops. All states mitigate agricultural methane and nitrous oxide emissions where it is cost effective. *2030 impact*: Land carbon sink improved by about 80 Mt CO_2e, 11% higher than today.	Federal investments and incentives promote low-cost natural climate solutions nationwide. Strong federal incentives promote methane biodigesters to reduce methane from livestock. *2030 impact*: Land carbon sink improved by about 167 Mt CO_2e, 23% higher than today. Livestock methane emissions reduced by 29% from reference case.
Cross-Cutting		
Carbon Caps	Tier 1 states meet their legislated economy-wide emissions reduction goals and partially meet their aspirational goals. *2030 impact*: Emissions at the national level (all states) reduced 10%.	Tier 1 states meet their legislated economy-wide emissions reduction goals and fully meet their aspirational goals. *2030 impact*: Emissions at the national level reduced 11%.

See the technical appendix for more details and assumptions for other sectors and discussion of state tiering.

The Transformation Must Be Fast and Far-Reaching

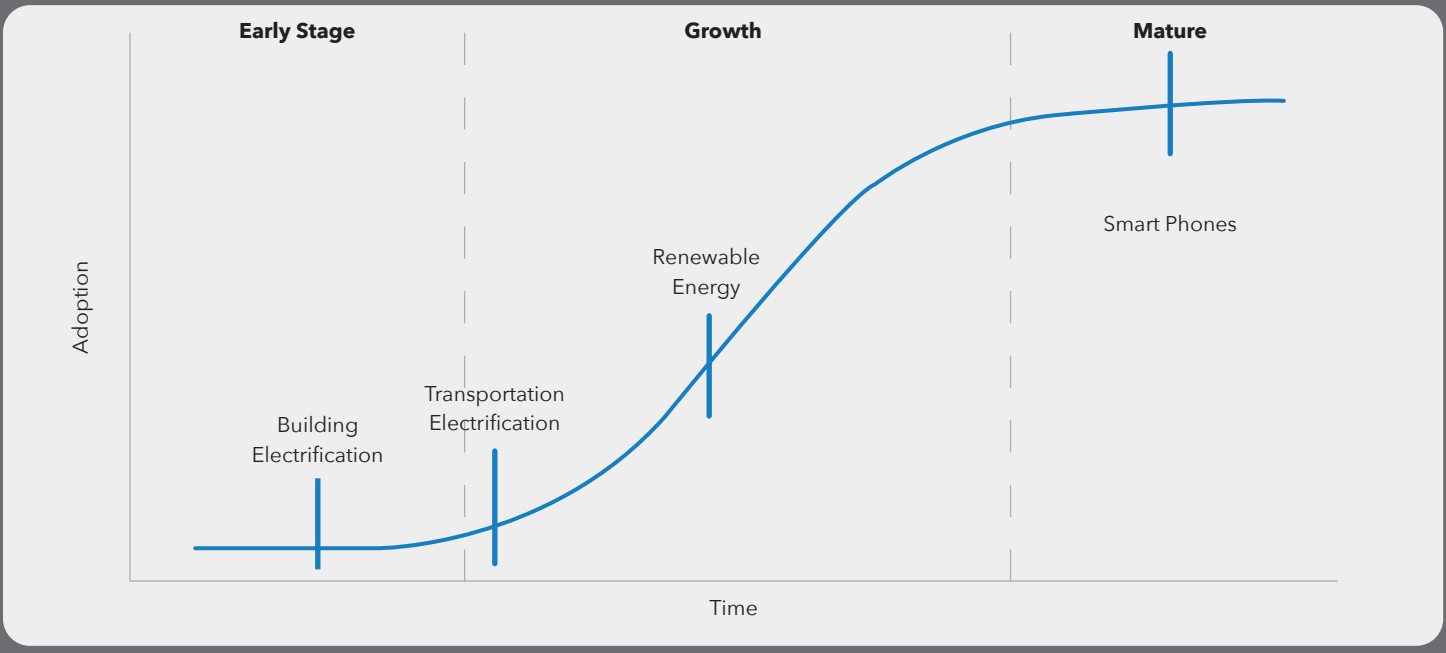
Achieving the All-In climate strategy will require profound changes across our economy and political system at a pace with few precedents in recent history—on the scale of the Interstate Highway System or the New Deal. While many clean energy technologies are increasingly cost-competitive with their fossil-fuel competitors, deploying these technologies at the speed and scale envisioned in our scenarios will present many challenges—including political, economic, logistical, regulatory, and market- and investment-related. All levels of government, the private sector, and citizens at-large must substantially prioritize climate action, investing considerable political and financial capital to mobilize all parts of the economy to scale clean technologies and sustainable practices.

Politics: In recent years, we have seen the American people recognize the enormity of the climate crisis and begin to reshape the politics on the issue. We assume the current divide between ambitious leader states and the current administration gives way to a broader, shared commitment to climate action at all levels of society in the early 2020s. In addition, bottom-up citizen mobilization will be necessary to accelerate the transition.

Increased energy productivity and decarbonized energy: The transformation will require that progress be made at both small and large scales. First, energy productivity must steadily and incrementally improve through innovation, deployment, and scaling. However, energy productivity alone is insufficient to achieve deep decarbonization unless it is paired with zero-carbon, non-fossil fuel technologies to replace carbon-based energy. Recent deployments of such technologies include: renewable energy in the power sector, electric vehicles in on-road transportation, and heat pumps, inductive cooktops, and other electrification technologies for heating, cooling, and cooking in buildings. Each of these three types of technologies is at a different phase of the innovation and adoption S-curve—renewables well on the upward adoption slope, EVs just entering that phase, and all-weather building electrification not yet fully adopted across the United States (Figure 2-9). As clean technologies costs continue to fall, more and more households and businesses will embrace these technologies. Additional investment is needed to speed the adoption of technology and system solutions that deliver electrification and efficiency.

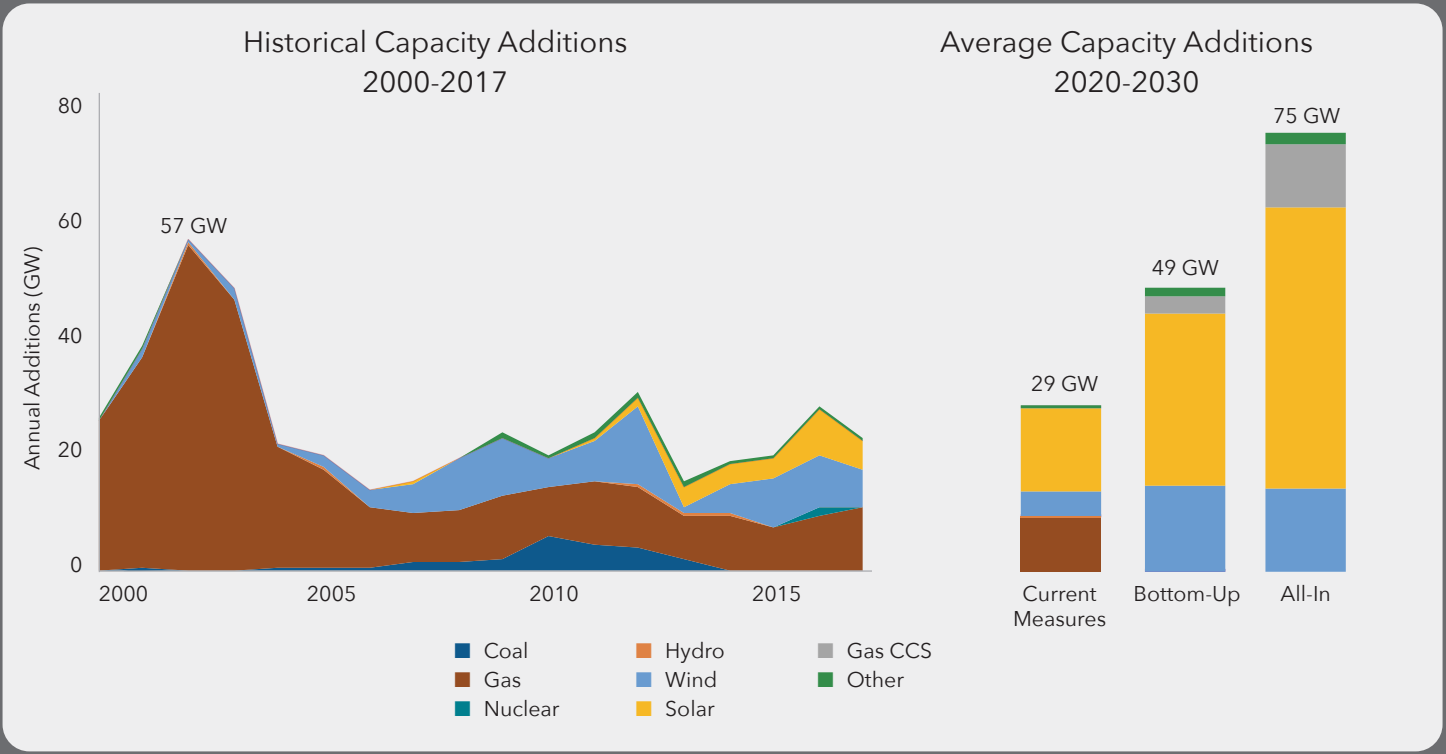
The All-In climate strategy is designed to combine energy productivity and clean energy. The more efficiently electricity is used, the less additional

Figure 2-9 | **The S-Curve of Adoption**



▲ **Zero-carbon technologies, ranging from renewables to electric vehicles to all-weather building electrification, are each at a different phases of the adoption S-curve in the United States. Electric buildings exist all over the United States, and electric technologies are widely available; however efforts to ensure that buildings are electric are in early stages.**

Figure 2-10 | **Annual Power Sector Capacity Additions in the Past and What is Needed in the Future**



▲ **The clean energy buildout needed between today and 2030 surpasses anything that has taken place in the past decade.**

renewable energy will be needed to replace coal and gas; electric cars and trucks become more competitive with internal combustion engines as the vehicle itself needs less energy; and highly efficient, net-zero buildings put far less load on a heat pump to stay comfortable in a Minnesota winter. Such changes in both productivity and energy supply enable rapid, affordable, and competitive deep decarbonization.

Technological build-out: If we achieve the All-In scenario, we will witness technological change and build-out at an unprecedented speed and scale. It's true—in industrial history we have seen changes this far-reaching before, as horses gave way to steam engines and cars, as wood gave way to coal, and more recently, as telephones were replaced by cellphones which became smartphones. We have seen large-scale infrastructure build-outs before, for example with the transcontinental rail, interstate highways, and the rapid build-out of nuclear power plants in the 1970s and gas power plants in the early 2000s. However, what is unprecedented is aiming for dramatic change across the entire economy over the course of only a decade.

In the electric sector, we will need to build 48 GW of solar energy and 15 GW of wind energy per year on average through 2030 in the All-In scenario (See Figure 2-10). While more than 50 GW of generating capacity (primarily gas) was added to the U.S. grid in 2003, the average annual capacity addition over the last decade was much lower. Going all in will require a major increase in renewable power construction and will also require new transmission lines to connect that wind and solar power to demand centers and significant investment in storage and demand side resources to help manage the grid and ensure reliability.

In the transportation sector, the auto industry will need to massively reshape its product lines, assembly lines, and supply chains to transition away from internal combustion engines to EVs. At the same time, millions of EV charging stations will need to be put in place to keep these vehicles charged and ready to roll. We also envision a shift in land use planning practices that de-emphasizes dependence on personal vehicles as the primary mode of transportation in urban areas and begins to offer transportation choice, with more pedestrian-, transit- and bicycle-friendly places to live and work.

Other sectors will see similar changes, as described earlier in this chapter.

Market structures: Achieving this level of build-out over a decade will

also test our regulatory and market structures, particularly in the electric sector. Wholesale electricity markets that manage efficient dispatch over large geographic regions are important to renewable development. We have examples, such as recent improvements to renewable energy forecasting in regional transmission organizations (RTOs), that show that incremental changes to better integrate low-carbon technologies into wholesale markets are under way. But many of these markets lack good mechanisms for incorporating storage and demand-side resources and, more broadly, were not designed to address integration of an increasing share of variable renewable resources. Market reforms would allow easier integration of clean energy resources but will require development and agreement on what those reforms should be, and quick action by the market regulators that will prove elusive without stakeholder consensus. Similarly, current transmission planning processes are not adequate to support renewable integration in either pace of development or full utilization of existing assets. RTOs such as PJM are grappling with price signals and cost recovery models that were developed for large fossil fuel resources and are now at odds with the needs of renewable resources. In some cases, such as in capacity markets, existing rules create bias against clean energy or functionally subsidize fossil resources. In others, such as PJM's consideration of a minimum price-setting rule, markets are trying to move in the wrong direction. In addition, parts of the country where the vertically integrated business model persists will also need to find ways to align regulated utilities with renewable development in ways that are consistent with the traditional market structure.

Investment: Many of the changes we describe in this report will end up saving families and businesses money, creating better communities, and improving health while helping address climate change. However, incremental purchase costs still pose a barrier to many consumers and businesses with limited capital, so up-front costs associated with the necessary build-out will be significant. Investments by both public and private sectors in low-carbon options and infrastructure will need to scale to levels commensurate with the pace and magnitude of the formidable challenge. Innovation in financing models will need to continue, building on early successes of state green banks, pay-as-you-go models for building efficiency, and others, in order to meet the scale needed.

RESULTS

Emissions Reductions From an All-In Climate Strategy

The transformations described in our Bottom-Up and All-In scenarios would deliver significant economy-wide emissions reductions by 2030. This lays the groundwork for continued reductions toward carbon neutrality by 2050, as is necessary to meet the goals of the Paris Agreement.

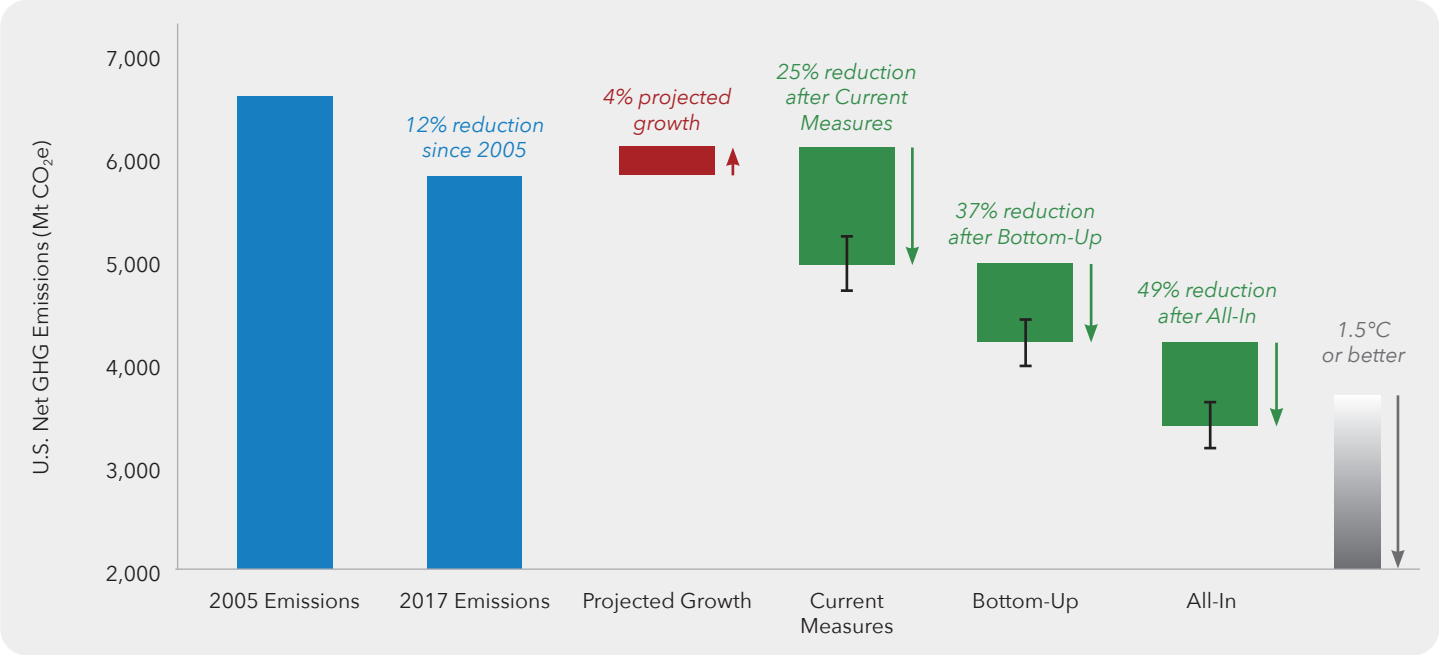
Specifically, our analysis finds that aggressively expanded bottom-up action could reduce U.S. greenhouse gas emissions 37 percent below 2005 levels by 2030. Bottom-up initiatives combined with ambitious federal engagement in a comprehensive All-In strategy could reduce U.S. greenhouse gas emissions 49 percent below 2005 levels by 2030 (see Figure 2-11, 2-12, 2-13). This is compatible with what climate science says is necessary to avert the most dangerous climate change, with the United States doing its fair share to limit global warming to 1.5°C (See "Reaching a Sustainable Climate Pathway" below).

Fundamentally, the policies and ambition levels modeled in the All-In scenario will be necessary to limit temperature change to 1.5°C and avert the most damaging and dangerous impacts of climate change. Even then, the pace of reductions modeled in the All-In scenario for 2030 would need to continue between 2030 and 2050 even as reductions are obtained from increasingly challenging sectors. Post-2030, the United States must continue an ambitious agenda of mitigation, expand the scope of climate policies, and encourage other countries to follow suit. The level of ambition modeled in the All-In scenario lays the foundation for deeper reductions in the long term. For instance, while transportation and building-sector emissions remain relatively high in 2030, the All-In scenario rapidly scales zero-emission vehicles and fossil-free buildings to ensure that these sectors are on pace to broadly decarbonize by 2050 as vehicle and appliance stock turn over after 2030.

Testing Uncertainties

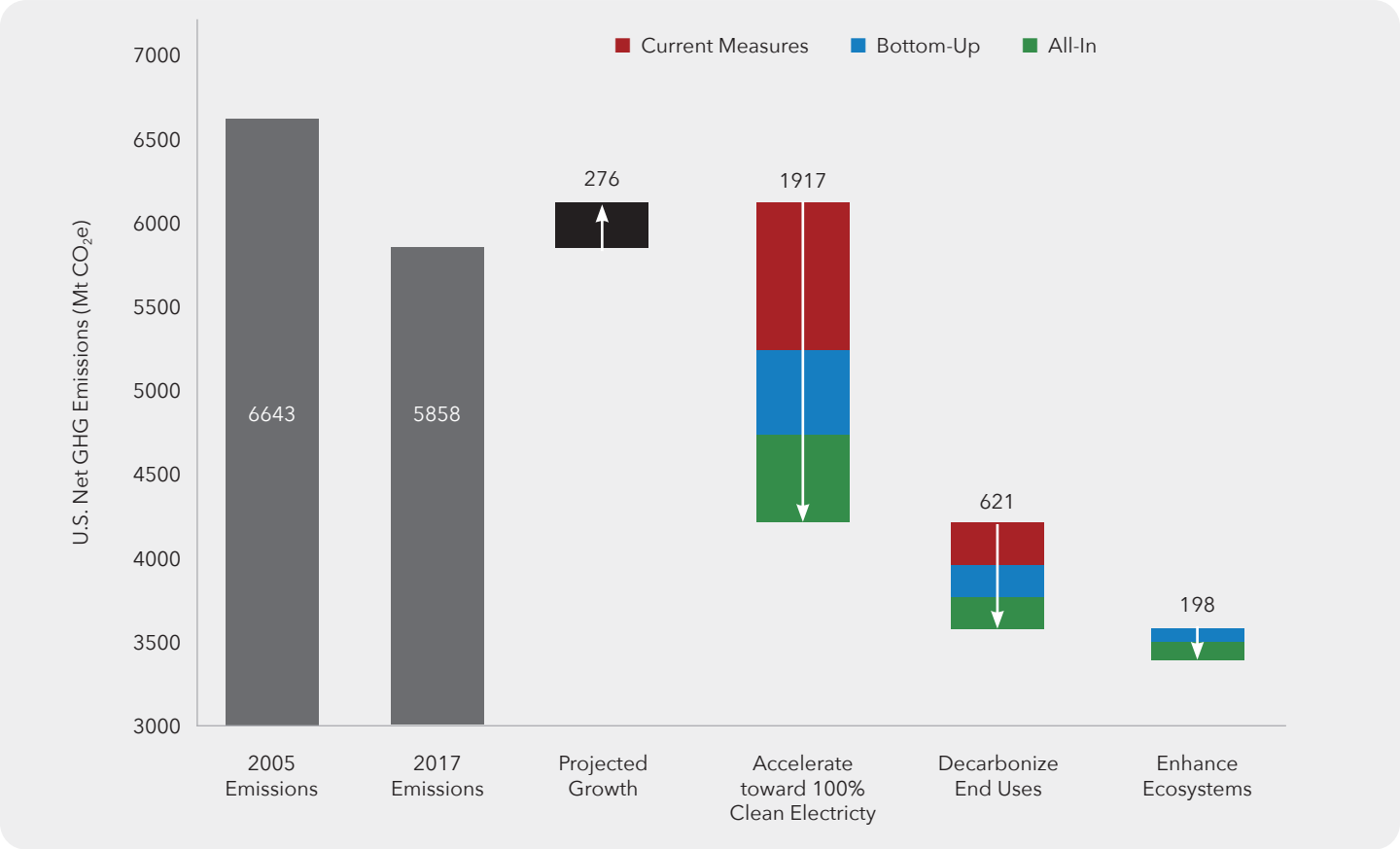
It is not possible to predict precisely how emissions will evolve in the coming decade because so many important factors cannot be known with certainty today. Future economic and population growth, for example, will drive energy demands, but the exact level cannot be known today. Technological changes, including for example the rate of improvements

Figure 2-11 | **America's Pledge U.S. Emissions Analysis in 2030**



▲ **More aggressive bottom-up action could reduce emissions 2,435 Mt CO_2e, 37% below 2005 levels by 2030. An All-In Climate Strategy that combines bottom-up action with federal reengagement could reduce emissions 3,245 Mt CO_2e, 49% below 2005 levels by 2030. This is in line with the Paris Agreement's mid-century targets.**

Figure 2-12 | **2030 Emissions Analysis by Principle**



▲ **Power, Transport, Buildings & Industry, Methane, HFCs, and Agriculture & Natural and Working Lands all have a role to play in reaching a sustainable climate pathway. While power shows the biggest GHG impact in 2030, the strategies implemented in 2030 in the other sectors lay the groundwork for growing emissions reductions in the later years.**

in renewable energy technologies, will influence relative economics and choices about which technologies to install. Fossil fuel prices and trade policies influence the competitiveness of fossil technologies. There are also uncertainties in the current U.S. land use carbon sink and the ability to maintain this sink over time.

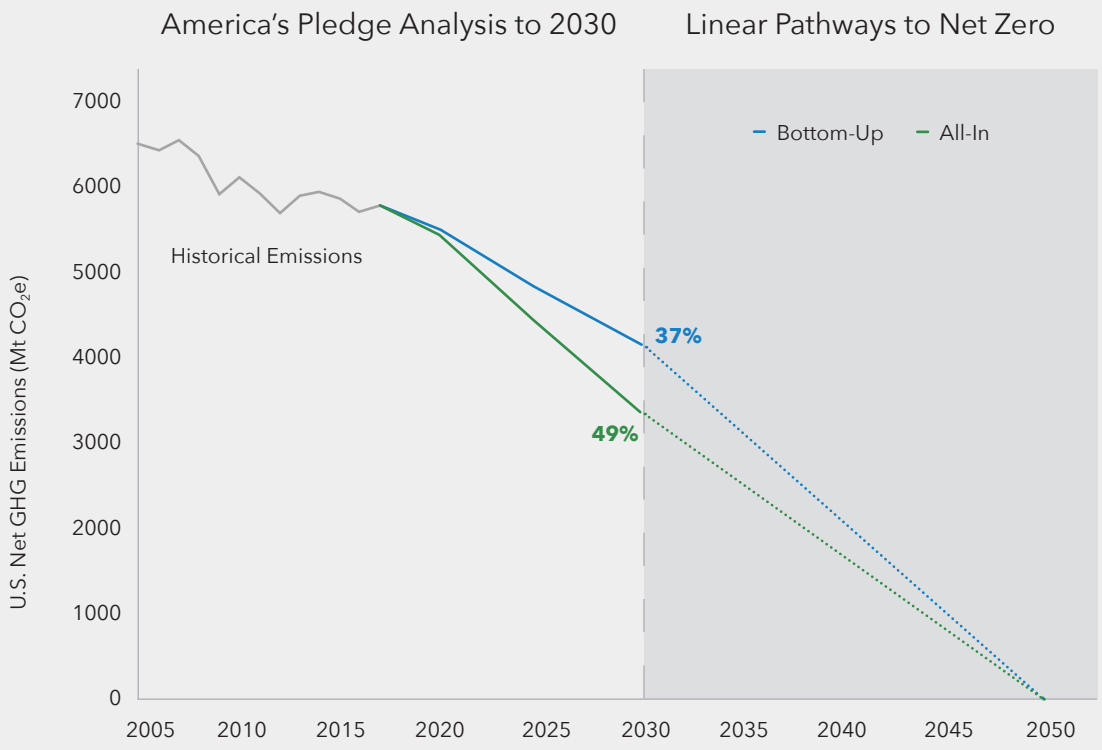
To better characterize the range of possible emissions reductions of the scenarios in this study, each of our scenarios was also examined under varying assumptions about socioeconomic change, technological change, fossil prices, and the size of the land use sink. Based on these assumptions, reductions in the All-In scenario could be as low as 46 percent or as high as 52 percent. While these are only a subset of uncertainties, they provide a window into the range of possible emissions associated with each of the three scenarios in this study.

Reaching a Sustainable Climate Pathway

Limiting temperature change to 1.5°C is an ambitious proposition. All sectors, globally, will need to be on a meaningful pathway to zero CO_2 emissions by mid-century, non-CO_2

Fundamentally, the policies and ambition levels modeled in the All-In scenario will be necessary to limit temperature change to 1.5°C and avert the most damaging and dangerous impacts of climate change.

Figure 2-13 | **Emissions Trajectories in Bottom-Up and All-In Scenarios**



▲ **The trajectory of U.S. emissions from 2005-2030 in the Bottom-Up and All-In scenarios. The dotted lines show a straight line path from 2030 levels to 2050 net zero emissions.**

greenhouse gas (GHG) emissions will need to decline substantially, and we will need to be in a position to quickly scale up carbon dioxide removal. Emissions reductions in the United States through 2030 are therefore only the start of a multi-decade process of transforming the global energy and economic systems. The activities we undertake over the next decade will not only determine our emissions over that time; they will also shape the possibilities for the deeper emissions reductions necessary after 2030. The comprehensive policy approach in this study focuses on both the near term and the long term and includes actions across all sectors. It includes policies and actions that reduce emissions substantially over the next decade in those sectors that are most amenable to near-term emissions reductions (e.g., electricity), and it includes policies and actions that avoid locking into emitting technologies and initiate action in sectors that are more difficult actions to address but that will be the focus beyond 2030.

There is no single 2030 U.S. emissions level associated with 2°C or 1.5°C pathways (see Box). There are, however, commonly used global benchmarks that bound the possibilities. Global CO_2 emissions decline to zero around mid-century in most 1.5°C pathways; they decline to zero several decades later in 2°C pathways, calling for CO_2 emissions reductions of around 80 percent by 2050. Non-CO_2 emissions are reduced substantially by mid-century but never decline to zero in either pathway.[80]

These targets can be translated to indicative U.S. 2030 benchmarks of a little less than 40 percent GHG reductions for 2°C pathways (relative to 2005 levels) and around 45 percent for 1.5°C scenarios.[ii] The Bottom-Up scenario positions the United States to meet the 2°C goal (37 percent reduction for all greenhouse gases). The All-In scenario makes substantially more progress (49 percent), putting the country firmly on track to be able to meet a 1.5°C goal by 2050.

ii These approximations are produced by assuming straight-line reductions in emissions starting in 2016 and extending through 2050. For 1.5°C, CO_2 emissions are reduced to zero; for 2°C they are reduced to 80 percent below 2005 levels. Non-CO_2 emissions are reduced by 50 percent relative to 2005 levels for both 1.5°C and 2°C. There is no precise way to define consistency of national 2030 emissions with these temperature goals. The approach here provides one of several reasonable approximations (see Box).

Pathways to 1.5°C

An international consensus has emerged that it is important to limit the change in global mean surface temperature (GMST) to 1.5°C above preindustrial levels by the end of the century. No precise definition exists, however, for what it means for individual countries to be on emissions pathways to 1.5°C. One complication is that limiting warming to 1.5°C can mean different things. It could, for example, be defined as either never allowing warming above that level or allowing warming to exceed ("overshoot") 1.5°C and then return to that level by the end of the century. If temperature exceeds 1.5°C temporarily, then the degree to which it exceeds is important, as is the duration. Furthermore, despite advances in our understanding of climate change, it is not possible to say with certainty how much GMST will change for any emissions pathway. Temperature goals are therefore defined as the probability that GMST will be below 1.5°C.

Another complication is that emissions reductions might be distributed multiple ways across the different greenhouse gases. Because of CO_2's prevalence, it is the most important greenhouse gas, but other gases such as CH_4, N_2O, and hydrofluorocarbons have an important influence both on long-term GMST and near-term rates of change. Furthermore, how emissions reductions can or should be distributed among countries is bound up in debates about economic efficiency, equity, and historical responsibility.

Nonetheless, an increasing body of evidence can guide national efforts to undertake mitigation "consistent with 1.5°C." The recent IPCC special report *Global Warming of 1.5°C* produced estimates of global CO_2 and non-CO_2 GHG emissions associated with a 50 percent probability that GMST will fall at or below 1.5°C by the end of the century and that GMST will only modestly exceed this temperature during the century. Under this definition, CO_2 emissions need to reach zero around 2050, and non-CO_2 GHG emissions need to decline substantially. The IPCC further concluded that this 2050, zero-CO_2 goal translates to about 45 percent reductions in CO_2 emissions by 2030 relative to 2010 levels. This 2030 reduction, however, is for the whole world and does not account for differences in conditions across countries.

A direct, but still approximate, indicator of U.S. emissions consistent with a 1.5°C goal is the 2030 emissions that lie on a straight line to zero CO_2 emissions in 2050. For example, assuming a straight line from current CO_2 emissions to zero in 2050, 2030 CO_2 emissions would be approximately 50 percent below 2005 levels in 2030. Assuming a similar straight line cutting non-CO_2 emissions in half by 2050 would yield about a 45 percent net CO_2e reduction across all greenhouse gases. Simple estimates such as these do not account for the many complexities that confront efforts to define roles and responsibilities in limiting temperature change. They are nonetheless indicative of what it means for the United States to be on a pathway consistent with limiting GMST to 1.5°C.

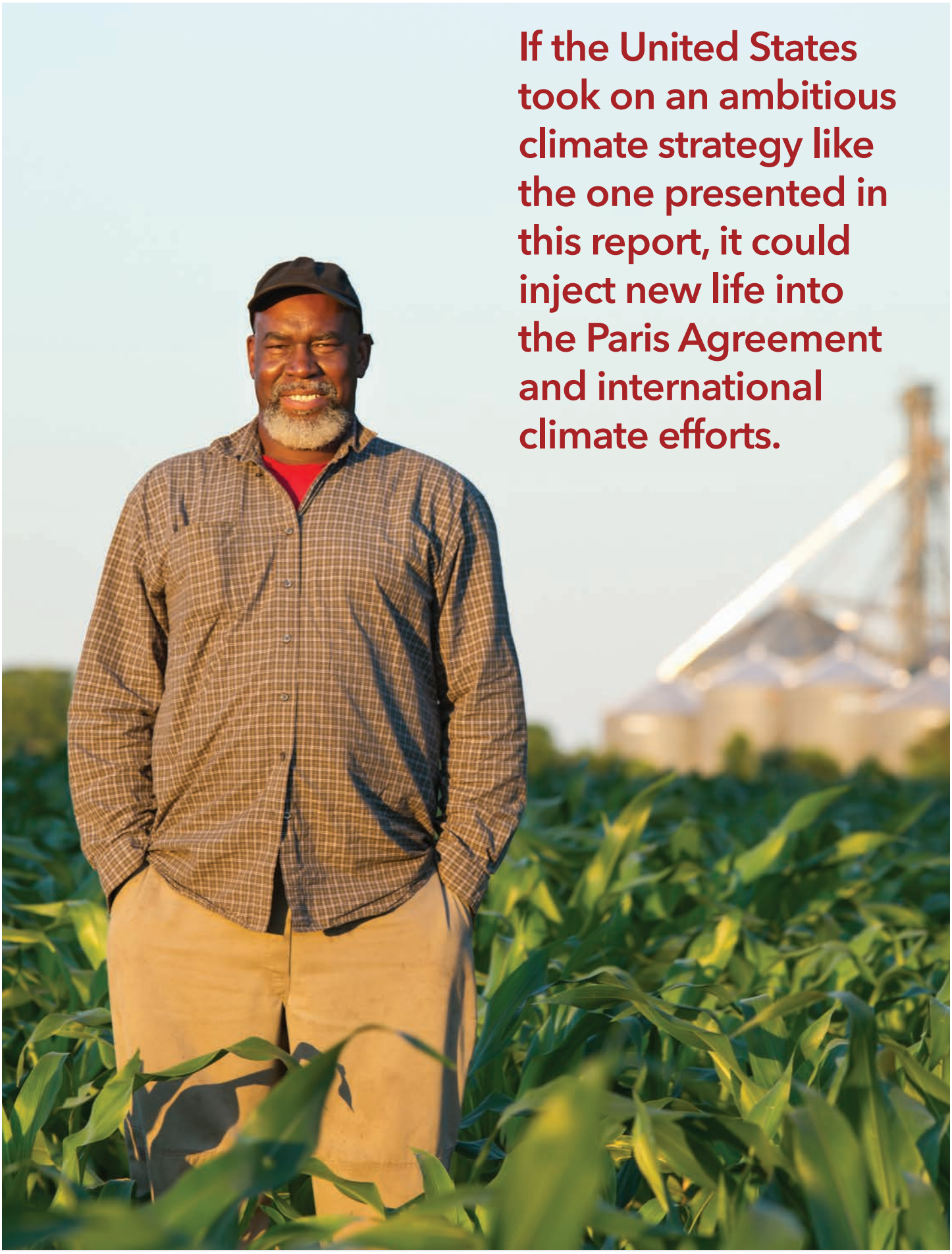
Applying Lessons Globally

Climate change is one of the most fraught and complex governance challenges humanity has ever confronted. While the rapid pace of change is possible technologically and the benefits outweigh the costs, our politics, from the local to the global, pose serious obstacles. It has long been clear, and has been widely acknowledged, that the challenge requires "all hands on deck"—but those hands have not all responded and some remain in active opposition. What is needed is a mechanism to enlist and inspire all levels of society.

The United States today is pursuing a strategy that can do just this. The story of American climate action is happening today based on an expanding group of ambitious leaders across the economy, including governors, state legislatures, city mayors and councils, corporate boards, and CEOs. Initiatives based on bottom-up engagement, with politics built on local or organizational-level approaches, will be key to supporting the robust and rapid transformations needed across the economy, and will also be key to supporting the ambitious new climate action that will need to emerge from our U.S. national federal institutions—the Executive Branch and Congress. Across political issues, true change cannot happen from just one president or party but rather must be shared and committed to.

And that story is not unique to the United States. While other countries have diverse political systems, the lessons learned in the United States can have weight elsewhere, and vice versa. Whether a country pursues bottom-up or top-down policies, or a mix of both, it is necessary to embed climate action across the economy with committed and willing leaders at all levels of government and institutions as well as the private sector.

If the United States took on an ambitious climate strategy like the one presented here, it could inject new life into the Paris Agreement and international climate efforts. It would prove that the world's largest economy is willing to do its part and be a leader again. The speed and scale of the United States' transformation could inspire other major economies to do the same.



If the United States took on an ambitious climate strategy like the one presented in this report, it could inject new life into the Paris Agreement and international climate efforts.

3

We Are on Our Way: States, Cities, and Businesses Are Already Delivering

Previous chapters have illustrated scenarios for high-ambition climate action in the United States, built on a foundation of bottom-up mobilization with a substantial boost from federal re-engagement. While this path requires rapid deployment of clean technology and transformative politics, we already know that a strategy based on bottom-up initiatives across the American economy can work. We know it because it is already working. Across the country, in both red and blue states, in cities of all sizes, and in businesses and a host of other organizations, momentum is already building to deliver on the huge potential outlined earlier. These leaders are motivated in part by the increasing visibility of climate impacts across the country. Local government officials recognize that climate change is a real issue affecting their communities. Manufacturing facilities are affected by extreme weather and supply chains are being disrupted,[81] causing companies to view climate action not solely in terms of a business opportunity but also as important for protecting their bottom lines.

The first part of this chapter highlights the range of actors already moving forward and the actions they are taking to embrace the opportunities of a low-carbon economy, with a spotlight on new leadership since the last America's


A strategy based on bottom-up initiatives across the American economy can work. We know, because it already is.

Pledge report was published. In just the past year, we have seen progress across our three principles of climate action—decarbonizing electricity, decarbonizing energy end uses, and enhancing ecosystems. We have also seen the "coalition of the ambitious" continue to grow as more and more state and local actors pledge to take action on climate.

In the second part of this chapter, we describe the emissions impact of the Current Measures scenario, which explores the implications of state and local actors implementing the decarbonization policies they have already adopted. In modeling this scenario, we focus on the impact of existing, currently in-force policies that have been adopted by state and local governments. This leads to a more conservative modeling result than if we included non-binding, more aspirational pledges that are discussed earlier in the chapter. However, both binding policies and aspirational commitments and pledges are vitally important in driving down emissions; the latter raise the bar of ambition, while the former provide "teeth" to make good on decarbonization goals. The technical appendix accompanying this report includes additional information on how both binding and nonbinding climate actions described in this chapter were identified and incorporated into the analysis.

MOMENTUM IS BUILDING THROUGH NEW CLIMATE ACTIONS

In the last several years, the United States has seen increased momentum from states, cities, businesses, and others on clean energy and climate change. Across the country there is a growing "coalition of the ambitious" that includes signatories to the "We Are Still In" declaration, businesses taking on Science-Based Targets for greenhouse gas (GHG) emission reductions as part of "We Mean Business" and other commitments, governors joining the U.S. Climate Alliance, mayors joining the Climate Mayors, and more.

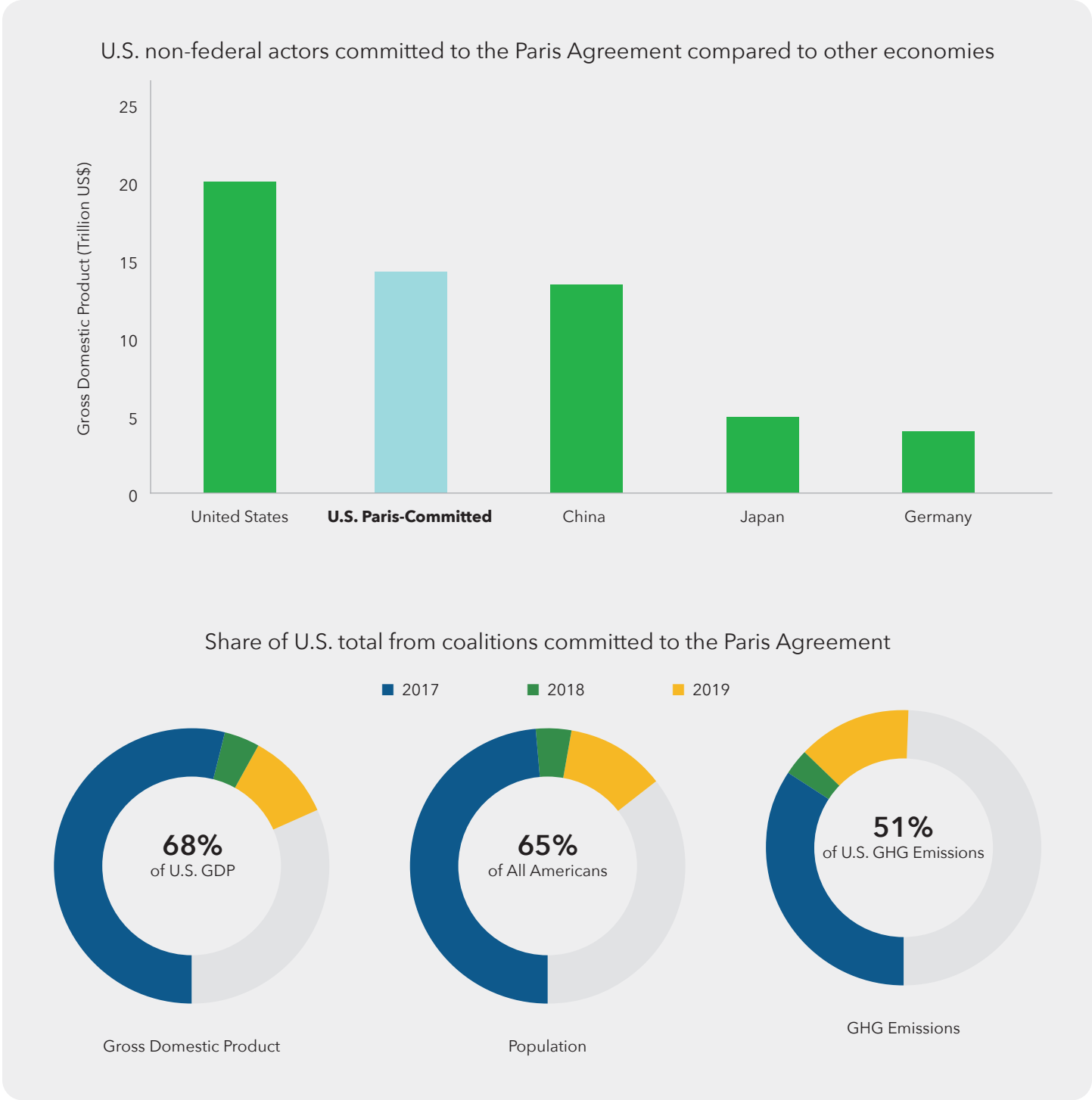
The states, cities, and counties forming one or more of these coalitions make up 65 percent of the U.S. population, 68 percent of gross domestic product, and 51 percent of GHG emissions. These are all substantial increases from 2017 and 2018. If U.S. non-federal actors were their own country, they would represent the largest economy in the world except for the United States itself (Figure 3-1). Indeed, if the U.S. were split between the climate-forward states and cities and those not acting on climate, U.S. climate-forward states, cities, and counties would be the largest economy in the world.

Since we published *Fulfilling America's Pledge* in September 2018, these leading coalitions have grown significantly. Figures 3-1 and 3-2 reflect the combined footprint of three of the largest of these coalitions:

- **We Are Still In:** Since its launch in June 2017, the "We Are Still In" declaration has gathered over 3,800 signatories committing to the goals of the Paris Agreement. This includes 2,227 businesses and investors, 10 states, 287 cities and counties, 353 colleges and universities, 28 health care organizations, and 10 tribes.[82]
- **U.S. Climate Alliance:** Since the 2018 elections, eight additional governors have joined the U.S. Climate Alliance, representing Pennsylvania, Wisconsin, Illinois, Michigan, Montana, New Mexico, Maine, and Nevada. This brings the total to governors of 24 states and Puerto Rico, all committed to continue to lead on climate change and reduce emissions consistent with the goals of the Paris Agreement.[83] Members of the U.S. Climate Alliance are growing their economies faster than the rest of the country while also reducing their emissions faster.[84]
- **Climate Mayors:** U.S. Climate Mayors includes 430 cities, up from 412 a year ago.[85] It is a bipartisan network of mayors working on climate action in their communities.

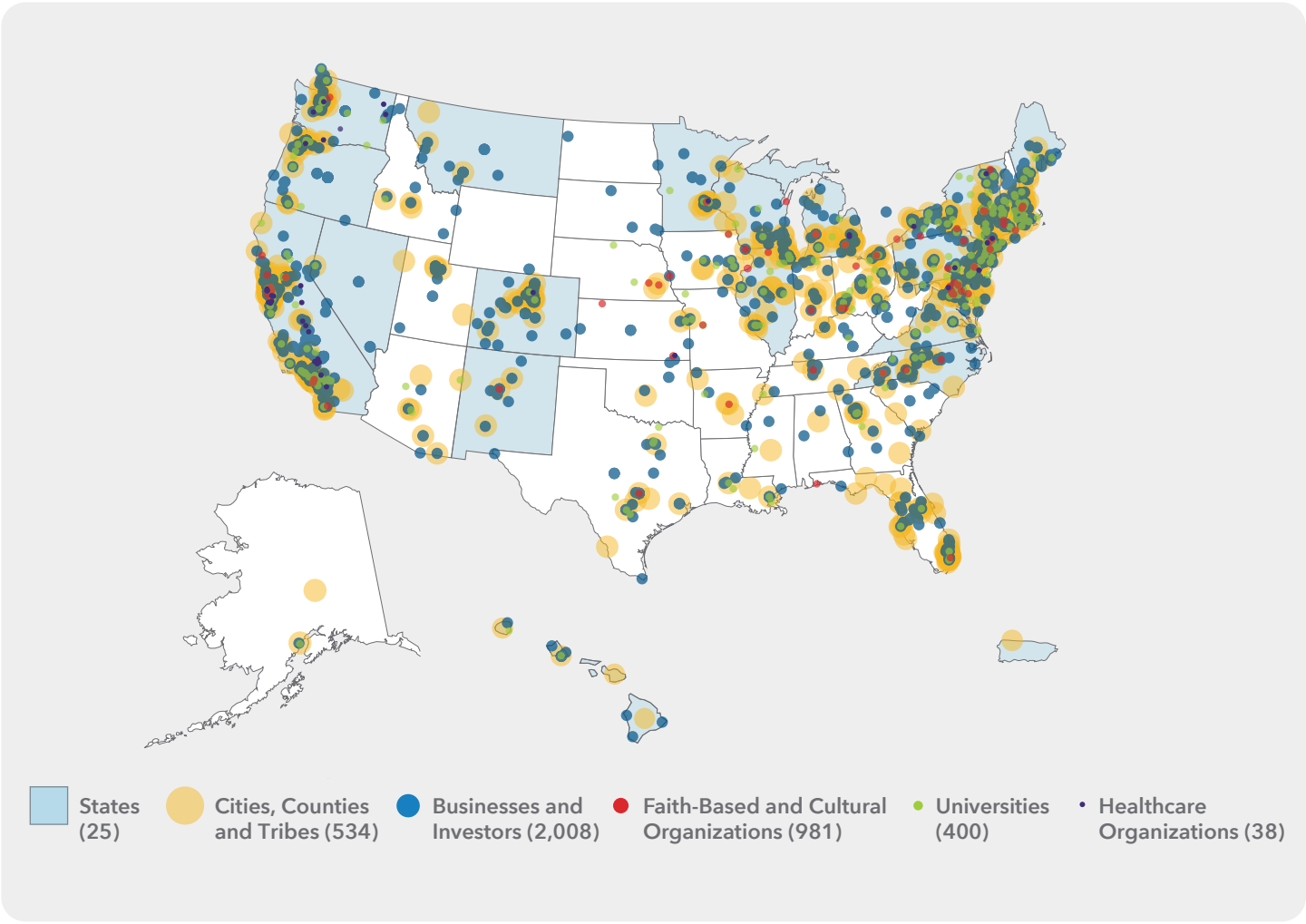
The continued growth of coalitions supporting ambitious climate policy and action demonstrates the potential to rapidly drive down emissions in the U.S. That said, significant reductions will only be achieved by translating this momentum into concrete, sector-specific policies and actions.

Figure 3-1 **The Growing Footprint of U.S. States, Cities, and Counties Committed to Climate Action in Support of the Paris Agreement**



▲ **Coalitions of states, cities, and counties committed to climate action in support of the Paris Agreement continue to grow, particularly after the U.S. mid-term elections. They now represent 68% of GDP, 65% of the population, and 51% of GHG emissions. If these U.S. non-federal actors were a country, they would be the world's largest economy besides the United States itself.**

Figure 3-2 | **Actors Committed to the Paris Agreement**



▲ The coalitions supporting the Paris Agreement have expanded even further in 2019.

Multijurisdiction Initiatives Advancing Climate Action

In addition to nationwide coalitions like We Are Still In, U.S. Climate Alliance, and Climate Mayors, there are several Multijurisdiction initiatives supporting reduced greenhouse gas emissions, including the examples below:

- Regional Greenhouse Gas Initiative (RGGI): Entering into force in 2009, RGGI is the nation's first mandatory, market-based program to reduce carbon dioxide emissions from the power sector. The cooperative between nine northeastern states is expected to reduce their power sector emissions 45 percent below 2005 levels by 2020.[86] And RGGI is growing. By January 2020, New Jersey will complete the procedure to rejoin RGGI and in October 2019, Pennsylvania's governor initiated the process to join RGGI.[87]
- Regional Electric Vehicle (REV) West Plan: REV West is a memorandum of understanding between eight western states to develop a plan to equip 5,000 miles of interstate highways with electric vehicle charging infrastructure. Other activities include EV awareness campaigns and incorporating chargers into building codes, metering policies, and renewable energy projects.[88]
- Building Electrification Initiative (BEI): BEI is piloting strategies to scale electrification of building heating and cooling in North American cities through market development for technologies like electric heat pumps and eventual state and regional partnerships. The initiative currently includes eight pioneering cities across the country.[89]

TURNING GREENHOUSE GAS TARGETS TO POLICY

Since our last report was released in September 2018, state legislatures in New York, Colorado, New Jersey, and Maine have passed new or updated GHG reduction laws, and governors in California, North Carolina, New Mexico, Maine, and Pennsylvania have issued new or updated executive orders. In total, 23 states and the District of Columbia now have GHG reduction mandates.[90] Thirteen have put these mandates into law, eight have issued executive orders, and three have set goals in climate change action plans.

Hawaii was the first state to pass a law with a full carbon-neutrality target, and now California, New York, and Maine have done the same. California has already met the 2020 emissions target that it put into law in 2006,[91] and in September 2018 Gov. Jerry Brown signed an executive order committing the state to economy-wide carbon neutrality by 2045.[92] New York's goal of net-zero carbon emissions by 2050 is now law (with New York State sources required to reduce their direct emissions by at least 85 percent by 2050 and 40 percent by 2030). It also specifies that a third of the benefits of the investments go to disadvantaged communities.[93]

Other states are following up on their decarbonization goals with policies to implement them. For example, Washington state passed strong legislation in 2019 to back up its decarbonization goals across multiple sectors of the economy. These measures include requiring utilities to retire all coal power by 2025 and be 100 percent carbon-neutral by 2030, over $100 million in EV incentives, new building and appliance efficiency standards, and a requirement for manufacturers to find alternatives to super-polluting hydrofluorocarbons (HFCs), which are used in refrigerators, aerosols, and foams.[94] Washington—along with states such as New York, Maine, New Jersey, and Colorado (see Case Study)—sets a strong example for climate leadership at the state level.

Cities are also taking actions to turn their goals into reality. For example, 25 of the 100 largest cities in the United States are participating in the American Cities Climate Challenge (ACCC). The challenge was launched in 2018 to help cities establish high-impact policies to reduce emissions from electricity, buildings, and transportation. ACCC recently released a playbook for city climate action, highlighting actions already underway—ranging from foundational actions such as strengthening enforcement of building energy codes to providing commuter incentives to reduce driving—as well as more ambitious and "moonshot" actions such as creating energy resource centers and achieving ubiquitous EV-charging infrastructure.[95] ACCC estimates that if the 100 largest cities adopted the recommendations in the playbook, they would reduce their emissions by almost 20 percent.

Case Study: Colorado Embraces Enforceable, Science-Based Carbon Reduction Targets

In the past year, a number of U.S. states have moved ahead with legislation to enact or update emissions reductions targets. Several of those states include a mandate for developing regulatory policies necessary to ensure emissions reductions. This legislation represents some of the most ambitious action at the state level and provides a blueprint for both other states and the federal government.

As one example, Colorado passed an enforceable emissions reductions target in May 2019. This legislation, HB-1261,[96] and its development and acceptance process present a compelling case study in effectively moving forward with climate legislation, including for other non-coastal and fossil fuel-producing states. HB-1261 stipulates that Colorado reduce its greenhouse gas emissions by at least 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050, relative to 2005 levels—science-based targets that are roughly in line with IPCC's global decarbonization timeline.[97] The legislation does not, however, dictate how the state must reach these goals; instead, it defers the responsibility of designing a set of policies and rules to the Air Quality Control Commission, and outlines several considerations the commission must take into account. These considerations include "the benefits of compliance and the equitable distribution of those benefits, the costs of compliance, and opportunities to incentivize clean energy in transitioning communities."[98] By focusing on the high-level goal of reducing pollution to levels recommended by scientists—rather than getting into the details of how to reach those goals—the state legislature was able to find common ground in supporting this legislation.

Notably, major power company Xcel Energy supported this legislation. Prior to HB-1261, Xcel already had a plan—overseen by the Public Utilities Commission—to reduce carbon emissions by 80 percent by 2030 and 100 percent by 2050. HB-1261 acknowledges the leadership of the power sector in the clean energy transition by requiring the Air Quality Control Commission to consult with the Public Utilities Commission regarding any rules affecting retail electricity providers and exempting any electric public utility that already has a plan filed with the PUC to reduce emissions by at least 80 percent by 2030.

In tandem with the emissions target, Colorado Gov. Jared Polis signed four electric vehicle laws. The legislation extends EV tax credits until 2025, allows public utilities to recover costs for EV charging stations, and allows charging station owners to establish EV-only parking.

CURRENT ACTION ACROSS THE THREE PRINCIPLES

Accelerate toward 100 percent Clean Electricity and other Energy Supplies

State Clean Electricity Targets

In mid-2018, Hawaii was the only state with a 100 percent renewable electricity goal. Then, in September 2018 California passed a bill to reach 100 percent clean electricity by 2045, with a milestone of 60 percent renewable penetration by 2030. In the first half of 2019, five more states plus Puerto Rico and the District of Columbia enacted similar 100 percent clean electricity legislation.[99] Examples include New Mexico, where a 50 percent renewable by 2030 and 100 percent zero carbon by 2050 bill was signed by the governor in March,[100] as well as New York, which passed new legislation targeting 100 percent zero-carbon electricity by 2040.[101] To help reach this goal while incorporating the social cost of carbon emissions into wholesale energy markets, the New York Independent System Operator is also developing a proposal for putting a price on carbon emissions.[102]

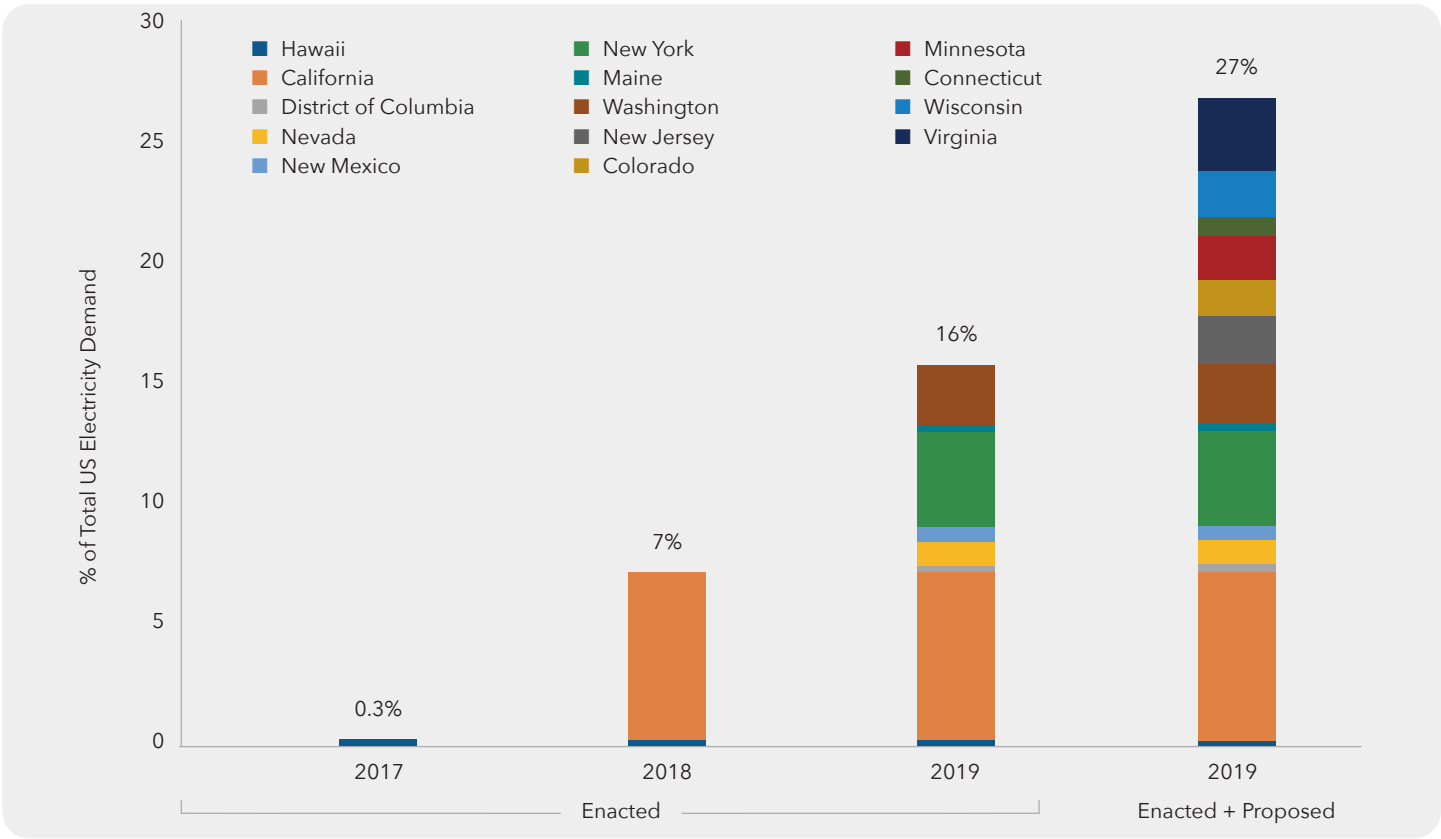
Today, states with 100 percent clean electricity goals cover 16 percent of U.S. electricity demand. In addition, governors in six more states have signed executive orders or announced proposals supporting 100 percent clean electricity. If all these proposals are enacted, states with 100 percent clean electricity goals would represent 27 percent of demand (see Figure 3-3).[103]

Despite strong leadership in the last year, momentum has not been uniform across the country. In Ohio, the state legislature passed an energy bill in 2019 that will subsidize two struggling coal plants, effectively keeping them online at the expense of ratepayers. The bill also cuts the state's original 2026 RPS target by nearly half, from 12.5 percent to 8.5 percent by 2026.[104]

City and Business Clean Energy Targets and Purchases

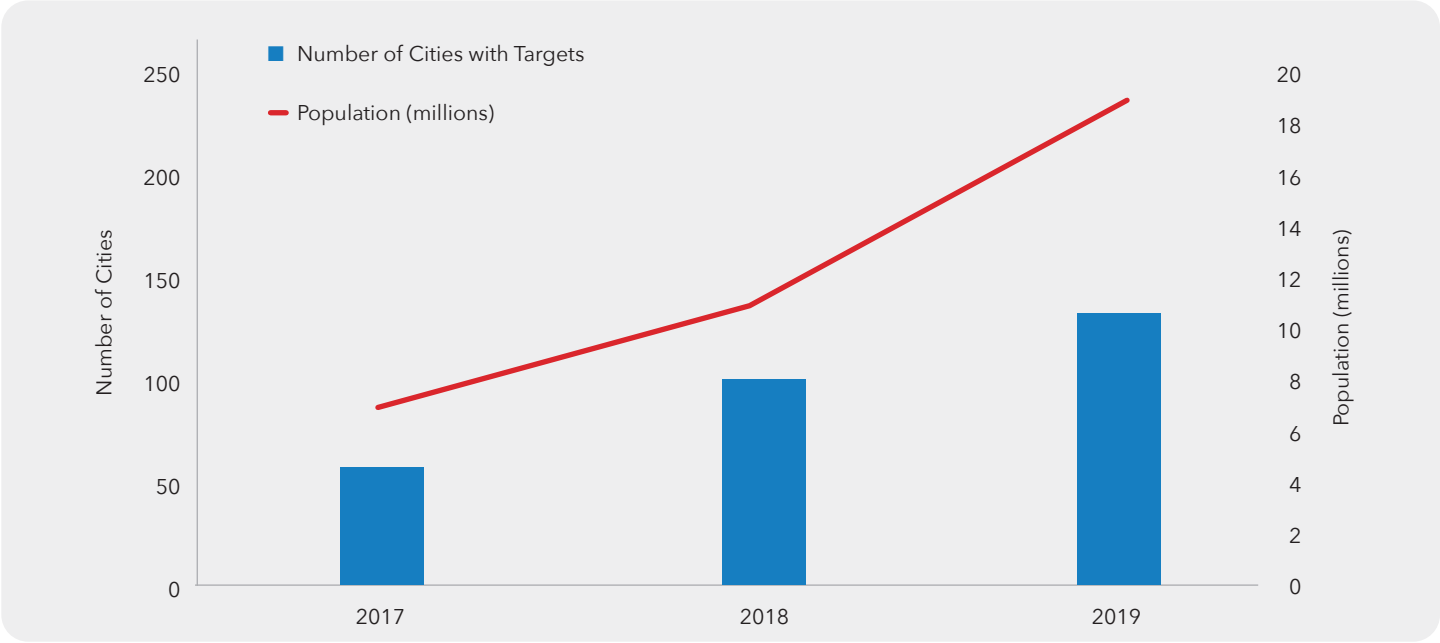
As of September 2019 there were 138 cities with 100 percent clean energy or

Figure 3-3 | **States with Enacted or Proposed 100% Clean Electricity Mandates**



▲ **In 2019 states that have enacted 100% clean electricity goals into legislation account for 16% of the U.S. electricity demand. If executive orders and governor's proposals supporting 100% clean electricity in other states are all enacted into law, these goals will reach 27% of the electricity demand.**

Figure 3-4 | **Cities with 100% Clean Electricity Targets**



▲ **In 2019, 133 American cities had 100% clean energy or clean electricity targets, with a population of 19 million.**

clean electricity targets, up from 101 cities in 2018 and 58 cities in 2017 (see Figure 3-4).[105] They have a population of 19 million and are responsible for 202 terawatt hours in total electricity demand.

Sixty-two companies with American operations have committed to 100 percent renewable electricity through RE100, with a total market capitalization of over $7.8 trillion. This includes many Fortune 500 companies such as Apple, Johnson & Johnson, Bank of America, Starbucks, and Walmart.[106]

Cities and businesses are increasingly pursuing off-site renewable deals. For example, Albuquerque added 25 MW of new solar and Philadelphia is finalizing a deal for 70 MW of solar. In the last year, businesses have brought over 1,765 MW of utility-scale offsite renewables online.[107] At least 45 colleges and universities source 100 percent clean power.[108]

Utility Commitments

The growing demand for renewables from both cities and businesses, combined with improved economics, has resulted in increased renewable generation from utilities. More than 40 utilities nationwide have adopted formal clean electricity or emissions reduction goals.[109] All told, utilities with deep decarbonization goals of 80-100 percent now represent approximately 28 percent of U.S. electricity sales and 31 percent of power sector emissions.[110]

Reducing Methane Leaks from Energy Supply

In August 2019, the EPA moved forward with a proposal to roll back the New Source Performance Standards, originally issued in 2012 to limit emissions from volatile organic compounds (VOCs) and then updated in 2016 to explicitly regulate methane emissions from oil and gas facilities. The rollback would rescind the methane-specific requirements, including the requirement for operators to install technology that monitors leaks.[111] While many oil and gas producers may still be in compliance with the earlier rules, the administration's move—and the regulatory uncertainty it leaves in its wake—undermines efforts to reduce unchecked methane leakage at the national level.

Countering these setbacks, several U.S. states will maintain already-on-the-books regulations to limit methane emissions from oil and gas facilities within their own jurisdictions, such as California and Colorado. And a few states have made moves to develop new policies that can serve as a benchmark for future ambition. One promising example is New Mexico, where in January 2019 Gov. Michelle Lujan Grisham issued an executive order calling for the development of a statewide regulatory framework to ensure reductions in oil- and gas- sector methane emissions.[112] Since then, the state has brought together critical stakeholders to inform the creation

of a Methane Mitigation Roadmap,[113] published by the New Mexico Oil and Gas Association.[114] The road map details comprehensive best practices to be incorporated into state-level policy and avoid methane leakage that is costly for businesses and the environment alike.

Decarbonize Energy End-Uses in our Transportation, Buildings, and Industry, primarily through Electrification and Efficiency

Buildings

In the past year numerous cities and states have implemented policies and incentives to reduce building emissions. California cities like Berkeley,[115] Carlsbad,[116] and Palo Alto[117] have all recently adopted ordinances requiring or encouraging all-electric buildings. In July 2019, Berkeley was the first city to set requirements to limit gas in new construction. Since then, additional California cities such as San Jose and San Luis Obispo have followed suit, with similar policies proposed in other cities including Seattle, Minneapolis, and San Francisco. The Sacramento Municipal Utility District is offering 1.5 million customers rebates for heat pumps, induction cooktops, and other electrification investments.[118] The California Public Utilities Commission recently updated a policy from the 1990s to allow its $1 billion annual energy efficiency budget to include building-electrification efforts.[119] Maine has also made strides on building electrification by funding a program that aims to install 100,000 new heat pumps by 2025.[120]

Nearly 45 percent of all residences in the Southeastern United States are already all-electric.

In many parts of the country, the transition to all-electric appliances is well under way and driven largely by factors of economics and convenience. Nearly 45 percent of all primary residences in the Southeastern United States are already electric.[121] In warmer climates, electric homes have long been cost-effective and thus often preferred by consumers, and advances in heat pump technology are improving their performance. The share of total U.S. homes using electricity for their main heating equipment has increased to 36 percent.[122]

Some states and cities have worked to reduce building emissions by updating existing efficiency standards for residential and commercial buildings. Washington, D.C., passed an energy performance standard for existing buildings that is expected to cut the District's emissions by almost 1 million tons annually.[123] A leading state in the Midwest, Nebraska also recently updated its statewide building efficiency code to rival that of other states such as Massachusetts.[124] New York City passed a new bill this year that mandates that large existing buildings reduce emissions by 40 percent by 2030 and 80 percent by 2050.[125] Similarly, Washington state provided $75 million in incentives for retrofitting older buildings after establishing the nation's first state-level energy performance standard for large commercial buildings.[126]

Other states and cities have targeted gas utilities and appliances as a method of cutting emissions in buildings. Massachusetts released its three-year efficiency plan with the highest gas efficiency goal to date for electric and gas distribution companies.[127] Washington, Colorado, and Rhode Island have passed similar legislation.[128] Colorado, Hawaii, Washington, and Nevada adopted appliance efficiency standards that will save consumers more than $3 billion by 2035, benefits that have lawmakers in New York, Massachusetts, Minnesota, and Washington, D.C., discussing efficiency standards as well.[129]

Transportation

California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont have all adopted—and Minnesota and New Mexico have plans to adopt—a Zero Emission Vehicle (ZEV) program, mandating increased sales of battery electric or fuel cell vehicles through section 177 of the Clean Air Act (CAA).[130] Together these states now comprise roughly a third of annual vehicle sales. In Colorado—the most recent state to adopt the standard—the Environmental Defense Fund estimates that the standard will more than quintuple the annual number of EV sales that the state would have otherwise seen by 2030 and is also expected to save the state up to $658 million annually by 2030 in economic and pollution benefits.[131] In response to the current administration's move to revoke California's authority under the Clean Air Act to set its own vehicle standards, 23 states comprising over 50 percent of vehicle sales in the United States filed a lawsuit to prevent the action.[132,133]

Cities and local transit authorities are also moving to electrify public bus fleets. Thanks to commitments in states like California and New York, and cities like Seattle and Pittsburgh, a third of U.S. public bus fleets are now committed to going all electric. In 2019, 127 cities and 15 counties joined the Climate Mayors Electric Vehicle Purchasing Collaborative. The collaborative leverages the purchasing power of major cities across the U.S. to reduce costs and barriers to public fleet electrification.[134] Some corporations are also taking action to electrify their fleets. Amazon, for example, placed an order for 100,000 electric delivery vans from Rivian, as part of the company's pledge to achieve carbon neutrality by 2040.[135]

Case Study: Decarbonizing Through Smart-Growth–The Intersection of Land-Use Planning and Transportation Emissions

States and municipalities that pursue strategies to decarbonize transportation end uses in concert with reforming outdated urban planning practices can address both short- and long-term implications for transportation emissions. Studies completed for the Environmental Protection Agency have concluded that promoting compact development could reduce vehicle miles traveled by 20-40 percent, and when combined with investments in public transit, would reduce transportation emissions by 9-15 percent by 2050.[136] More specifically, single-family zoning and large lot size requirements are just two of many traditional land-use planning policies that are ripe for reform.

Single-family zoning laws prevent the development of any housing that is not a detached, single-family home. Originally designed to separate homes from highly polluting industry, single-family zoning has also proliferated as a tool to segregate neighborhoods by affluence and race. In major cities across the United States, 75 percent of residential land is blocked from building townhomes, apartment complexes, and other multifamily structures.[137]

Thus, cities and states that hope to reduce transit emissions through land use will need to reform these types of laws. In December 2018, Minneapolis voted to overhaul its 2040 comprehensive plan to "upzone" the city to allow increased density and more housing citywide. The most critical component of this policy was to eliminate zoning that only allows single-family housing—in effect lifting the ban on apartment buildings. The new policy means that duplexes, triplexes, and fourplexes, which were previously illegal in much of the city, are now allowed in all neighborhoods.[138] In July 2019, Oregon also passed a law that banned single-family zoning around the state, becoming the first state to do so.[139]

In addition to single-family zoning, many cities across the country currently require that homes be built on large lot sizes, another contributor to sprawl. For most of today's urban and suburban communities, these rules are unnecessary, impede the densification of housing, and reduce the viability of reasonable access to public transit. Minimum lot sizes also hamper affordable housing developments by resulting in large, expensive homes.[140] In 1999, the City of Houston reduced its minimum lot size from 5,000 to 1,400 square feet. As a result, a city core once marked by extremely low density has witnessed a massive growth of infill development.[141]

Some utilities are beginning to prepare for—and support—the increase in electric transportation as well. For example, Seattle City Light recently released a Transportation Electrification Strategy[142] with the goal of playing an enabling role in the electrification of the transportation sector.

Leading cities and states also recognize that addressing carbon pollution in personal transportation is not just about EVs and are beginning to address land use planning and its effects on vehicle miles travelled (VMT). States like Vermont, California, and Washington have already incorporated VMT into their statewide emissions reduction goals, and a number of cities are addressing zoning (see Case Study).

Industry

HFCs: Cooling without Warming

Following White House HFC action summits in 2014 and 2015 as well as the 2016 Kigali Amendment to the Montreal Protocol that will eliminate up to 0.5°C of global warming by phasing down HFCs globally, a broadening coalition of subnational actors are recognizing the vital importance of mitigating and phasing out super-polluting HFCs.[143] While EPA's rules aimed at phasing in low-carbon alternatives to HFCs were overturned in court, in 2019 Washington and Vermont became the most recent states to pass legislation consistent with the vacated federal rules, ensuring a phasedown of HFCs within their own jurisdictions.[144] New York, Maryland, Connecticut, and Delaware also have announced their intention to pass similar bills.

Buy Clean

Buy Clean initiatives focus on using government procurement for infrastructure to incentivize use of materials such as iron/steel, cement, and glass that are manufactured in a cleaner, more efficient, climate-friendly manner. California was the first state to formally implement a Buy Clean law[145] in October 2017; campaigns exist to implement similar laws in Washington, Oregon, and Minnesota. California's program could be expanded to cover more materials and reformed to ensure that it encourages purchase of the cleanest available materials rather than simply eliminating the highest-carbon products from the California market.

Case Study: Reducing Barriers to Adoption for Non-HFC Refrigerants

Many common refrigerants used for refrigeration and air-conditioning systems are responsible for significant climate impact. Supermarket refrigeration is a critical intervention point since many supermarkets in the United States use hydrofluorocarbons (HFCs) as a refrigerant and have inherently leaky systems. HFCs have very high global warming potentials—a measurement of how much heat a greenhouse gas traps in the atmosphere—typically in the range of 2,000 to 4,000 times that of carbon dioxide.[146] And supermarket refrigeration systems lose on average one quarter of their HFCs per year.[147]

Some supermarkets across the United States are moving toward natural refrigerants, which have a global warming potential of 3 or less.[148] The North American Sustainable Refrigeration Council (NASRC), a nonprofit formed by the supermarket community, is helping to create the economies of scale that will be critical to bringing down the price point of natural refrigerant systems to more broadly enable this transition across the country. Several pilot projects—such as at Grocery Outlet stores in the western U.S. and Aldi supermarkets throughout the Northeast and Southern California[149]—are supporting this goal by documenting and reporting the energy performance of the systems. The results of these pilots can help other retailers make more informed economic decisions about the return on investment of various options and can provide contractor training opportunities, addressing a significant barrier of this relatively new technology.

Enhancing Carbon Storage in Forests, Farms, and Coastal Wetlands

Preserving and enhancing the ability of natural and working lands to sequester carbon is a critical element of addressing climate change, but it can be difficult to design the right incentives. The U.S. Climate Alliance, which currently has 25 state governors committed to climate action, has taken on this challenge as one of several priority initiatives.[150] The Alliance is working with NGOs and others to identify opportunities for climate mitigation on natural and working lands in their states and to develop detailed strategies to take advantage of those opportunities. At the Global Climate Action Summit in September 2018, the Climate Alliance issued a challenge to all countries, subnational governments, tribes, businesses, and others to make their own commitments to protect and enhance carbon sequestration on their natural and working lands.[151]

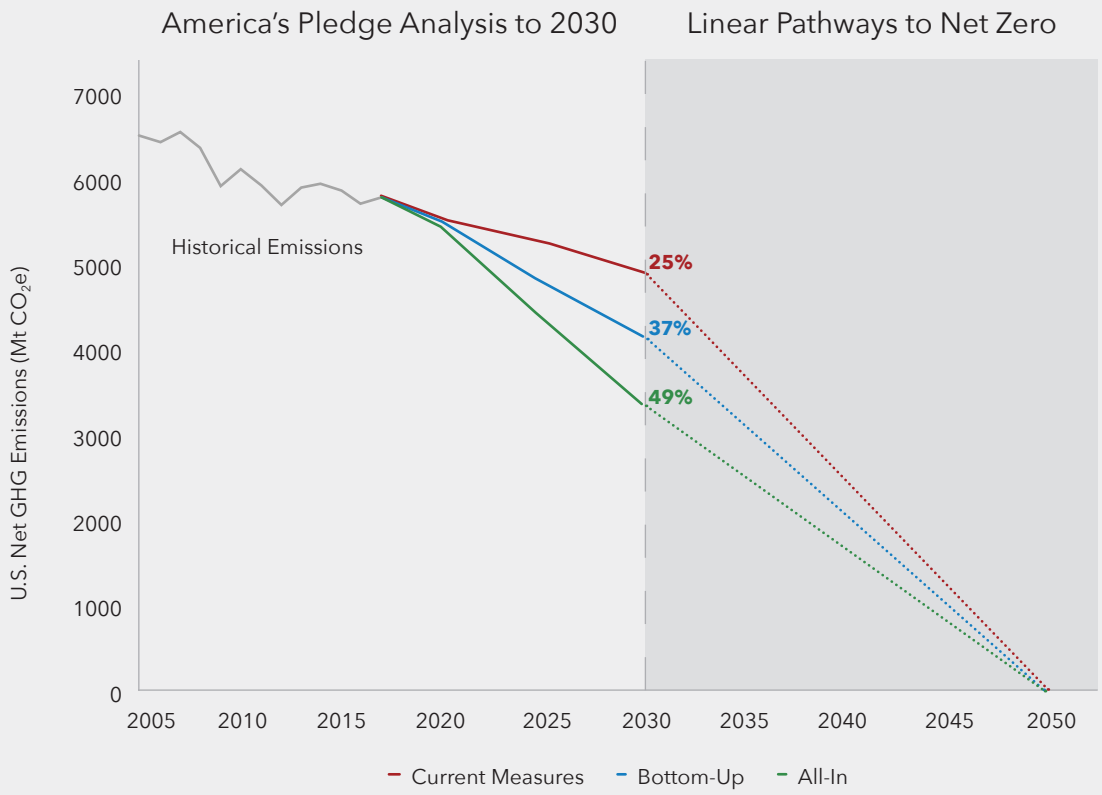
For example, Howard County, Maryland, is one of a number of locales to have accepted the U.S. Climate Alliance's Natural & Working Lands Challenge.[152] As part of its Agricultural Land Preservation Program, the county has preserved over 20,000 acres by purchasing agricultural preservation easements and dedicating agricultural preservation parcels in the county's zoning regulations. The county's Green Infrastructure Network Plan allows planners to take into account natural resources when making development and zoning decisions. The county has additional programs aimed at planting trees and installing or retrofitting stormwater management systems to filter water and sequester carbon.

ADDING IT ALL UP: THE CURRENT MEASURES SCENARIO

In our previous 2018 analysis, we found that current state and local policies in the United States would bring emissions down to 17 percent below 2005 levels by 2025 and 20 percent by 2030. Since last year, we have seen developments that both contribute to and undercut progress. At the federal level, the current administration has continued to push for rollbacks of critical climate policies, including the Clean Power Plan, federal and state vehicle emissions standards, federal appliance standards, and rules to limit methane emissions from oil and gas facilities. What's more, recent analysis of economy-wide U.S. emissions shows that emissions actually increased in 2018 rather than continuing to decline as in prior years,[153] although in the first half of 2019 energy CO_2 emissions have declined relative to the same period last year.[154]

At the same time, the ground has continued to shift toward ambitious climate action over the last year, and economic forces have continued to drive falling renewable costs and the retirement of uneconomic coal-fired generation in the power sector. Our updated Current Measures scenario takes into account significant actions adopted within the

Figure 3-5 | **Emissions Trajectories in Current Measures, Bottom-Up, and All-In Scenarios**



▲ **Current Measures could bring emissions down to 25% below 2005 levels by 2030.**

last year and assumes full achievement of those policies, as summarized in the tables below. We have also updated modeling assumptions to reflect uncertainty over federal rules, shifting economics in the power sector, and updated estimates of non-CO_2 emissions and land sinks. This scenario thus represents an updated depiction of not just the increasing impact of bottom-up climate action but also baseline assumptions that continue to shift as new data become available.

We estimate that the achievement of existing policies, alongside current technological and economic trends that include the continued retirement of uneconomic coal plants, can reduce emissions by 1,655 Mt CO_2e, 19 percent below 2005 levels by 2025 and 25 percent by 2030 (see Figure 3-5). In some cases, assumptions regarding policy achievement and other uncertainties are more optimistic than those assumed in peer studies, and are described in full detail in this report's technical appendix. These caveats aside, the results below show an improvement from the Current Measures scenario in our 2018 report, *Fulfilling America's Pledge,* and demonstrate the vital role that state and local actions can play if we are to decarbonize our economy.

Table 3-1 on page 60 describes the wide array of subnational actions and power sector economic assumptions included in this analysis in more detail. The table distinguishes between binding actions currently on the books and pledged actions that are more aspirational in nature. As mentioned earlier in this chapter, the Current Measures scenario results (shown in Figure 3-5 above) reflect only the former category, and so policies shown below are for binding actions only. The decision to include only binding actions was made to keep results conservative and does not reflect any judgment on the part of the authors of this report regarding the likelihood of achieving various actions. While not included in the Current Measures scenario, the aspirational actions described below are assumed to be achieved in the Bottom-Up and All-In scenarios along with the full suite of sector-specific climate strategies described in Chapter 2. Additional details about the specific policies and actions included in each scenario can be found in the technical appendix.

Table 3-1 | **Summary of Current Policies and Commitments**

PRINCIPLE 1: ACCELERATE TOWARD 100% CLEAN ELECTRICITY		
Type of Action	**Specific Measures Evaluated**	**Projected Impact in Current Measures Scenario if Achieved**
Renewable Mandates	Binding Renewable Portfolio Standards in 28 states.	Renewable generation increases to **26% of total generation by 2030.**
Renewable Goals	Significant non-binding renewable goals in 6 states, commitments in 142 U.S. cities, and recent renewable energy and/or decarbonization commitments from 24 utilities.	*Not included in current measures scenario (achievement of these actions is assumed in Bottom-Up and All-In scenarios)*
Retirement of Coal-burning Power Plants	Coal plants continue to retire according to announced and scheduled retirements and projected closures of additional uneconomic units.	Coal falls to **16% of total generation by 2030 from 27% in 2018.**
Nuclear Fleet Retention	Policy actions in Connecticut, Illinois, New Jersey, New York, and Ohio preventing at-risk plants from retiring.	Nuclear generation supplies **17% of total generation by 2030.**
Regulation of Fugitive Emissions from Oil and Gas Operations	Regulations to limit fugitive emissions through equipment standards for new or new and existing facilities in 7 states. Federal standards to limit emissions from new facilities are also assumed to remain in effect, but at 75% effectiveness.	*Cumulative **995 Mt CO_2e** avoided emissions (2020-2030)*
Power Sector Carbon Caps	Participation in Regional Greenhouse Gas Initiative (RGGI) by nine northeast states.	*Cumulative **160 Mt CO_2e** avoided emissions (2020-2030)*
Voluntary Mitigation of Fugitive Emissions from Oil and Gas Operations	Voluntary mitigation actions on the part of oil and gas companies through EPA's GasStar to limit methane losses.	*Not included in current measures scenario (achievement of these actions is assumed in Bottom-Up and All-In scenarios)*

Table 3-1 | **Summary of Current Policies and Commitments (continued)**

PRINCIPLE 2: DECARBONIZING END USES		
Type of Action	**Specific Measures Evaluated**	**Projected Impact in Current Measures Scenario if Achieved**
Energy Efficiency Mandates	Binding energy efficiency resource standards (EERS) in 20 states	Cumulative electricity savings of **1566 TWh** and gas savings of **2360 BCF** (2020-2030), or **541 Mt CO_2e** in avoided emissions.*
Energy Efficiency Goals	Non-binding standards in 7 states and efficiency targets in 40 cities.	*Not included in current measures scenario (achievement of these actions is assumed in Bottom-Up and All-In scenarios)*
Zero Emission Vehicle (ZEV) Mandates	Current ZEV Mandates in 10 states requiring minimum share of LDV vehicle sales to be zero emissions.	Cumulative total U.S. EV sales (BEV + PHEV) of **13.5 million** (2020-2030), or **139 Mt CO_2e** in avoided emissions.*
Electric Vehicle Procurement Goals	Procurement targets to electrify public fleets in 13 major U.S. cities.	*Not included in current measures scenario (achievement of these actions is assumed in Bottom-Up and All-In scenarios)*
Vehicle Emissions Standards	States and automakers adopt California's clean cars compromise ensuring incremental vehicle improvements through 2025.	New conventional cars achieve on-road efficiency of 42 miles per gallon by 2025 and remain at that level through 2030. New conventional light-duty trucks achieve 32 miles per gallon by 2025.
Regulations to Mitigate HFC Emissions	Regulations designed to phase down and replace HFCs with low-GWP alternatives in California, Vermont, and Washington and federal standards to limit leakage from refrigerants (EPA Sec. 608).	Cumulative **160 Mt CO_2e** avoided emissions (2020-2030).
Voluntary Mitigation of HFC Emissions	Voluntary mitigation actions on the part of U.S. supermarkets to reduce HFC emissions through EPA's GreenChill program.	*Not included in current measures scenario (achievement of these actions is assumed in Bottom-Up and All-In scenarios)*
* Calculated using EPA Greenhouse Gas Equivalencies Calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator		

PRINCIPLE 3: ENHANCING ECOSYSTEMS		
Type of Action	**Specific Measures Evaluated**	**Projected Impact in Current Measures Scenario if Achieved**
Maintenance of Land Sink	No specific actions evaluated for current measures scenario	Land sink is assumed to remain at current levels (-714 Mt CO_2e) through 2030.

The leadership of states, cities, and businesses is a bright spot at a time when the Executive Branch has been dismantling regulatory frameworks rather than making efforts to reduce emissions. Going forward, states, cities, and businesses can lay the foundation for even more ambition by following the pathways described in the Bottom-Up and All-In scenarios. It will be crucial to more rapidly apply current best practices, deploy clean technology, and expand leadership at regional and local levels to get back on a pathway that can lead to a high-ambition, next-generation U.S. emissions target for 2030. As has been demonstrated over the last year, changing political realities and market forces can rapidly raise the bar on what we can achieve.

The Dawn of a New American Economy: The Opportunity for 2030

A well-designed and well-executed comprehensive All-In climate strategy could deliver a dramatic economic renewal compared to a high-carbon future by 2030, leading to a fundamental transformation of the U.S. economy by 2050. Communities across America would experience broad-based benefits built on U.S. leadership in new global industries and supply chains; opportunities for high-skill careers; improved human health; more vibrant farms, forests, and open spaces; and greater resilience to climate impacts. Federal, state, and local agencies would work collaboratively toward a transition away from fossil fuel extraction and use that also takes into account the adverse impacts to workers, households, and state and municipal finances of such a shift. The payoff would be the creation of more economically diverse, inclusive, and equitable local economies across the country.


The payoff of the All-In strategy would be the creation of more economically diverse, inclusive, and equitable local economies across the country.

Opponents of the low-carbon transition argue that clean technologies and practices are too costly compared to continued reliance on our fossil fuel-based system. It is in the economic interests of fossil fuel producers and their suppliers to assert that the public will need to "foot the bill" for the transition. They are wrong. Not only does this assertion ignore the fact that taxpayers are already bearing often significant costs from fossil fuel externalities and the impacts of climate change, but the latest data show also that low-carbon power, transportation, and buildings will be cheaper than fossil incumbents, and could deliver net economic benefits instead. In fact, when public investment is coupled with tested policy tools aimed at low-carbon technologies and practices, these technologies and practices get better, are deployed at scale more quickly, and become cheaper. Today, many consumers and businesses can not only afford cleaner electricity, cars, and buildings, but in fact are saving money by choosing them. In the coming years, this will be the norm. Energy savings to consumers will in turn free up more local spending and investing, which boosts regional economies via output and productivity gains.

This chapter begins with an overarching vision statement describing the potential benefits and changes to our economy and society by 2030 under the All-In climate strategy. The rest of this chapter provides specific examples and evidence describing how such a commitment could manifest in Americans' day-to-day lives, including cheaper energy, economic development opportunities, the types of investments and innovative finance needed to fund it, and potential benefits to human health and natural landscapes. Finally, we explain how challenges to fossil fuel- dependent industries, regions, and workers resulting from a rapid low-carbon transition can be managed in a way that is fair and just.

2030 VISION OF THE NEW AMERICAN ECONOMY WITH THE ALL-IN CLIMATE STRATEGY

A New American Economy is one possible future, realized by a rapid decoupling from our current high-carbon energy dependence. As described in Chapter 2, achieving such a future will require far more than commitment, desire, and pledges. It will also require innovation, political buy-in, financing, advance planning, coordination, and collaboration across the public and private sectors, in every part of the country. If we commit to making this happen now, we will transform the American future and will realize substantial benefits by 2030.

Affordability. Under the All-In scenario, by 2030 homeowners and businesses enjoy cost savings from clean energy investments in light-duty electric vehicles, clean electric power, and new zero-emission buildings in most parts of the country. As we decarbonize more rapidly, lifetime savings accelerate and broaden to include existing buildings and heavy-duty trucks. Aggressive performance standards will ensure that cheap renewable power has replaced coal and gas, on-road transportation is irrevocably committed to electrification, and both new buildings and replacement appliances are zero-emissions. Coal is completely phased out and gas is following coal on a downward importance curve. At the heart of this revolution lies economies of scale and learning from deployment.

Economic Development and Jobs. By 2030, America's economy is reaping benefits of public policy aimed at the emerging and growing clean energy industries and careers of the future, including grid management, energy storage, offshore wind, green building construction and management, sustainable forestry, and regenerative agriculture, among others. America's bold investments could help trigger a race to the top with other countries, creating even greater progress on the world stage. Retrofitting existing buildings for high energy performance will be a significant industry itself, initially comparable to new construction, and then exceeding its impact as more and more buildings benefit from deep performance retrofits. New facilities producing energy storage, wind, and heat pump technologies will thrive in states with strong DNA in manufacturing, supply chains, logistics, and

operations. This is already happening today in geographies as diverse as Fremont, California (Tesla Vehicles); Greenville, South Carolina (Proterra); Reno, Nevada (Lithium Ion Gigafactory); and Sweetwater, Texas (Sweetwater Wind Farms). Entirely new markets for software, intelligent control systems, and data analytics—industries long characterized by American excellence—will develop around the management of "smart grids" featuring high levels of renewables and energy storage,[155] as well as building management and regenerative, precision agriculture.

Health and Ecosystem Benefits. By 2030, benefits to human and ecosystem health from the shift away from fossil fuels will already be visible in many communities. Air quality and health benefits resulting from shifting away from coal plants and to electrification of vehicles, buildings, and industry will be realized immediately. Replacing fossil fuel-based energy infrastructure with cleaner technologies reduces toxic air pollutants associated with combustion of coal, oil, and gas, which in 2017 were a major contributor to nearly 110,000 premature deaths in the United States.[156] Electric infrastructure also eliminates risks associated with pipeline explosions or in-home gas leaks. Broader economic benefits include growth opportunities for electricity production companies; increased job opportunities in electricity and other clean technology industries; and cost savings for building developers and municipal governments that will not need to invest in gas infrastructure for new buildings. Electrification also offers an energy security and resilience opportunity, weaning off price volatility and safety risks associated with importing and transporting fossil fuels across the country.

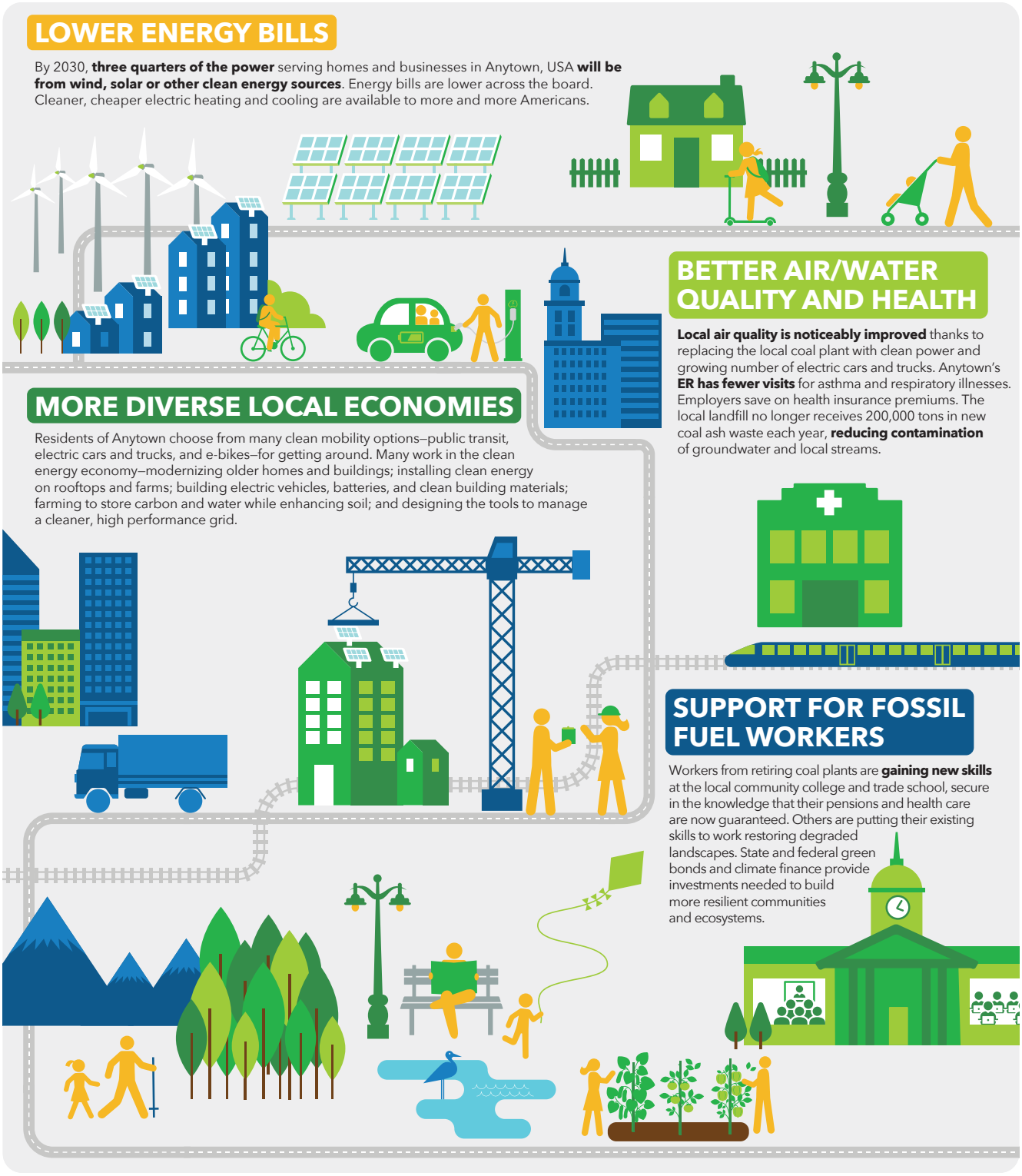
These benefits are critical for disadvantaged communities located downwind of coal plants, large industrial sites and next to busy roadways, where rates of childhood asthma and other respiratory illnesses are highest.[157,158] And there is potential for even greater cumulative benefits to local air and water quality and human health by 2050. Production of new coal ash would cease, and hundreds of legacy coal ash ponds could be appropriately remediated to reduce existing risks of groundwater contamination. According to a report by Environmental Integrity Project in 2019, approximately 96 percent of coal plants have dangerous levels of coal ash pollutants in nearby groundwater,[159] with over 4,900 monitoring wells reporting water quality contaminated above safe levels.[160] By 2030, all communities, but especially those currently exposed to high levels of toxic pollution and poor air and water quality from fossil-based energy, could begin to see measurable improvements to health and local ecosystems and enjoy greater access to healthy open spaces.

Investment and Finance. Federal investment in research and development (R&D) for energy, building materials and performance, transportation technology, and sustainable forestry and agriculture returns to the levels that made America thrive a half century ago. These investments will prime emerging technologies—including currently marginal options like hydrogen smelting of steel—and innovative practices like net zero buildings for full commercialization. Investments in infrastructure and the "grid of the future" are optimally well-funded to maximize overall prosperity. In addition, a full phaseout of existing fossil fuel subsidies helps to even the playing field for industries specializing in efficient and fuel-saving technologies while freeing up over $25 billion each year for investments in a fair transition.

Fair Transition. If managed well, the new low-carbon economy in 2030

If we commit to making this change happen now, we will transform the American future and begin realizing substantial benefits by 2030.

Figure 4-1 | **Life in Anytown USA in the All-In Climate Scenario**



▲ If we have 100% commitment across government, business, and citizens to execute the vision of the All-In climate strategy, daily life in the average American town will have improved substantially by 2030. By protecting the climate, we can achieve cheaper energy, cleaner air and water, and better-performing buildings and vehicles.

can be more balanced and inclusive of American workers across gender, race, and socioeconomic groups than today's economy. Industry-funded and publicly-funded training and education programs will provide the skills and know-how needed to run low-carbon businesses and operations. These programs should be widely available across all professions—white and blue collar—and be geared to providing steady, secure employment.

By 2030, workers, businesses, and communities formerly dependent on fossil fuels can be well along in the process of reorienting to new industries, careers, and sources of municipal revenues, supported by public policies and programs which anticipate the transition and are closely tailored to local needs. Former employees of coal mines, oil and gas drilling operations, and retiring coal and gas plants will have access to new employment opportunities; older workers will take advantage of income and pension transition assistance, funded by green bonds issued by local utilities and redeployment of funds from the elimination of fossil fuel subsidies. States and municipalities continue to design and implement programs to replace lost tax revenues, borrowing from innovative examples in states and cities where the transition is already under way. Cities and towns use improved bond ratings to fund infrastructure improvements that increase resilience to climate impacts, including updates to buildings, backup power, and stormwater and emergency management systems.

KEY FEATURES OF THE U.S. ECONOMIC TRANSFORMATION

Affordability

Available evidence makes clear that by 2030, the low-carbon transformation in the United States will deliver equal or better performance in electric power, vehicles, and buildings, but at a smaller energy price tag than today. Today, many households and businesses with electric vehicles, clean energy, and heat pumps are already enjoying life-time savings in energy costs. American households and businesses currently purchase $1 trillion of gasoline, diesel, gas, and other fossil fuels each year, equivalent to roughly 5 percent of U.S. GDP.[161,162] Costs for critical fuel-saving low-carbon technologies have fallen precipitously: solar PV by 85 percent, wind by 49 percent, lithium batteries by 79 percent since 2010, and LED lights by 85 percent since 2012.[163,164] Projected cost reductions for emerging technologies for storage, electric trucks, and buildings may be underestimated, as expert projections for renewable power have been for the past 10 years. Public policy has been a key driver of these price declines; learning effects have also led to improvements and efficiencies in how we deploy these technologies. Continued reductions in costs are expected for other energy, building, and vehicle technologies in the near future. These will generate more significant energy savings from 2030 to 2050.

Electric power is the sector where this virtuous cycle of sound policy driving technology improvements—and those improvements leading to

cost reductions, growing market share, and lower overall system cost—has progressed the furthest. Today, electric generation from renewables is cheaper than coal-fired power across the country: replacing roughly three-quarters of existing coal plants nationally with wind and solar would immediately reduce electricity costs.[165] Forward-looking utilities are taking actions spurred by these cost differentials: Xcel Energy is targeting 100 percent renewables by 2050 and plans to retire numerous coal plants early, Pacificorp revealed that 60 percent of its coal fleet is currently uneconomic, and Northern Indiana Public Service's 2018 resource plan found that replacing its entire coal fleet by 2028 with a portfolio of solar, wind, storage and demand management resources would save customers $4 billion.[166,167, 168,169]

Electric power is the sector where this virtuous cycle of sound policy driving technology improvements has progressed the furthest…. Today, electric generation from renewables is cheaper than coal-fired power across the country.

Today many EVs provide savings to consumers over the lifetime of ownership, through lower costs of fuel and maintenance relative to comparable combustion vehicles. As recently as 2015, batteries accounted for 57 percent of the cost of a medium-sized EV; today, they account for only 33 percent.[170] Operating an EV in many locations in the US can save over $500 per year, and savings will increase if gasoline prices increase.[171] As the incremental purchase price of EVs continues to fall with further improvements in batteries, the net savings from electric driving will increase. If the current trend holds, the showroom cost of an EV could be at parity with that of a combustion engine vehicle as early as 2022.[172] At that point, operating that EV will be cheaper than operating its internal combustion competitor. Total operating costs of heavy-duty electric trucks are already verging on outcompeting those of diesel 16-wheelers.[173] Electric trucks are likely to reach parity with diesel early in the 2020-2030 time frame, due to declining costs of batteries and electric motors and increasing costs of emission standards compliance.[174] [175]

Similarly, electrification of heating and cooling in buildings offers lifetime savings for many building owners right now. Current estimates of the impacts of electrification of residential space and water heating in four cities with a range of climates—Oakland, Houston, Providence, and Chicago–show savings between $1,000 and $10,000 in lifetime costs in both new construction and retrofit homes.[176] Overall, the cost of ownership for electric air source heat pumps and heat pump water heaters is below that of conventional gas furnaces for new homes. For existing homes and buildings, gas heating is currently still more economic in some parts of the country, but heat pumps make sense for homes currently using oil and propane.[177] In the Southeastern United States, electrification of homes is quite advanced, with nearly 45 percent of all primary residences all-electric.[178]

Even with additional declines in costs for renewable energy, EVs, and electric heat pumps, however, strong policies to drive massive up-front investments will be needed to realize the promise of the All-In scenario. Additional system costs will be incurred, for example to integrate and balance variable renewable energy into the grid via new transmission, energy storage, and demand management. Up-front investments are needed for transportation charging infrastructure. An electrified passenger transportation fleet requires charging infrastructure as convenient and ubiquitous as the century-old network of gasoline pumps. These costs need to be financed as public goods similar to investments in the original highway network, so that they do not unduly increase costs to consumers for switching to clean energy. To date, higher-income households have dominated uptake of key technologies like rooftop solar and electric vehicles.[179] More attention must be paid so that lower-income households enjoy equal benefits from clean technologies, particularly when public investments are involved.

Affordability is also further from reality in certain sectors that account for the remaining one-third of U.S. GHG emissions. For heavy industry, aviation, and shipping, we are still in search of the right combination of technologies and policies to achieve full decarbonization, or to achieve it without burdening consumer with direct costs.

Economic Development

Clean energy and other industries aimed at deep decarbonization include some of the fastest-growing, most dynamic sectors in the U.S. economy. Investing in a major acceleration of the low-carbon transition and designing that transition with all Americans and regions of the country in mind will benefit the entire economy through the creation of new industries and supply chains, greater diversification of regional economies, higher energy productivity, and a potential increase in economic activity. Economic activity and jobs in a low-carbon economy benefit all parts of society, as people gain access to jobs in sectors that are growing rather than contracting, with further opportunities to advance through training. A low-carbon economy also protects consumers from volatility in fossil fuel prices. Diversifying local economies through smart low-carbon investments can help communities that are highly dependent on fossil fuel-based industries improve their fiscal and economic health. Finally, producing clean technologies and developing their supply chains offer market opportunities that can provide the U.S. with a strategic advantage in sectors that are already developed (such as batteries) but also in nascent ones (such as grid analytics and hydrogen manufacturing).

Economic Development and the Jobs of the Future

When households and businesses spend less on fossil fuels (which most U.S. states import) but receive the same level of energy services, economic output receives a boost.[180] Some regional economies are already experiencing this type of macroeconomic benefit from well-designed decarbonization efforts. Under the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program to reduce carbon emissions from large power plants, participating Northeast states have reinvested RGGI

revenues (from auctions of CO_2 emission allowances) into energy efficiency; community-based renewable projects; customer bill assistance; and research, education, and job training programs. From 2015 to 2017, consumers and businesses enjoyed savings of $220 million on electricity bills as a result.[181] In turn, the RGGI states experienced an estimated $1.4 billion of net positive economic activity and 14,500 additional job-years through states' reinvestment.[182]

Clean energy production is becoming an important engine of employment and economic development in the United States. Currently, clean energy generation employs 1.3 million workers across over 110 occupations, and employment is growing.[183] Solar PV installers and wind turbine service technicians are two of the fastest growing occupations in America, with both expected to roughly double between 2016 and 2026.[184] These occupations pay relatively good wages for a technical occupation—median pay is about $42,000 per year for PV installers and $54,000 for a typical wind power job.[185] Estimates show that hourly wages in the renewable energy industry are 8 percent to 19 percent higher than the national average for comparable jobs.[186] Jobs in clean energy and energy efficiency also provide important opportunities for those without a bachelor's degree, with the majority of these workers without a four-year degree.[187] Although these numbers look impressive, there is still a way to go to ensure that all of these jobs are stable and of good quality. Many are part-time or do not offer the type of benefits comparable to other jobs in the traditional energy sector.[188] To make sure that the clean energy sector creates high-quality jobs, we need to strengthen labor and benefits agreements, prioritize full-time work, and invest in training and apprenticeship programs.[189]

Energy efficiency, a fast-growing sector currently employing over 2 million Americans, must continue to grow for the All-In scenario to be as cost-effective as possible.[190,191] Efficiency job growth is more than a one-off opportunity, as long-lived assets like buildings will need retrofitting for decades to come. One study estimates that over half a million new full-time jobs could be sustained over a decade through retrofitting roughly 40 percent of the nation's residential and commercial building stock. These

retrofits would also generate over $60 billion per year in cost savings for U.S. energy consumers.[192] Investments in energy efficiency also provide benefits to a U.S.-dominated supply chain—over 95 percent of sheet metal for ductwork, vinyl windows, and rigid foam insulation is made in America. Mechanical equipment like furnaces (94 percent) and air conditioning and heat pumps (82 percent) also have high American content.[193]

Automakers and suppliers in the United States and elsewhere are quickly retooling for a global marketplace under major transformation, where the focus is on low-carbon solutions but also on mobility rather than on vehicles alone. Policymakers around the world, including the largest single market of China, are signaling an effective ban on combustion vehicles in their markets post-2030. Right now, the number of EVs on U.S. roads is just over 1 million in 2018, a fraction of what will be needed to achieve the All-In scenario.[194] EV manufacturing and sales are poised for growth globally, but U.S. automakers will need to compete not only with traditional European and Asian rivals but also recent Chinese entrants to the industry. In 2018, 231,000 employees worked on all-electric, plug-in hybrid, and hybrid vehicles, making up less than 10 percent of total motor vehicles employment in the United States.[195] United Auto Workers sees both risk and opportunities for U.S. autoworkers as demand for EVs grow. Electric drivetrains are simpler, requiring fewer but also different components than traditional combustion drivetrains. U.S. firms will need to secure a foothold on production of key parts of the EV supply chain, otherwise production and employment could shift to companies lacking a large U.S. manufacturing base.[196]

Finally, large-scale deployment of EVs may benefit the economics of certain electricity markets—electricity rates could decline as EVs begin fueling on the grid, allowing fixed costs to be spread across more customers. A recent study has shown that a large-scale increase in plug-in electric vehicles through 2040 could increase U.S. economic output by up to $20 billion annually and generate up to 147,000 net jobs, while saving households hundreds of dollars per year in lower fuel costs. For five Northeast states, savings are expected to be from $4 to $24 billion per state by 2050 with a net combined savings of over $200 billion by 2050.[197]

Energy storage, which provides needed flexibility to the grid as renewable generation grows, is another emerging clean energy industry experiencing growth. The number of battery storage jobs grew 18 percent in 2018, reaching about 63,000.[198] More storage is being added as costs fall, the technology improves, and new policy incentives are introduced. In 2018, 760 MWh of energy storage were added to the grid, a 45 percent increase over 2017, bringing cumulative storage to nearly 2,000 MWh nationwide.[199] By some estimates, more than 35 gigawatts of storage systems will be deployed in the United States in 2025.[200] The development of the energy storage sector is also critical for smoothing disruptions in the electricity network—e.g., power outages, surges—which cost the American economy more than $150 billion annually.[201]

By investing in low-carbon supply chains as well as technologies, the U.S. can expand economic growth and employment while also gaining an advantage in global export markets. For instance, utilities invested almost $22 billion in the national transmission system in 2017 and were planning to invest $89 billion from 2018 to 2021.[202] In 2017, more than

100,000 Americans were employed in the smart grid, grid modernization, and advanced battery sectors, which combined generated over $2 billion in equipment exports.[203] Grid modernization also opens the opportunity to further develop the growing utility data analytics sector. In the United States, this market is expected to reach $1.4 billion with a 60 percent market share by 2022.[204]

Economic Diversification

In the short term, a transition which massively reduces the use of fossil fuels will negatively affect companies and communities most heavily involved in their extraction and production. As globally traded commodities, however, oil, gas, and coal are subject to high price volatility. Evidence shows that economies which rely heavily on extraction of natural resources including coal, oil, and gas generally do not exhibit sustained economic growth or diversified economies.[205] Appalachia, for example, was one of America's poorer regions even when the coal economy was at its peak.[206] Economic growth, fiscal health, and employment often fall in tandem with declining commodity prices, especially when governments do not invest in "rainy-day funds" to smooth out these "boom-bust" cycles. And in fact, despite record levels of fossil fuel production, many companies and states heavily oriented toward coal and gas extraction and production in particular are currently faring poorly due to historically low prices.

West Virginia, which has already experienced a major downturn in coal production, is now, only a few years after the shale gas boom began, experiencing a major downturn in its gas industry.[207,208] Since gas spot prices began to fall under $3/MMBtu in 2014, West Virginia's top gas-producing counties have lost over 1,500 jobs despite producing $4.8 billion worth of gas.[209] A similar story is developing in Wyoming, with an economy where fossil fuels extraction (e.g., coal, gas, and oil) accounted for 20 percent of GDP and 7 percent of employment in 2016.[210] With employment in Wyoming's extractive sectors about 3.5 times larger than the national average and industrial production about 40 percent lower than the national average, it experiences a "mineral tax trap"—when energy markets collapse so do public revenues, leading to a need for austerity to balance budgets.[211]

Diversification in Rural Economies

American foresters and farmers' livelihoods are already experiencing climate impacts as rising heat, drought, wildfires, and extreme flooding are expected to increasingly disrupt forest and agricultural activities across the U.S.[212] But there is a potential for a new rural economy that enhances the carbon storage potential of America's natural and working lands, builds more sustainable economic development and job security, and increases the resilience of our ecosystems to growing climate risks.

Forest restoration, agroforestry, and regenerative agriculture are all strategies with the potential to enhance carbon storage, economic development, and ecosystem health. Land restoration brings marginal land back into productive use, enabling the expansion of productive areas while keeping natural ecosystems intact. Ecological restoration is already a sizable contributor to economic activity—in 2015, the sector directly employed about 126,000 workers, more jobs than coal mining (79,000) or steel production (91,000), and generated about $9.5 billion annually in economic output.[213]

Regenerative agriculture includes "no-regrets" practices that regenerate topsoil, such as such as cover cropping and crop rotations. These practices not only sequester carbon but can also increase agricultural productivity, improve soil health, and conserve

By investing in low-carbon supply chains as well as technologies, the U.S. can expand economic growth and employment while also gaining an advantage in global export markets.

biodiversity.[214] Research shows that corn yields could increase between 28 percent and 34 percent under regenerative practices; for wine grape cultivation, gross margins could be up to 50 percent larger than under conventional practices.[215] Given the potential importance of regenerative practices to farmers' bottom lines, large-scale food companies are seriously engaging—in 2017 General Mills announced that by 2030 it will invest in regenerative agriculture practices on 1 million acres of farmland.[216] These practices are gaining bipartisan support in statehouses across the country in healthy-soils legislative proposals that would provide support for farmers and livestock managers to revert from conventional practices that deplete soil carbon. As of June 2019, nine states (California, Hawaii, Maryland, Nebraska, New Mexico, Oklahoma, Utah, Illinois, and Vermont) have passed healthy-soils legislation and about 25 others have proposals in place.[217]

Paying forest owners and farmers not only to produce timber and crops but essentially to farm carbon could become an integral feature of the low-carbon transition. Many of the opportunities to increase carbon storage on natural and agricultural lands have net negative or low costs. Recent estimates are that over 220 Mt CO_2e of carbon storage could be achieved nationally by 2050 at less than \$10/Mt CO_2e.[218,219] A number of federal and state policy and investment programs can help realize this potential in forests and farms. For example, California has implemented the California Healthy Soils Initiative, a pilot program that uses revenue from the state's cap-and-trade initiative to provide grants of \$50,000 to 50 farmers to engage in sustainable land management.[220] Carbon-rich soils and healthy ecosystems also provide far more effective and climate resilient underground storage of water—which will become increasingly critical in a climate-stressed world, as states like Texas have recognized.

Case Study: The Biogas Opportunity in American Agriculture

Biogas produced from renewable, waste-derived feedstock has potential to curb GHG emissions from U.S. farms and landfills and create new revenue streams and environmental benefits in rural communities. Derived from the anaerobic digestion of wet-waste organics like manure and food scraps, biogas delivers climate benefits in two primary ways: it directly reduces methane emissions from decaying organic matter and displaces the use of fossil fuels.[221] Raw biogas may be cleaned and upgraded to nearly pure methane, referred to as biomethane, that is interchangeable with pipeline gas. The fuel may then be used in sectors that are otherwise tough to decarbonize, such as industrial heat or heavy-duty freight, resulting in net-negative emissions over the fuel lifecycle. Supply is finite; a 2018 study found the potential for biogas derived from organic wastes could equal 18 percent of today's on-road diesel consumption.[222]

Production of biomethane used in transportation fuel markets has grown dramatically, from 1.4 million ethanol-equivalent gallons in 2011 to nearly 304 million in 2018.[223] This growth has been driven in large part by federal and state policies that account for the fuel's GHG benefits. As of 2014, the EPA's Renewable Fuel Standard (RFS) gives credits to biomethane delivered to transportation markets.[224] At the state level, California's Low Carbon Fuel Standard (LCFS) came into effect in 2011, allowing biomethane producers across the country to generate credits through the California renewable fuel market.[225] California is also helping to accelerate waste-to-energy projects in areas like the Central Valley, a massive agricultural hub with dairies producing about 20 percent of the nation's milk, through a targeted grant program which awarded nearly \$70 million to bio-digesters in 2018.[226] Oregon's Low Carbon Fuel Standard, implemented in 2016, also credits biomethane using carbon intensity values certified by the California Air Resources Board.[227]

Beyond emissions benefits, biogas and biomethane projects are providing an economic boost to many agriculture-dependent communities. CalBioenergy (CalBio) is working with California dairy farmers to develop, operate, and finance projects, and generate credits eligible under the federal RFS and California LCFS programs.[228]

Equally important, biogas and biomethane projects are delivering benefits to local air and water quality. Missouri-based Roeslein Alternative Energy (RAE) has emerged as a leader in this area. RAE uses waste-to-energy projects to drive ecological services and wildlife restoration, aiming to restore 30 million acres of native prairie plants to marginal lands over the next 30 years.[229] In 2019, RAE partnered with Smithfield Foods, the worlds' largest pork producer, with the goal of converting manure to energy at all Smithfield hog farms in Missouri by 2021. Once completed, these projects will improve air quality by eliminating open lagoons, reduce ground water contamination, and prevent methane emissions of roughly 850,000 tons of CO_2 equivalent.[230] RAE also plans to convert erodible crop lands to polyculture prairies, which can be harvested and used as an additional biogas feedstock. This will improve wildlife habitat, reduce erosion, and control fertilizer run-off along rivers.[231]

Finally, renewable energy has been improving local economics in rural America for years. Farms hosting renewable energy installations have income diversification and added financial security at a time of severe economic stress due to low commodity crop prices, extensive flooding, and trade disputes. In 2015, wind companies paid American farmers and other rural landowners hosting wind turbines over $220 million, with nearly three-quarters of that going to landowners in counties with below average incomes.[232,233,234,235] These communities also benefit from tax revenues and other income from the wind value chain.[236] In 2017 renewable energy, low-emissions vehicles, clean fuels, grid technologies, and energy efficiency represented about 160,000 jobs in the rural economies of 12 Midwestern states.[237]

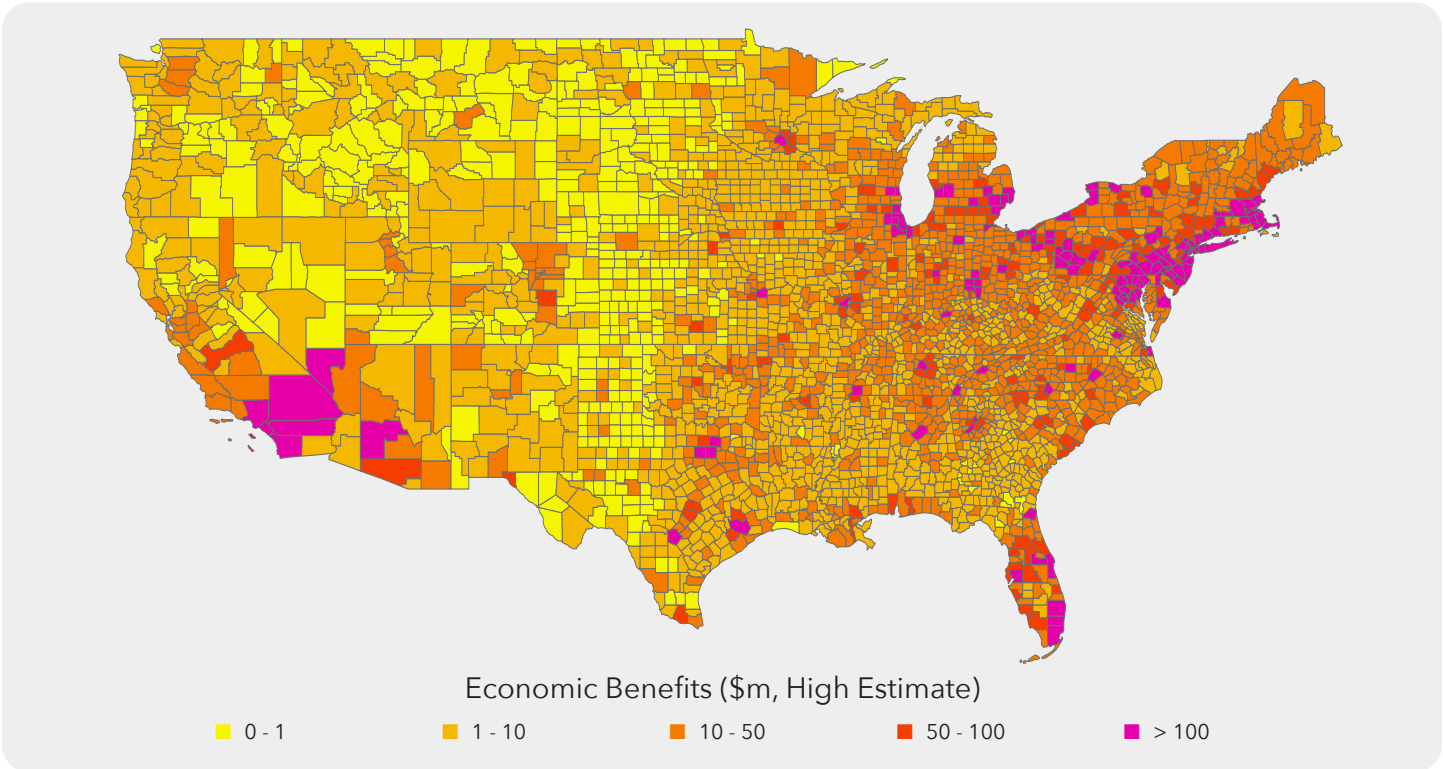
Health and Ecosystem Benefits

Benefits to human health and the environment, air and water quality in particular, are arguably reason alone to pursue a rapid All-In transition from fossil fuel usage. Each component of the fossil fuel supply chain generates pollutants with negative impacts on human health and the environment: coal mining disturbs habitat while mine tailings pollute streams and drinking water; oil and gas extraction and distribution are responsible for significant methane emissions; fossil-fired power plants are still one of the largest sources of air emissions in the United States despite the ongoing decline in coal generation; and coal ash wastes, which contain arsenic, mercury, lead, and other toxic contaminants, are a major risk to groundwater, drinking water wells, and local ecosystems, affecting humans exposed to these systems.

EPA estimates that its 2015 rule on coal ash residuals, which is being delayed by the current administration, would reduce exposures to fish contaminated by coal ash pollutants, including over 3 million young children exposed to lead and over 400,000 children exposed to mercury.[238]

Only a portion of fossil fuel's pollution impact on local communities is currently

Figure 4-2 **Value of Incremental Health Benefits from Reductions in Fossil Fuel Generation Under the All-In Scenario**



▲ **In the All-In Scenario, benefits in 2030 from reductions in air pollution from coal and gas plants alone result in 5,700 avoided premature deaths (in addition to 7,000 deaths avoided from previous coal plant retirements), 70,000 fewer asthma episodes, and 290,000 avoided lost work days, all valued at an estimated $26 to $58 billion.[318]**

addressed by regulations. The Clean Air Act regulates air emissions from combustion of coal, oil and gas in power plants, vehicles, and industrial boilers. But many places still regularly experience exposures to air and water pollution in excess of levels set by EPA to be protective of human health, especially low-income communities located close to power plants, highways, industrial facilities, and landfills. As recently as 2017, air pollution accounted for over 109,00 premature deaths in the United States, and more than 40 percent of the U.S. population was living in counties reporting unhealthy levels of either ozone or particle pollution.[239,240] And even with fewer coal plants operating overall, sulfur emissions are actually increasing at some of the largest, most polluting coal plants. For example, at the Martin Lake plant in East Texas, SO_2 emissions increased by 54 percent between 2017 and 2018.[241] And although EPA issued a rule in 2015 that requires managing of coal ash waste under the Resource Conservation and Recovery Act, older and closed landfills and ponds storing coal ash are grandfathered from this rule.

In 2017, an estimated 85,000 premature deaths resulted from exposure to fine particle pollution (known as $PM_{2.5}$) in the United States.[242] While coal-fired power plants are now responsible for only a portion of fine particle pollution in the U.S. each year (e.g., roughly 11 percent in 2011) retirement of coal generation creates an immediate improvement to ambient air quality.[243] Since 2010, the Sierra Club's Beyond Coal campaign has contributed to the shut-down of 270 coal plants, driving major reductions in particle pollution and avoiding over 7,000 premature deaths and over 80,000 asthma cases.[244] The rapid retirement of nearly all remaining coal plants (and avoiding some gas generation) under the All-In scenario would significantly compound these benefits, by nearly eliminating coal's contribution to remaining particle pollution by 2030. These benefits would begin immediately, with each successive plant closure, and continue out to 2030. As shown in Figure 4-2 above, we estimate that retiring the 258 remaining coal plants operational in 2018 and decreasing gas generation in line with our All-In scenario would avoid an *additional* 5,700 premature deaths annually; 70,000 fewer asthma episodes; 3,000 avoided cardiovascular- and respiratory-related hospital admissions and emergency room visits; 3,000 fewer non-fatal heart attacks; and 290,000 avoided lost work days, at an estimated economic value ranging from $26 to $58 billion in 2030.[245]

With this trend of coal plant retirements that began in the last decade, emissions from transportation have now become the largest single source of fine particulates in the United States.[246] And premature deaths in the U.S. from exposure to ozone have been steadily increasing in the last decade.[247] Therefore, the estimates above, which focus on impacts from fossil-fueled electricity, are only a fraction of total benefits to health expected from with full implementation of the All-In scenario. Even greater benefits to air quality and human health will likely result from vehicle and building electrification, particularly in the period from 2030 to 2050. Moreover, a shift to more sustainable agricultural practices under the All-In will further reduce dust, application and storage of manure, and fertilizer use, all of which also contribute significantly to ground-level particle pollution. The upshot is that the *total elimination of much of the very large negative health consequences of fossil fuel combustion is feasible* by extending the All-In scenario strategies in 2030 to complete decarbonization in 2050.

A rapid transition away from coal power generation would also reduce risks to water quality and local ecosystems in communities located near coal ash waste ponds, one of the largest sources of industrial pollution in the United States.[248] In 2012, 470 coal-fired electric utilities generated about 110 million tons of coal ash.[249] Dozens of spills at coal ash ponds have been recorded since the 1950s; the largest of these occurred in 2008 at the Kingston Fossil Plant in eastern Tennessee, resulting in 4.1 million cubic meters of coal ash flowing into Watts Bar Reservoir, and remediation costs over $1 billion.[250] Based on groundwater monitoring data from 265 coal plants, 91 percent of these are currently contaminating groundwater with toxic substances at levels exceeding federal safe standards.[251] Over 730 coal ash sites remain today. Closing remaining coal-fired power plants will eliminate new deposits of coal ash to these sites, thereby decreasing the potential for groundwater and ecosystem contamination. But existing coal ash ponds still pose risks for additional spills, so further remediation of these sites could be a priority for the transition.

Case Study: A Carbon Neutral America Is a Healthy America

The connection between climate change and public health is clear. Burning fossil fuels contributes to air pollution and incidences of respiratory disease such as asthma nationwide. Climate change is also resulting in more frequent and extreme weather events, including heat waves—which are responsible for more U.S. deaths each year than hurricanes, lightning, tornadoes, floods, and earthquakes combined.[252] Rising temperatures also make new populations susceptible to vector-borne diseases carried by insects such as Dengue fever, West Nile Virus, Lyme disease, and malaria.[253]

As the sector with a healing mission and a commitment to "first, do no harm," the U.S. health care sector is recognizing its responsibility to protect patients, employees, and communities from the health impacts of climate change. Representing 18 percent of U.S. GDP, the health care sector can use its purchasing power to drive the transition to clean energy and a low-carbon supply chain. Hospitals are also often one of the largest local employers, making them valued anchor institutions and essential partners for advancing pollution reduction and climate resilience strategies in the communities they serve. Health care can also influence policy decisions at the federal, state, and city levels; work with health agencies and departments; and tap into national and international health organizations and networks to advance climate solutions.

Health Care Without Harm (HCWH), which joined We Are Still In in August 2018, works to foster climate-smart health care

in hospitals and reframe the climate solutions discussion by broadening the conversation to include a powerful public health dimension. HCWH's U.S. Climate and Health program aims to inspire the health care sector to take action, define goals and strategies, provide the tools and resources for implementation, design metrics to track progress, and build a community of practice and public momentum. Among its many programs, the Health Care Climate Challenge[254] is a HCWH campaign pushing hospitals to adopt ambitious GHG reduction goals. To date, the 450 hospitals participating in this challenge have made commitments to reduce 3.6 million metric tons of CO_2e, the equivalent of avoiding nearly 9 billion miles driven. Another HCWH initiative is the Health Care Climate Council,[255] a leadership body of 19 health systems in 32 states, serving 70 million patients per year with $200 billion in annual operating revenue. Collectively, these leaders are generating or purchasing over 2 million MWh of renewable energy annually, equivalent to the electricity needed to power 250,000 homes for a year.

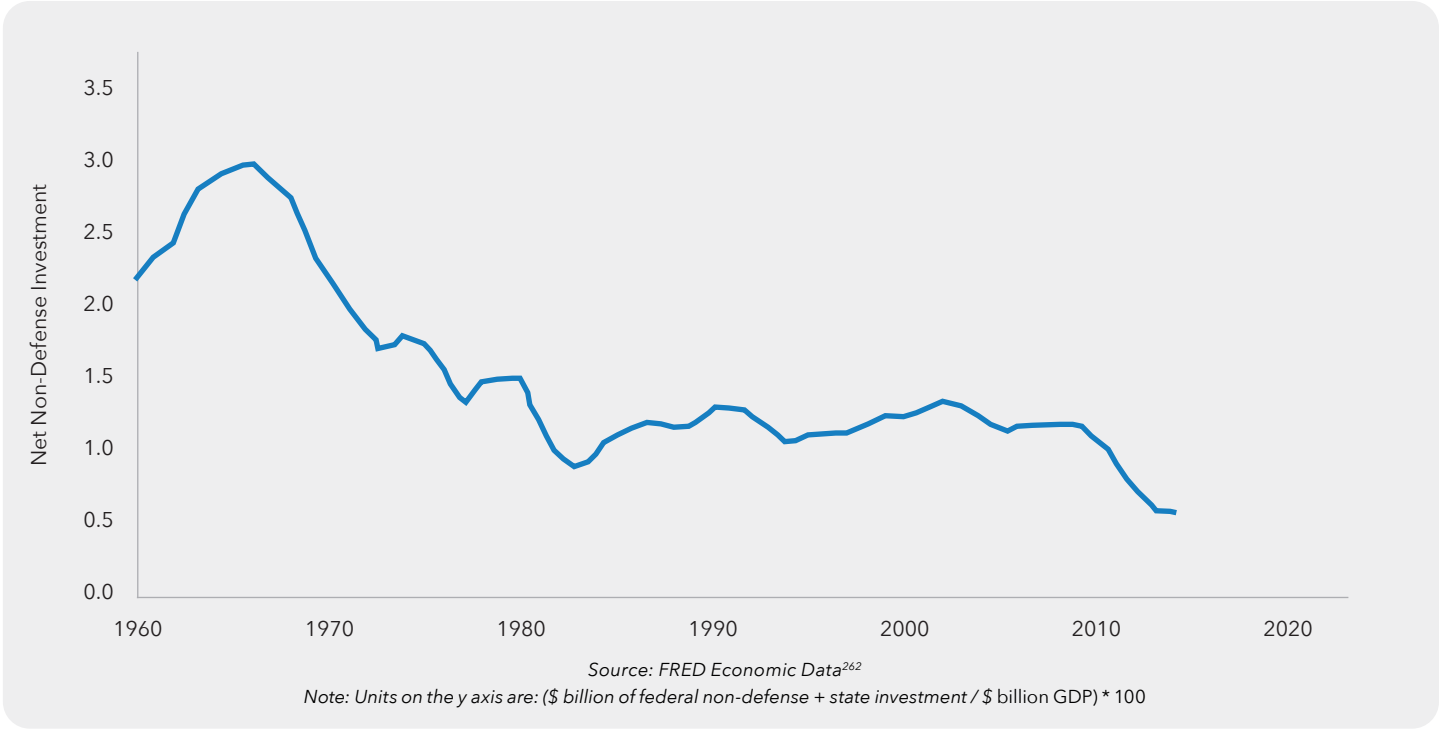
Investments and Innovative Finance

The clean energy revolution will require significant new public finance to help realize further gains in energy affordability. The level of public investment needed to achieve the All-In scenario will be large, but also consistent with other times in U.S. history when we set a major priority around a national policy goal, such as the New Deal and the Interstate Highway system. We will need to reverse the trend in declining government investment in fixed assets like infrastructure (Figure 4-3).

There is ample positive precedent for broader federal investment. For example, the New Deal's Rural Electrification Administration stepped in to fill the credit void that prevented rural families from achieving electrification, providing guaranteed low interest loans to rural co-ops. As late as 1935, 90 percent of rural homes had no electricity; by 1950, 90 percent had electricity, and modest net profit was returned to the U.S. Treasury.[256] The Roosevelt Institute argues that with current unused capacity in the economy and low interest rates, public and private investment in decarbonizing the U.S. economy of $1 trillion per year over the next decade would be worthwhile.[257]

More investments will be needed in low-carbon infrastructure, such as high-voltage transmission lines, EV charging stations, energy storage, and smart grid technologies. New investments in grid modernization can help reduce the costs of grid integration for variable renewables. NREL estimates that the costs of EV charging infrastructure range from $1,857 per light-duty plug-in hybrid vehicle (PHEV) to $25,308 per heavy-duty BEV.[258] Under our All-In scenario, we estimate that there will be approximately 10 million new EV sales in 2030; for these light duty vehicles alone, the costs of charging infrastructure would amount to $13.6 billion in 2030. The federal government can also expand research and development spending to help drive down technology costs, for example, with storage and decarbonization in difficult to abate sectors, such as industry. The value of energy R&D is well established: Since the Advanced Research Projects Agency–Energy (ARPA-E) was funded in 2009, it has provided $1.8 billion in R&D funding to over 660 projects, resulting in 240 new patents, 71 new companies, and billions of dollars in private investment.[259] New federal public spending could stimulate private production, jobs, and wages by boosting demand and encouraging private investment.[260] Yet, between 1978 and 2018, spending by the U.S. Energy Department on research in renewable energy totaled just $28 billion in constant 2016 dollars—less than what Americans spent on pet food last year.[261]

Figure 4-3 | **U.S. Non-Defense Investment**



Source: FRED Economic Data[262]

Note: Units on the y axis are: ($ billion of federal non-defense + state investment / $ billion GDP) * 100

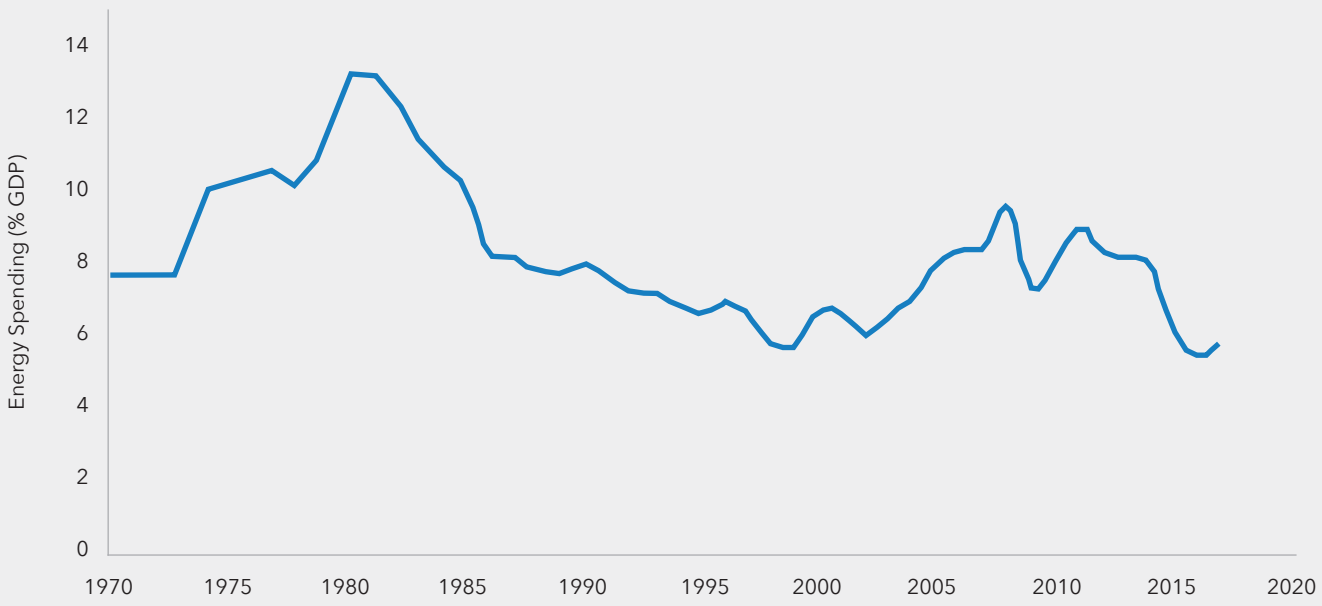
▲ **The decades-long decline in federal non-defense investment will need to be reversed.**

While total energy system costs are not estimated in this study, recent studies of deep decarbonization (generally 80 percent emissions reductions) in the United States out to 2050 have generally found additional up front system investment costs to be fairly modest–typically less than 2 percent of the U.S. GDP (See section 5 of technical appendix). One recent study found that an additional $2.6 trillion will be needed for capital investments from 2017 to 2050 compared to business-as-usual, but that fossil fuel savings over this period ($5.5 trillion) will more than offset those costs.[263] With energy spending as a percentage of GDP in decline, it is likely that total energy spending would be consistent with historical levels. (Figure 4-4). We think the pace of change in the power sector, light-duty transport, and in some buildings can be even faster than depicted, given how the costs of renewable energy have been consistently overestimated in the past.[264] Moreover, estimates of total energy system costs also exclude the large avoided social costs from fossil fuel combustion, such as the health costs that amount to billions of dollars a year described above.[265]

A key element of reorienting investment to realize the potential of the All-In scenario will be to remove fossil fuel subsidies (including those for gas production)–estimated at up to $27 billion a year[266]–that artificially prop up fossil fuels and slow investments in more efficient, low-carbon technologies. Moreover, the federal government could offer loan guarantees for green investments and create a public green investment bank to lend directly to green startups. This could be accompanied by the incorporation of a decarbonization mandate into the Federal Reserve Bank's (Fed's) monetary policy.[267] Public green banks and the federal government can use long-term debt to finance decarbonization, and the Fed could act as a buyer of last resort.

The federal government will need to establish the regulatory framework to redirect private sector investment away from fossil fuels. The Fed could conduct 'stress tests' on commercial banks that look at fossil fuel stranded asset risk, while also allowing lower capital requirement for green investments, such as green bonds.[268] There is a need for the Securities and Exchange Commission to require banks, insurance companies, asset managers, and others to report on climate-related risks, including risks associated with stranded fossil fuel assets, in their financial disclosures, drawing on the recommendations of the Task Force on Climate-related Financial Disclosures.[269]

Figure 4-4 | **Energy Spending in the U.S. as a Percentage of GDP**



Source: US Energy Information Agency[270]

▲ **U.S. energy spending is near historic lows. The additional energy system costs associated with the low-carbon transition would likely be comparable to historical averages.**

The Costs of Waiting

The costs of climate change are expected to progressively increase with mean global temperature change.[271] In the United States, Hsiang et al. (2017) have estimated that each increase of 1°C would lead to a mean reduction of about 1.2 percent of GDP due to impacts on agricultural production, coastal storms, crime, mortality, labor, and energy demand.[272] But mitigation can reduce these costs. The U.S. National Climate Assessment has estimated that in a high-emissions scenario (Representative Concentration Pathway 8.5) climate change would cost the U.S. more than about $510 billion dollars annually in 2090 (2015 dollars), but reduced warming (Representative Concentration Pathway 4.5) would reduce the annual damages to about $280 billion in 2090. The largest avoided damages include reductions in extreme temperature mortality ($140 billion), lost labor hours ($160 billion), and coastal property loss ($120 billion).[273,274] Costs of adaptation measures would generally be a fraction of the avoided damages. For example, the incremental costs of making infrastructure resilient to climate change have been estimated to be around 3 percent of the total infrastructure costs.[275] And there are significant co-benefits to climate change adaptation: A recent global study estimated that investing $1 in adaptation in five key areas could yield between $2 and $10 in benefits.[276]

Recent experience with the costs of a disrupted climate strongly suggest that these historical estimates are far too low. For example, estimates of the level of investment needed to make California's electric grid safe to operate during the newly intensified and extended fire season range up to $150 billion, and the cost of temporary shutdowns during the decade that work would take appear to be running about $5 billion a year for one power utility in one state.[277]

In the agriculture and natural land sector, spending could be redirected towards more sustainable land management. The federal government spends more than $20 billion a year on subsidies for farm businesses, with the lion's share going to the largest producers of corn, soybeans, wheat, cotton, and rice.[278] The money currently spent on subsidies and price supports should be redeployed to incentivize more climate-friendly practices. The conservation title of the Farm Bill[279] could be expanded, allowing for higher payments for cover cropping and more land under easement and enrolled in the Conservation Reserve Program. Lastly, crop insurance could be reformed by awarding farmers with lower rates and expanded coverage if they shift to more sustainable management practices.[280]

We will need to ensure a worker-centric, fair transition for all fossil fuel industry workers and impacted local communities.

Even when low-carbon technologies result in lower lifetime costs, upfront costs can be a barrier that require new public finance and innovative programs. Federal tax credits can expand to emerging technologies. States and local municipalities can also adopt complementary fiscal policies similar to support for renewables, particularly for consumers. Twenty-one states offer about 60 financial programs for residential renewables, such as loans, rebates, and tax incentives.[281] California, Massachusetts, and New York have introduced new incentives for solar PV-plus-storage projects.[282] These renewable energy finance programs could be expanded in scope to include vehicle and building technologies and be brought to new states. Green banks, which blend limited public capital with private investment, can be important drivers for scaling up low-carbon technologies by providing a range of financing options, loans, credit enhancement, bonds, and securitization. There are now 14 green banks at the state and local level, providing $676 million in financing in 2018.[283]

Cities can offer personal property tax exemptions for investments in various renewable energy technologies, as has been done for solar thermal and solar PV in Washington, D.C.[284] City governments can use renewable energy certificates (RECs) to purchase electricity more cheaply in bulk. New business models, such as solar leasing and energy service companies (ESCOs), can help make renewable electricity more affordable to consumers. Peer-to-peer energy trading platforms can allow consumers with distributed energy generation to be prosumers and make higher returns than selling excess energy to the grid.[285]

Extending and enlarging federal tax credits for EVs and heat pumps would help address the upfront costs of electrification. The Milken Institute has identified a number of innovative financing mechanisms for EVs, including the use of multibank community development corporations to extend credit to small-businesses, real estate development, and affordable housing construction; interest rate buy-downs; and the use of dealer commissions by utilities to incentivize EV sales.[286] The charging infrastructure could be financed by municipal green bonds, small business microloans, and pooled procurement funds that save costs through bulk purchases.[287]

A number of policy responses can help building electrification, including rebate programs for heat pumps, as is being done in Boulder, Colorado[288] and the bundling of electrification with demand for flexibility customer programs.[289] One notable financing mechanism is Property-Assessed Clean Energy (PACE) financing, which allows property owners to borrow money to pay for renewable energy and/or energy-efficiency improvements, including electrification, where the borrowed money is repaid via a special assessment over a period of years. PACE financing has grown exponentially nationwide from about $208 million in 2015 to $868 in 2018.[290]

A Fair Transition for Fossil Fuel Workers and Communities

The Challenge

As we plan for a transition to a zero-carbon economy, we will need to ensure a worker-centric, fair transition for all fossil fuel industry workers and impacted local communities. Rapidly phasing out remaining coal generation and reducing reliance on gas and oil by 2030, as envisioned in the All-In scenario, will mean economic hardship for many workers and communities dependent on fossil-based industries whose economies are less diversified. When any large mine, factory, or plant closes, effects ripple throughout the economy, as local government budgets shrink, provision of essential public services becomes more difficult, reduced spending forces the closure of local small businesses, and the housing market loses value. Job and income loss can increase levels of stress, leading to drug and alcohol addiction, domestic violence, and divorce.

We are already seeing these kinds of impacts today, but for reasons that are often independent of the energy transition. A range of automated technologies have taken the place of humans in the coal mining industry—the key reason that employment in the

coal industry has fallen over several decades even as production grew. One of the early harbingers of automation in coal mining was the shift from labor-intensive underground coal mines in Appalachia to the more automated open surface mines of the West.

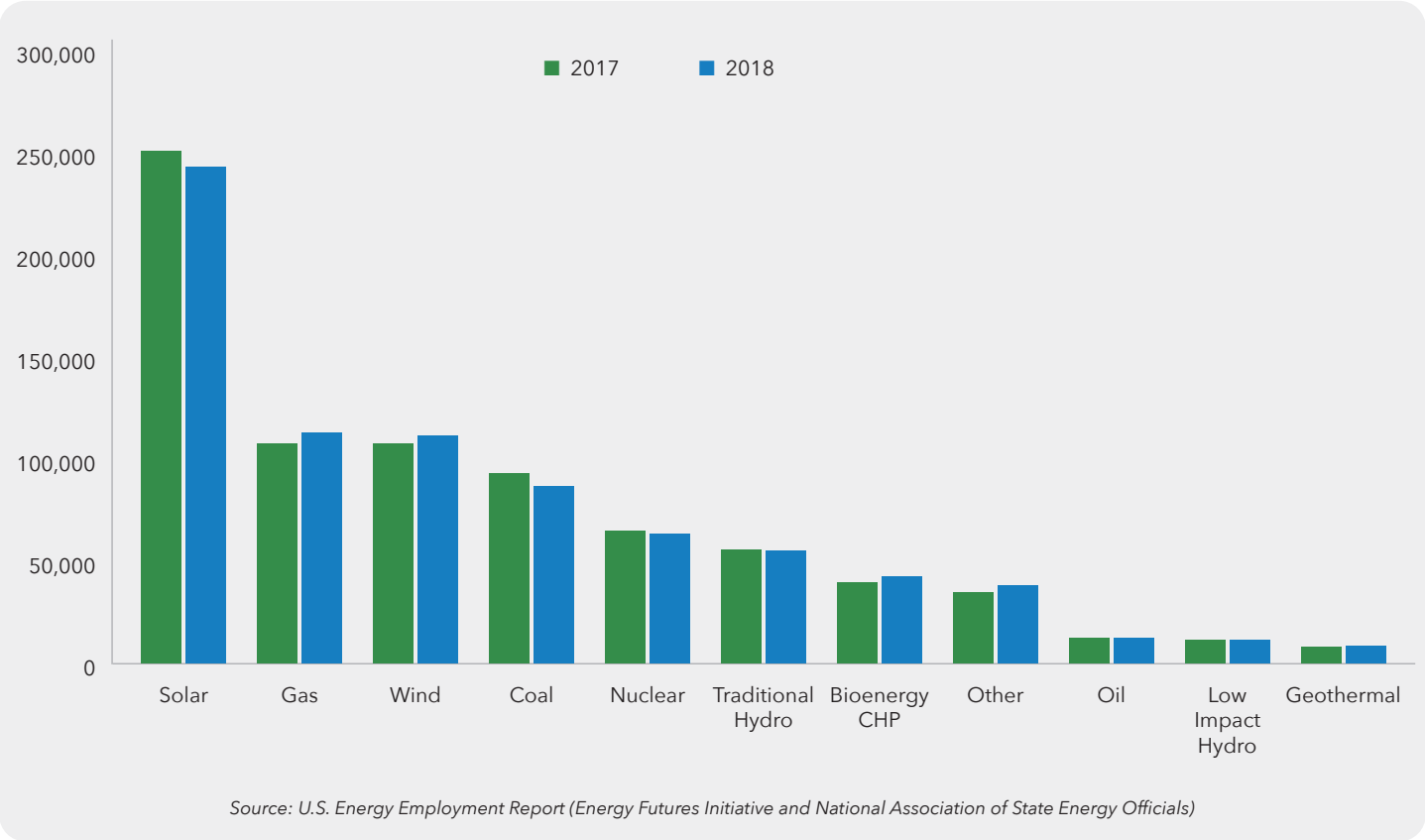
As globally traded commodities, oil, gas, and coal regularly go through boom-bust cycles characterized by periods of high prices, economic gain, and increased industrial activity followed by periods of low prices, economic slowdown, and decreased industrial activity. But each region also goes through a decline as its reserves are depleted. For example, the once robust oil fields of Los Angeles County are now a shadow of their former production. The current downturn being experienced in many shale gas and coal communities due to oversupply and low prices is different—it is driven by increased production of gas and lower demand for coal, not depleted supply—and is hitting supply chains as well as local economies and families.

The low-carbon transition is only one of many trends poised to impact fossil fuel industries and the entire U.S. economy going forward. Technological changes, artificial intelligence, increasing automation, and changing customer preferences are just a few mega-trends driving transitions to new industries, technologies, and practices. In addition to expected improvements in fuel efficiency and growth in U.S. EV sales under the All-In scenario, which could lead to 18 percent decline in liquid fuel consumption compared to business as usual, other factors including changing car ownership patterns and autonomous vehicles will also impact demand for oil.[291] The U.S. coal industry is also being buffeted by a wide array of forces beyond competition from renewable energy sources—increasing automation, productivity gains (i.e., workers can produce more coal per hour), global competition, and environmental requirements.

The Opportunity

As forward-thinking states and communities are demonstrating, however, proactive planning which acknowledges the low-carbon transition is happening can lessen or even negate impacts on employment and economic activity. Planning ahead can also position regional economies for more sustainable growth, through

Figure 4-5 | **Employment in Electric Power Generation**



Source: U.S. Energy Employment Report (Energy Futures Initiative and National Association of State Energy Officials)

▲ **In electric power generation, both solar and wind support more jobs than coal.**

diversifying economic activity in ways that avoid volatile cycles associated with fossil fuel prices but also other myriad challenges of competing in a dynamic, globalized economy.

Proactive planning and collaboration across government, industry, and unions will be critical to finding solutions for fossil fuel workers who have been the backbone of the nation's energy system for so long. Working with affected communities to collaboratively develop a clear plan so that fossil fuel workers and communities are not left behind in the transition will be essential to building political buy-in and durability for an All-In scenario. Solutions will need to be tailored to each community, rather than "one-size-fits-all." Together with workers and communities in transition, policymakers have to address three fundamental questions: How to transform former fossil fuel sites, how to support communities and workers negatively impacted by plant and mine closures, and, over the long-term, and how to restructure and diversify local economies so that the loss of a single plant or decline in one industry is not fatal.

Former fossil fuel sites such as closed coal mines often boast access to existing infrastructure assets like rivers, highways, railroads, and utilities, making them prime areas for redevelopment. Several states are responding with smart policy to address this opportunity. Pennsylvania has rolled out an initiative to repurpose its former coal plants, including as medical marijuana farms, warehouses and data centers.[292] Using contaminated mined land for renewable electricity generation can transform these liabilities into revenue generating assets, and is a trend catching on in many states.[293] Federal funds are converting a coal mine in southwestern Virginia into a solar farm to power nearby data centers serving government and commercial clients.[294] Washington State's largest coal mine, which closed in 2006, and an adjacent coal plant slated to close by 2025 are being converted into one of the state's largest solar projects.[295] In Massachusetts, a former coal-fired power plant site is being transformed into a world-class logistics port, manufacturing hub, and support center for the offshore wind energy sector.[296] Finally, in Illinois, legislation has been introduced to convert uneconomic coal plants into solar-plus-storage facilities.[297]

Assistance targeted to support workers in the transition can include income support, pensions, health insurance, and access to educational and training opportunities to develop, upgrade, or expand into new skill areas geared toward tomorrow's growth and emerging industries. The transition presents an opportunity to build a more equitable and cohesive American workforce than our current, highly unequal one. Clean energy industries can in some cases employ displaced coal and other fossil fuel workers. As previously discussed, the clean energy industry has become a major U.S. employer, creating employment opportunities for blue-collar workers in some of the country's most fossil fuel-heavy states. The solar (242,343 people) and wind (111,166) industries employ about four times as many people in the generation side of electricity as coal (86,202), for instance.[298] Adding in coal mining jobs (74,831), solar and wind still have twice as many people working in them.[299] In short, between employing twice as many people in industries that are growing vs. an industry that is shrinking simply because the markets have shifted, solar and wind jobs provide a clear opportunity.

Retraining programs are not an ironclad guarantee of new employment in clean energy for fossil workers. One challenge for coal miners that want to switch industries is that the location and number of renewable jobs will not be one for one with coal miners available in states such as Kentucky and West Virginia. Furthermore, the right apprenticeship and training programs have to be available. Some state governments, non-profits, and even the private sector have tailored retraining specifically for unemployed coal workers. In Illinois, the government supports training designed to increase growth in renewable industries. The Future Energy Jobs Act (FEJA) authorized a total of $30 million to develop and establish clean energy-related job training programs over 12 years through the Workforce Development Implementation Plan.[300] However, the effectiveness and success of programs to attract and retain displaced workers is still mixed, and older workers in particular are less likely to be successfully retrained and reemployed.[301]

A few promising solutions being implemented in different regions, however, raise optimism. Colorado created a Just Transition Office—the first-of-its-kind office—charged with creating an equitable plan for coal-dependent communities and workers and armed with a dedicated staff and an advisory committee of diverse stakeholders.[302] The creation of the Just Transition Office represents an explicit recognition by the state that the transition to a low-carbon economy will entail adverse impact on some workers and communities. Minnesota's recently-introduced bill laying out a plan for achieving 100 percent carbon-free energy includes a number of equity considerations, such as directing the Public Utility Commission to create high-quality jobs with wages that support families and ensuring that workers have the necessary tools, opportunities, and economic assistance to adapt successfully during the energy transition, particularly communities that host retiring power plants and contain historically marginalized and underrepresented populations.[303]

Providing funds for transition assistance for workers will also require innovative finance. Some states including

Colorado, Montana, and New Mexico are using securitization—giving coal-owning utilities the option to issue bonds secured by the certainty of customers paying their bills—as a tool to pay off stranded coal assets and provide transition funds to affected communities.[304] New Mexico's "Energy Transition Act" enables the state's utilities to use securitization to refinance investments in coal-fired power plants that retire operations early. A portion of the revenues from the bond sale will go towards economic development in coal communities and assist displaced workers after the closure of facilities such as the coal-fired San Juan Generating Station, planned for 2022, and the enormous Four Corners Power Plant, planned for 2032. Starting in 2026, the legislation also requires that 25 percent of workers employed during the construction of new electricity generation facilities come from to-be-established apprenticeship programs.[305]

Similarly, finance will need to be made available at the municipal level when plants close. In New York, $45 million in "gap funding" was made available to help replace property tax revenues a closed power plant would have generated.[306] In Tonawanda, New York, NRG—the operator of the town's coal-fired Huntley Power Plant—began to reduce production and tax payments to the town as falling cost of gas made the coal plant economically uncompetitive. Between 2008 and 2012, the town lost $6.2 million in tax revenues. A diverse coalition, including the Kenmore Teachers Association, the Western New York Area Labor Federation, the United Steelworkers of America, Tonawanda, the IBEW Local 41, and the Clean Air Coalition of Western New York, came together to develop a vision for the town's future.[307] The resulting plan, "Growing the Town's Economic Future," was released in 2017 and received financial support from the state legislature to implement the strategies outlined in the report.[308]

An Equitable Transition For All

The Challenge

Existing inequalities in the energy system should not be compounded in the low-carbon economy. A fair transition for fossil fuel workers and communities must be in addition to transition programs targeted at under-resourced, marginalized communities that are hit first and worst by climate change impacts. Transition programs should also target communities that have experienced environmental racism that left them with the negative environmental consequences of fossil fuel use without its benefits. Not all fossil fuel communities have been enriched and many face a legacy of toxic environments and deep poverty. These overlapping transition challenges can be met through smart, expansive programs that both address the challenges specific to the cessation of fossil fuels and mitigate the historic burden on marginalized communities from fossil fuel use or other reasons.

The evidence is overwhelming. Climate change will impact everyone, but the negative impacts will not be shared equally. Low-income communities in both urban and rural areas will be disproportionately impacted by climate change relative to other communities.[309] We are already seeing this play out in the aftermath of devastating hurricanes affecting Texas, Puerto Rico, the Carolinas as well as the wildfires in California. Low-income communities already have higher rates of many adverse health conditions, are more exposed to environmental hazards, and take longer to bounce back from natural disasters. For instance, low-income, households of color, and renting households, particularly in rural areas, are energy cost-burdened.[310] Many live in homes without air conditioning and sufficient insulation to keep cool, increasing the risk of heat stress illnesses. Likewise, facilities emitting dangerous particulate air pollution like soot disproportionately impact low-income communities and communities of color, causing devastating impact on human health including severe asthma attacks, heart attacks, and premature death.[311] These impacts compound socio-economic disadvantages borne of decades of inequitable economic development, public disinvestment, and gentrification, among other things.

Furthermore, access and deployment of low-carbon technologies and their cost-savings, employment opportunities, and other benefits must accrue to everyone including low-income households. Less than half of U.S. community solar projects have any participation from low-income households—who stand to benefit the most from access to renewable energy and lower utility bills.[312] Of projects that do include lower-earning families, only about 5 percent involve a sizable share, or more than 10 percent. To date, public support of low-carbon technologies and products are not equally benefiting low-income households. EV tax credits, for example, have been claimed primarily by high-income households.[313] The U.S. EIA, citing data from the 2017 National Household Travel Survey, reported that two-thirds of households that buy EVs have annual income in excess of $100,000, nearly twice the nationwide average.[314] There are also disparities in rooftop photovoltaics deployment in the country with Black- and Hispanic-majority census tracts showing significantly less rooftop PV installed.[315]

The Opportunity

The climate crisis presents an opportunity to address another major crisis in our society: rising inequality. To the extent decarbonization and equity goals can be aligned in terms of public policy and political strategy, not only can we break the long history of environmental racism at the center of climate change impacts today but also create a more inclusive and prosperous economy for all.

The low-carbon transition is a collective good and has to be driven by significant public investment. To seize the opportunities afforded us by the investments needed to reduce carbon emissions and protect against climate risks, policymakers at every level of government will need to pay attention to where the money is invested and who benefits. The policy approaches may vary from state to state and region to region. However, they should all explore how policies and programs can target resources to ensure that marginalized and low-income communities will see a fair share of the economic benefits of the low-carbon transition. It will be equally important that policies are developed from the bottom up, informed by the impacted communities. Local knowledge, community leadership, political transparency, and governmental accountability will be key for an equitable transition to a low-carbon economy.

In response, there have been federal, state, and local efforts to close the equity and access gap. The Renew300 Initiative aims to install 300MW of solar PV (enough to power 50,000 homes) on federally assisted housing in programs such as the U.S. Department of Housing and Urban Development's rental housing portfolio, U.S. Department of Agriculture's Office of Rural Development Multi-Family Programs, and rental housing supported by the Low-Income Housing Tax Credit. Several states have developed policies to further include low-income individuals and provide households with more access to low-carbon technologies. Many states have integrated rooftop solar into their low-income weatherization assistance programs. In California, low-income eligible applicants can receive an additional compensation of $2,500 under the state's Clean Cars 4 All Program towards low-carbon vehicles.[316] And San Diego Gas & Electric is placing at least 10 percent of new charging stations in low-income areas.[317] Oregon and other states have established a used EV tax credit to help make EVs more accessible to low-income residents. These are good initial steps, but much more work will be needed to link climate action with equity and inclusion. Considerable effort is required to ensure that equitable climate policy is viewed as an essential element rather than an afterthought.

There is no universal blueprint for implementing a fair transition to a low-carbon economy, but acknowledging and planning for a transition far in advance is the best way to address it. The process for a comprehensive transition strategy that includes social, fiscal, and economic redevelopment may take a decade, or even longer. A fair transition under the All-In scenario is possible provided that local, state, and federal leaders start immediately, and collaborate on solutions. The more policymakers can work together with local communities and workers dependent on the fossil fuel industry and low-income communities, the better positioned the country will be to equitably share the benefits of a low-carbon economy.

Conclusion

A remarkable story of bottom-up, transformative climate leadership is playing out today across America. This story contains in it the seeds of how we can succeed in growing our economy while emerging as the global leader to solve the global crisis of climate change. States, cities, businesses, and others have doubled down on their commitments and are driving forward new, robust policies to reach ambitious climate goals. These policies lay the groundwork on which expanded national policies can be built. A transformed climate politics—built on bottom-up initiatives, grounded in the local needs and opportunities across our diverse nation—will benefit not only our people, our economy, and our country, but also contribute to a global strategy to address climate change.

This report analyzes potential outcomes from these diverse and broad-based climate politics. New market dynamics, technological innovation, and political momentum can support a broad, inclusive, and comprehensive American climate strategy. Bottom-up leadership today provides a solid foundation for accelerating "All-In" national re-engagement after 2020. Current measures by states, cities, and businesses are already making a significant difference—potentially enough to reduce emissions 25 percent below 2005 levels by 2030. Going further, bottom-up climate action can deliver reductions of up to 37 percent. With transformed national politics and an all-in effort, we can reduce emissions up to 49 percent. Such reductions would put us on a pathway toward mid-century net-zero emissions.

If America takes the bold steps presented in this report, it will look very different in 2030 and beyond compared to today, yet will hold true to its core strengths. America will be an economic powerhouse, and it will be leading in industries like renewable energy, the smart grid, and zero emissions vehicles. It will remain the breadbasket of the world, and the farms will use climate-smart practices to get the most out of the land while not depleting it of carbon and nutrients. Americans will commute to work by walking, public transit, telecommuting, or with an electric car. They will heat and cool their homes comfortably, and they will do so with electric heat pumps and HFC-free air conditioners. Children can enjoy the outdoors in every city and town, and parents will not have to worry about the air that they are breathing or the climate that they are inheriting.

This vision is possible. But reaching transformational goals will require transformational thinking. Comprehensive approaches will require continued acceleration of efforts from the ground up, including citizen engagement to drive change across all 50 states across the nation. Action must be built around a suite of ambitious city, state, and business policies, but also needs a massive boost from full U.S. federal engagement by the Executive and Legislative branches. The current trends are promising, but much work lies ahead to deliver an aggressive level of action every year for the next one, two, five, and ten years. Transforming our politics to achieve such audacious goals is our task—and with the vision and boldness of our country's rapidly expanding ranks of leaders and citizen actors, it is within our reach.

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Endnotes

1 U.S. Department of Transportation Federal Highway Administration, "State Motor Vehicle Registrations, by Years (1900 - 1995)," accessed on October 24, 2019, https://www.fhwa.dot.gov/ohim/summary95/mv200.pdf

U.S. Census Bureau, "United States Census 2000", accessed October 24, 2019, https://www.census.gov/census2000/states/us.html

2 Institute of Medicine, "Secondhand Smoke Exposure and Cardiovascular Effects: Making Sense of the Evidence," 2010, Washington, DC: The National Academies Press, https://doi.org/10.17226/12649

3 Exec. Order 13058, 41 C.F.R. 1997, "Protecting Federal Employees and the Public from Exposure to Tobacco Smoke in the Federal Workplace," https://www.govinfo.gov/content/pkg/WCPD-1997-08-18/pdf/WCPD-1997-08-18-Pg1224.pdf; https://www.opm.gov/faqs/QA.aspx?fid=4313c618-a96e-4c8e-b078-1f76912a10d9&pid=42213bba-ce69-44fb-868b-36ef656894ce

4 Georgetown University Law Library, "A Brief History of Civil Rights in the United States," 2019, https://guides.ll.georgetown.edu/civilrights

5 Alliance to Save Energy, "The History of Energy Efficiency," 2013, https://www.ase.org/sites/ase.org/files/resources/Media%20browser/ee_commission_history_report_2-1-13.pdf

6 Kennedy, Kevin, "Putting a Price on Carbon: Evaluating a carbon price and complementary policies for a 1.5°C world," World Resources Institute, September 2019, https://www.wri.org/publication/evaluating-carbon-price

7 U.S. Energy Information Administration, "U.S. Energy-Related Carbon Dioxide Emissions," 2018, https://www.eia.gov/environment/emissions/carbon/pdf/2017_co2analysis.pdf

8 U.S. Executive Branch, "United States Mid-Century Strategy For Deep Decarbonization," 2016, https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf

9 Charles Teplin, Mark Dyson, Alex Engel, and Grant Glazer, "The Growing Market for Clean Energy Portfolios: Economic Opportunities for a Shift from New Gas-Fired Generation to Clean Energy Across the United States Electricity Industry," Rocky Mountain Institute, 2019, https://rmi.org/cep-reports

10 Wesley Cole, Will Frazier, Paul Donohoo-Vallett, Trieu Mai, and Paritosh Das, "2018 Standard Scenarios Report: A U.S. Electricity Sector Outlook," NREL, 2018, https://www.nrel.gov/docs/fy19osti/71913.pdf

11 Eric Gimon, Mike O'Boyle, Christopher Clack, and Sarah McKee, "The Coal Cost Crossover: Economic Viability Of Existing Coal Compared To New Local Wind And Solar Resources," Energy Innovation and Vibrant Clean Energy, March 2019, https://energyinnovation.org/publication/the-coal-cost-crossover/

12 Charles Teplin, Mark Dyson, Alex Engel, and Grant Glazer, "The Growing Market for Clean Energy Portfolios: Economic Opportunities for a Shift from New Gas-Fired Generation to Clean Energy Across the United States Electricity Industry," Rocky Mountain Institute, 2019, https://rmi.org/cep-reports

13 Charles Teplin, Mark Dyson, Alex Engel, and Grant Glazer, "The Growing Market for Clean Energy Portfolios: Economic Opportunities for a Shift from New Gas-Fired Generation to Clean Energy Across the United States Electricity Industry," Rocky Mountain Institute, 2019, https://rmi.org/cep-reports

14 Dyson, M., Engel, A. and Farbes, J., "The Economics of Clean Energy Portfolios," Rocky Mountain Institute, 2018, https://rmi.org/insight/the-economics-of-clean-energy-portfolios/

15 Aburn, George and Hough, Merlyn, "Implementing EPA's Clean Power Plan: A Menu of Options," Chapter 10: "Reduce Losses in the Transmission and Distribution System," National Association of Clean Air Agencies, 2015, http://www.4cleanair.org/sites/default/files/Documents/Chapter_10.pdf

16 Daniel Steinberg, Dave Bielen, Josh Eichman, Kelly Eurek, Jeff Logan, Trieu Mai, Colin McMillan, Andrew Parker, Laura Vimmerstedt, and Eric Wilson, "Electrification & Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization," NREL, 2017, https://www.nrel.gov/docs/fy17osti/68214.pdf

17 EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," 2019, https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-main-text.pdf

18 Alvarez et al.,"Assessment of methane emissions from the U.S. oil and gas supply chain," 2018, https://science.sciencemag.org/content/361/6398/186

19 The World Bank, Global Gas Flaring Reduction Partnership (GGFR), "Gas flaring volumes 2014-18 (billion cubic meters)," 2019, https://www.worldbank.org/en/programs/gasflaringreduction#7

20 International Energy Agency, "Flaring emissions," 2019, https://www.iea.org/tcep/fuelsupply/flaring

21 U.S. Energy Information Administration, "Carbon Dioxide Emissions Coefficients," 2016, https://www.eia.gov/environment/emissions/co2_vol_mass.php

22 Alexander Turner, Christian Frankeberg, and Eric Kort, "Interpreting contemporary trends in atmospheric methane," Proceedings of the National Academy of Sciences, February 2019, https://www.pnas.org/content/116/8/2805

23 Robert Howarth, "Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?" Biogeosciences, August 4, 2019, https://www.biogeosciences.net/16/3033/2019/

24 Alexander Turner, Christian Frankeberg, and Eric Kort, "Interpreting contemporary trends in atmospheric methane," Proceedings of the National Academy of Sciences, February 2019, https://www.pnas.org/content/116/8/2805

25 Ngene, Stanley, et al., "Environmental Implications of Flaring and Venting in Crude and Natural Gas Production," International Journal of Environmental Monitoring and Analysis, Vol 4, Issue 6, December 2016, pp. 154-159, http://article.sciencepublishinggroup.com/html/10.11648.j.ijema.20160406.13.html#paper-content-4-2

26 Kohler, Judith, "Colorado has new, stronger oil and gas regulations. Now what?" The Denver Post, April 24, 2019, https://www.denverpost.com/2019/04/24/colorado-regulators-new-rules-oil-gas/

27 Laila Kerney and Jeniffer Hiller, "New Mexico Governor moves to limit methane emissions, combat climate change," Reuters, January 29, 2019, https://www.reuters.com/article/us-new-mexico-regulation-energy/new-mexico-governor-moves-to-limit-methane-emissions-combat-climate-change-idUSKCN1PN35R

28 Miguel Yanez, et al., "Equitable Beneficial Electrification (EBE) for Rural Electric Cooperatives: Electrifying Residential Space and Water Heating," RE-AMP, 2019, https://www.eesi.org/files/REPORT-Equitable-Beneficial-Electrification-for-Rural-Electric-Cooperatives.pdf

29 EPRI, "National Electrification Assessement," http://mydocs.epri.com/docs/PublicMeetingMaterials/ee/000000003002013582.pdf

30 U.S. Energy Information Administration, "One in four U.S. homes is all electric," May 1, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39293

31 U.S. Energy Information Administration, "2012 CBECS Survey Data," https://www.eia.gov/consumption/commercial/data/2012/

32 Sherry Billimoria, Leia Guccione, and Mike Henchen, "The Economics of Electrifying Buildings," Rocky Mountain Institute, 2018, https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf

33 Energy+Environmental Economics, "Residential Building Electrification in California," April 2019, https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

34 NASEO-DOE Webinar, "Action Steps for States: Moving Towards a Future with Demand Flexibility," National Association of State Energy Officials, August 13, 2019, https://naseo.org/event?EventID=6927

35 Michael Sivak and Brandon Schoettle, "Relative Costs of Driving Electric and Gasoline Vehicles in the Individual U.S. States," University of Michigan, https://trid.trb.org/view/1508116

36 Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost; Deloitte, "New

Market. New Entrants. New Challenges.: Battery Electric Vehicles," 2019, https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf

37 Christer Tryggestad, et al., New reality: electric trucks and their implications on energy demand," McKinsey and Company, 2017, https://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/

38 North American Council for Freight Efficiency, "Regional Haul," 2018, https://nacfe.org/regional-haul/

39 Amol Phadke, et al., "Long-haul battery electric trucks are technically feasible and economically compelling," International Energy Analysis Department, Lawrence Berkeley National Laboratory, September 2019, https://eta-publications.lbl.gov/sites/default/files/working_paper_005_battery_electric_trucks_906_0.pdf

40 "Advanced Clean Trucks Workshop," California Air Resources Board, August 21, 2019, https://ww2.arb.ca.gov/sites/default/files/2019-08/190821actpres_0.pdf

41 Neandross, Erik, "Zero Emission Truck Regulations on the California Horizon," FleetOwner, October 1, 2019, https://www.act-news.com/news/zero-emission-truck-regulation-on-the-california-horizon/

42 Brandon Graver, Kevin Zhang, and Dan Rutherford, "CO2 emissions from commercial aviation, 2018," ICCT, 2019, https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf

43 Airport Carbon Accreditation, https://airportco2.org/; https://www.airportcarbonaccreditation.org/

44 S.B. 32, 2006, "California Global Warming Solutions Act of 2006," California 2006, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32

45 Exec. Order B-55-18. 2018, California, "Executive Order B-55-18 To Achieve Carbon Neutrality," https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

46 U.S. Environmental Protection Agency, "Sources of Greenhouse Gas Emissions," 2019, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

47 California Air Resources Board, "California Greenhouse Gas Inventory for 2000-2017 – by Category as Defined in the 2008 Scoping Plan," 2019, https://ww3.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_sum_2000-17.pdf

48 California Air Resources Board, "Overview: Diesel Exhaust and Health," 2019, https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health

49 Union of Concerned Scientists, "Inequitable Exposure to Air Pollution from Vehicles in California," 2019, https://www.ucsusa.org/sites/default/files/attach/2019/02/cv-air-pollution-CA-web.pdf

50 GreenBiz and United Parcel Service, "Curve Ahead: The Future of Commercial Fleet Electrification," 2018, https://sustainability.ups.com/media/UPS_GreenBiz_Whitepaper_v2.pdf

51 Southern California Edison, "Charge Ready Transport Program," 2019, https://www.sce.com/business/electric-cars/charge-ready-transport

52 Pacific Gas and Electric, "EV Fleet Program," 2019, https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page

53 San Diego Gas and Electric, "SDG&E gets greenlight to launch major program to build charging infrastructure for electric buses, trucks and more," 2019, http://www.sdgenews.com/article/sdge-gets-greenlight-launch-major-program-build-charging-infrastructure-electric-buses

54 Robert Walton, "California OKs $100M SDG&E commercial EV charging plan, testing electric buses as grid assets," Utility Dive, 2019, https://www.utilitydive.com/news/california-oks-100m-sdge-commercial-ev-charging-plan-testing-electric-bu/561071/

55 California Public Utility Commission, "Transportation Electrification Activities Pursuant to Senate Bill 350," 2018, https://www.cpuc.ca.gov/sb350te/

56 BP plc, "BP Energy Outlook 2019 edition," 2019, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2019.pdf

57 Daniel Steinberg, et al., "Electrification and Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization," National Renewable Energy Lab, 2017, https://www.nrel.gov/docs/fy17osti/68214.pdf

58 Jeff Deason, et al., "Electrification of buildings and industry in the United States," Lawrence Berkeley National Lab, 2018, http://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

59 Daniel Steinberg, et al., "Electrification and Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization," National Renewable Energy Lab, 2017, https://www.nrel.gov/docs/fy17osti/68214.pdf

60 Jeff Deason, et al., "Electrification of buildings and industry in the United States," Lawrence Berkeley National Lab, 2018, http://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

61 U.S. Energy Information Administration, "Use of energy explained: Energy Use in Industry," 2019, https://www.eia.gov/energyexplained/use-of-energy/industry.php

62 United States Environmental Protection Agency, "Sources of Greenhouse Gas Emissions," 2019, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

63 U.S. Department of Energy, Better Buildings, "Better Plants," 2019, https://betterbuildingssolutioncenter.energy.gov/better-plants

64 U.S. Department of Energy, Better Buildings, "Get Recognized: 50001 Ready for Facilities and End Users," https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/50001%20Ready%20-%20Participant%20Overview_0.pdf; https://betterbuildingssolutioncenter.energy.gov/iso-50001/50001ready/end-users

65 U.S. Department of Energy, Better Buildings, "Recognized Facilities," 2019, https://betterbuildingssolutioncenter.energy.gov/iso-50001/recognized-facilities#sep50001

66 U.S. Department of Energy, Better Buildings, "What is ISO-50001?," 2019, https://betterbuildingssolutioncenter.energy.gov/iso-50001/what-iso-50001

67 U.S. Department of Energy, Better Buildings, "Business Case," 2019, https://betterbuildingssolutioncenter.energy.gov/iso-50001/business-case

68 Charter Steel, "Awards and Recognition," 2019, https://www.chartersteel.com/about/sustainability/energy/awards-and-recognition

69 ArcelorMittal, "U.S. Department of Energy recognizes ArcelorMittal for leading energy management efforts," 2018, https://usa.arcelormittal.com/news-and-media/announcements/2018/aug/08-30-2018

70 Shannon George, "What is a Steel Mini Mill?" Career Trend, 2019, https://careertrend.com/facts-6882469-steel-mini-mill-.html

71 ArcelorMittal Cleveland, DOE Better Plant Summit, "Cooling Tower Automation," 2019, https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Best_of_the_Betters.pdf

72 U.S. Department of Energy, Better Buildings, "ArcelorMittal USA LLC: Cleveland – Re-attest as 50001 Ready Facility," 2019, https://betterbuildingssolutioncenter.energy.gov/iso-50001/showcase-projects/arcelormittal-cleveland-%E2%80%94-50001-ready-facility

73 Erv Evans, "Tree Facts," Trees of Strength, North Carolina State University, https://projects.ncsu.edu/project/treesofstrength/treefact.htm

74 Nature 4 Climate, US State Mapper, https://nature4climate.org/u-s-carbon-mapper/

75 Office of Governor Gina M. Raimondo, "Resilient Rhody: An Actionable Vision for Addressing the Impacts of Climate Change in Rhode Island," Rhode Island Statewide Climate Resilience Action Strategy, 2018, http://climatechange.ri.gov/documents/resilientrhody18.pdf

76 Scott Wolf and Scott Millar, "Rhode Island Should Lead by Example to Prevent Loss of Forest Land," ecoRI News, 2018, https://www.ecori.org/green-opinions/2018/5/18/rhode-island-should-lead-by-example-to-prevent-loss-of-forestland

Endnotes

77 Rhode Island Department of Environmental Management, "Rhode Island Greenhouse Gas Emissions Reduction Plan December 2016," 2016, http://climatechange.ri.gov/documents/ec4-ghg-emissions-reduction-plan-final-draft-2016-12-29-clean.pdf

78 District Department of the Environment, "District of Columbia Urban Tree Canopy Plan," 2013, https://doee.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/Draft_Urban_Tree_Canopy_Plan_Final.pdf

79 World Resources Institute, Cities4Forests, https://www.wri.org/our-work/project/cities4forests

80 Intergovernmental Panel on Climate Change, "Global Warming of 1.5 °C," 2018, https://www.ipcc.ch/sr15/

81 Timothy M. Smith, "Climate Change: Corporate Sustainability in the Supply Chain," Bulletin of the Atomic Scientists, May 2013, Volume 69 Issue 3, 43-52, https://doi.org/10.1177/0096340213487310

82 We Are Still In, 2019, https://www.wearestillin.com/

83 United States Climate Alliance, "About," accessed August 9, 2019, https://www.usclimatealliance.org/governors-1

84 United States Climate Alliance, "2019 Fact Sheet," 2019, https://www.usclimatealliance.org/us-climate-alliance-fact-sheet

85 Climate Mayors, "Members," http://climatemayors.org/about/members/

86 Center for Climate and Energy Solutions C2ES, "Regional Greenhouse Gas Initiative (RGGI)," 2013, https://www.c2es.org/document/regional-greenhouse-gas-initiative-rggi/

87 Marianne Lavelle, "A Major Fossil Fuel State Is Joining RGGI, the Northeast's Carbon Market," InsideClimateNews, Oct. 3, 2019, https://insideclimatenews.org/news/03102019/pennsylvania-rggi-coal-gas-power-plant-emissions-carbon-cap-trade-regulation

88 Alternative Fuels Data Center, "Regional Electric Vehicle (REV) West Plan," https://afdc.energy.gov/laws/11875

89 Building Electrification Initiative, "About," https://www.beicities.org/about

90 Center for Climate and Energy Solutions C2ES, "U.S. State Greenhouse Gas Emissions Targets," https://www.c2es.org/document/greenhouse-gas-emissions-targets/

91 California Air Resources Board, "California Greenhouse Gas Emissions for 2000 to 2017," CARB, Sacramento CA, https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf

92 State of California, "Executive Order B-55-18 to achieve carbon neutrality," https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

93 New York State Assembly, Bill No. S2992B, "New York state climate leadership and community protection act," https://legislation.nysenate.gov/pdf/bills/2019/s2992b

94 Washington State Legislature, "HB 1112-2019-20," 2019, https://app.leg.wa.gov/billsummary?BillNumber=1112&Year=2019&Initiative=false

95 Bloomberg Philanthropies, American Cities Climate Challenge, "Climate Action Playbook Brief: A Strategic Brief to Accelerate and Deepen Climate Action in Cities," October 2019, https://data.bloomberglp.com/dotorg/sites/2/2019/10/American-Cities-Climate-Challenge-Climate-Action-Playbook.pdf

96 HB19-1261, 2019, "Climate Action Plan to Reduce Pollution," Colorado, https://leg.colorado.gov/bills/hb19-1261

97 IPCC, "Summary for Policymakers: Global Warming of 1.5°C," 2018, https://www.ipcc.ch/sr15/chapter/spm

98 HB19-1261, 2019, "Climate Action Plan to Reduce Pollution," Colorado, https://leg.colorado.gov/bills/hb19-1261

99 Sierra Club, "100% Commitments in Cities, Counties, & States," 2019, https://www.sierraclub.org/ready-for-100/commitments

100 New Mexico State Legislature. Senate Bill 489 – Energy Transition Act, https://www.nmlegis.gov/Sessions/19%20Regular/bills/senate/SB0489.html

101 S. 6599, 2019. New York, https://www.nysenate.gov/legislation/bills/2019/s6599

102 New York Independent System Operator, "Carbon Pricing: Market Design Complete," 2019, https://www.nyiso.com/documents/20142/7129597/6.20.2019_MIWG_Carbon_Pricing_MDC_FINAL.pdf/cf67ebb8-d0fc-7b4b-100f-c3756d6afae8

103 Sierra Club, "100% Commitments in Cities, Counties, & States," 2019, https://www.sierraclub.org/ready-for-100/commitments

104 Ohio State Legislature, House Bill 6, https://www.legislature.ohio.gov/legislation/legislation-summary?id=GA133-HB-6

105 Sierra Club, "100% Commitments in Cities, Counties, & States," 2019, https://www.sierraclub.org/ready-for-100/commitments

106 We Mean Business, "Companies," 2019, https://www.wemeanbusinesscoalition.org/companies/#checkedOptions=RE100%20-%20100%25%20renewable%20power&country=USA&pageNum=1

107 Renewable Energy Buyers Alliance, "Home Page," 2019, https://rebuyers.org/

108 US Environmental Protection Agency, "Green Power Partner List," Green Power Partnership, 2019, http://web.archive.org/web/20190303094359/https://www.epa.gov/greenpower/green-power-partner-list

109 Smart Electric Power Alliance, "Utility Carbon Reduction Tracker," https://sepapower.org/decarbonization-tracker/

110 Clean Air Task Force, "Fact Sheet: State and utility climate change targets shift to carbon reductions, technology diversity," https://www.catf.us/wp-content/uploads/2019/05/State-and-Utility-Climate-Change-Targets.pdf

111 Federal Register, National Archives, "Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review," 2019, https://www.federalregister.gov/documents/2019/09/24/2019-19876/oil-and-natural-gas-sector-emission-standards-for-new-reconstructed-and-modified-sources-review

112 Exec. Order 2019-003, "Executive Order on Addressing Climate Change and Energy Waste Prevention," New Mexico, https://www.governor.state.nm.us/wp-content/uploads/2019/01/EO_2019-003.pdf

113 New Mexico Oil and Gas Association, "Methane Mitigation Roadmap," June 2019, https://www.nmoga.org/methaneroadmap

114 New Mexico Oil and Gas Association, "New Mexico Oil and Gas Association Publishes Methane Mitigation Roadmap," June 2019, https://www.nmoga.org/new_mexico_oil_gas_association_publishes_methane_mitigation_roadmap

115 City of Berkeley, Annotated Agenda for Berkeley City Council Meeting, 16 July 2019, https://www.cityofberkeley.info/Clerk/City_Council/City_Council__Agenda_Index.aspx

116 City of Carlsbad, "Residential Water Heating Ordinance," 2019, https://www.carlsbadca.gov/services/depts/pw/environment/cap/waterheat.asp

117 City of Palo Alto, "Energy Reach Code for Multi-family and Single Family New Construction and Renovation," https://www.cityofpaloalto.org/civicax/filebank/documents/48854

118 Sacramento Municipal Utility District, "Rebates for my home," 2019, https://www.smud.org/en/Rebates-and-Savings-Tips/Rebates-for-My-Home

119 California Public Utilities Commission, "R1311005 Fitch REV 1 Agenda Dec Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution," 2019, http://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=310053527

120 State of Maine Legislature, "Summary of LD 1766," 2019, https://legislature.maine.gov/LawMakerWeb/summary.asp?ID=280074129

121 EIA. One in four U.S. homes is all electric. May 1, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39293

122 EIA. One in four U.S. homes is all electric. May 1, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39293

123 Council of the District of Columbia, "Washington D.C. Council Bill 2202057," 2019, https://legiscan.com/DC/bill/B22-0257/2017

124 Nebraska Legislature, "LB405—Adopt updates to building and energy codes," 2019, https://nebraskalegislature.gov/bills/view_bill.php?DocumentID=37416

125 The New York City Council, "Commitment to achieve certain reductions in greenhouse gas emissions by 2050," 2019, https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3761078&GUID=B938F26C-E9B9-4B9F-B981-1BB2BB52A486&Options=&Search=

126 Washington State Legislature, "HB 1257-2019-20," 2019, https://app.leg.wa.gov/billsummary?BillNumber=1257&Chamber=House&Year=2019

127 The Commonwealth of Massachusetts Department of Public Utilities, "D.P.U. 18-110 through D.P.U. 18-119," 2019, https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/10317061

128 American Council for an Energy-Efficient Economy, "WA and CO Join Growing State Push for Efficient Appliances," May 7, 2019, https://aceee.org/press/2019/05/wa-and-co-join-growing-state-push; RI.gov, "Raimondo Signs Executive Order to Transform RI's Heating Sector," July 10, 2019, https://www.ri.gov/press/view/36269

129 Lauren Urbanek, "State Efficiency Standards Are Good for Everyone," Natural Resources Defense Council, May 22, 2019, HB 1444, Washington, 2019, https://www.nrdc.org/experts/lauren-urbanek/more-states-ever-are-pursuing-state-standards; http://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bills/House%20Passed%20Legislature/1444-S2.PL.pdf; HB 19-1231, Colorado, 2019, https://leg.colorado.gov/sites/default/files/documents/2019A/bills/2019a_1231_rer.pdf; HB 556 2019, Hawaii, "Relating to Energy Efficiency," https://www.capitol.hawaii.gov/session2019/bills/HB556_CD1_.pdf

130 Center for Climate and Energy Solutions (C2ES), "U.S. State Clean Vehicle Policies and Incentives," 2019, https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/

131 Rykowski, Richard, "Colorado Zero Emission Vehicle Program Will Deliver Extensive Economic, Health and Environmental Benefits," Environmental Defense Fund, July 2019, http://blogs.edf.org/climate411/files/2019/08/FINAL-EDF-Colorado-ZEV-report-2019.pdf

132 United States District Court for The District of Columbia Court, Case Number: 1:19-cv-02826 State of California et al v. CHAO et al. Filed 9/20/2019, https://oag.ca.gov/system/files/attachments/press_releases/California%20v.%20Chao%20complaint%20%2800000002%29.pdf

133 EIA, "Annual Energy Outlook 2018," Table 39.1, Light-Duty Vehicle Sales by Technology Type

134 Climate Mayors, "More than 140 Cities and Counties Have Committed to Purchasing over 2,100 EVs by 2020," June 27, 2019, https://driveevfleets.org/media/#1571673628671-db67d268-6b77

135 Amazon, "Amazon co-founds The Climate Pledge, setting goal to meet the Paris Agreement 10 years early," 2019, https://press.aboutamazon.com/news-releases/news-release-details/amazon-co-founds-climate-pledge-setting-goal-meet-paris

136 U.S. Environmental Protection Agency, "Smart Growth and Climate Change," accessed on October 1, 2019, https://www.epa.gov/smartgrowth/smart-growth-and-climate-change

137 Emily Badger and Quoctrung Bri, "Cities Start to Question an American Ideal: A House with a Yard on Every Lot," New York Times, June 2019, https://www.nytimes.com/interactive/2019/06/18/upshot/cities-across-america-question-single-family-zoning.html

138 Minneapolis City Council, "Minneapolis 2040: Access to Housing," 2018, https://minneapolis2040.com/policies/access-to-housing

139 Oregon State Legislature, 2019 Regular Session, "HB 2001 Enrolled," 2019, https://olis.leg.state.or.us/liz/2019R1/Measures/Overview/HB2001

140 Nolan Gray, "Do Minimum Lot Size Rules Matter?" Strong Towns, June 20, 2019, https://www.strongtowns.org/journal/2019/6/19/do-minimum-lot-size-rules-matter

141 Nolan Gray, "How Houston Regulates Land Use," Market Urbanism, September 19, 2016, https://marketurbanism.com/2016/09/19/how-houston-regulates-land-use/

142 Rocky Mountain Institute and Seattle City Light, "Seattle City Light: Transportation Electrification Strategy," 2019, https://www.eenews.net/assets/2019/09/04/document_ew_01.pdf

143 "Obama Administration Partners with Private Sector on New Commitments to Slash Emissions of Potent Greenhouse Gases," the White House, September 16, 2014, https://obamawhitehouse.archives.gov/the-press-office/2014/09/16/fact-sheet-obama-administration-partners-private-sector-new-commitments-; "Obama Administration and Private-Sector Leaders Announce Ambitious Commitments and Robust Progress to Address Greenhouse Potent Greenhouse Gases," the White House, October 15, 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/10/15/fact-sheet-obama-administration-and-private-sector-leaders-announce

144 Office of Washington Governor Jay Inslee, "Policy Brief: New state law will phase down HFC super-pollutants," May 2019, https://www.governor.wa.gov/sites/default/files/documents/hfc-policy-brief-bill-signing.pdf; Vermont General Assembly, "S.30 (Act 65)," accessed August 9, 2019, https://legislature.vermont.gov/bill/status/2020/S.30

145 Buy Clean, "Home," https://buyclean.org/

146 U.S. Department of Energy, Better Buildings, "Case Study: Transcritical Carbon Dioxide Supermarket Refrigeration Systems," https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Transcritical_CO2_Supermarket_Refrigeration_Systems.pdf

147 U.S. Environmental Protection Agency, GreenChill Partnership, "Prioritizing Leak Tightness During Commercial Refrigeration Retrofits," https://www.epa.gov/sites/production/files/documents/GChill_Retrofit.pdf

148 U.S. Department of Energy, Better Buildings, "Case Study: Transcritical Carbon Dioxide Supermarket Refrigeration Systems," https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Transcritical_CO2_Supermarket_Refrigeration_Systems.pdf

149 Environmental Investigation Agency, "How can supermarkets reduce the climate impacts of HFCs in cooling?," accessed on October 1, 2019, https://www.climatefriendlysupermarkets.org/

150 United States Climate Alliance, "Natural and Working Lands," accessed August 9, 2019, https://www.usclimatealliance.org/nwlands

151 United States Climate Alliance, "Natural and Working Lands," accessed August 9, 2019, https://www.usclimatealliance.org/nwlands

152 United States Climate Alliance, "Natural and Working Lands Challenge," accessed August 9, 2019, https://www.usclimatealliance.org/nwlchallenge

153 Rhodium Group, "Final US Emissions Estimates for 2018," https://rhg.com/research/final-us-emissions-estimates-for-2018/

154 EIA. Monthly Energy Review. September 2019, https://www.eia.gov/totalenergy/data/monthly/archive/00351909.pdf

155 U.S. Department of Energy, "Grid Modernization and the Smart Grid," Office of Electricity, https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid

156 Goodkind, A. et al., "Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions," PNAS vol. 116, no. 18: 8775-8780 (2019); Health Effects Institute (2019). "The State of Global Air," Data accessed November 1, 2019: https://www.stateofglobalair.org/data/#/air/plot

157 U.S. Environmental Protection Agency, "Asthma Facts," Office of Air and Radiation, 2015.

158 American Lung Association, "Socioeconomic and racial asthma disparities in asthma," https://www.lung.org/local-content/illinois/documents/socioeconomic-asthma-disparities.pdf

159 Environmental Integrity Project, "Coal's Poisonous Legacy: Groundwater Contaminated by Coal Ash Across the U.S.," March 2019, https://www.environmentalintegrity.org/wp-content/uploads/2019/03/National-Coal-Ash-Report-Revised-7.11.19.pdf

160 Earthjustice, Ashtracker (website) "Tracking Groundwater Contamination At Coal Ash Dumps," accessed October 28, 2019, https://ashtracker.org

161 U.S. Energy Information Administration, "In 2016, U.S. energy expenditures per unit GDP were the lowest since at least 1970," July 30, 2018, https://www.eia.gov/todayinenergy/detail.php?id=36754

162 U.S. Census, "America's Families and living Arrangements: 2018," 2018, https://www.census.gov/data/tables/2018/demo/families/cps-2018.html

163 Bloomberg New Energy Finance, "New Energy Outlook, 2019," 2019, https://about.bnef.com/new-energy-outlook/

164 U.S. Department of Energy, "Adoption of light-emitting diodes in common lighting applications," 2017, https://www.energy.gov/sites/prod/files/2017/08/f35/led-adoption-jul2017_0.pdf

165 Energy Innovation, "The Coal Cost Crossover: Economic Viability Of Existing Coal Compared To New Local Wind And Solar Resources," https://energyinnovation.org/publication/the-coal-cost-crossover/

166 Iuliua Gheorghiu, "PacifiCorp shows 60% of its coal units are uneconomic," Utility Dive, December 5, 2018, https://www.utilitydive.com/news/pacificorp-shows-60-of-its-coal-units-are-uneconomic/543566/

167 Xcel Energy, "Upper Midwest Integrated Resource Plan 2020-2034," https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Executive-Summary-with-Cover.pdf

168 Pyper, Julia, "Xcel Energy commits 100% carbon free electricity by 2050," Green Tech Media,2018, https://www.greentechmedia.com/articles/read/xcel-commits-to-100-carbon-free-electricity-by-20501#gs.6i5mk2

169 NIPSCO, "Your Energy, Your Future," 2019, https://www.nipsco.com/campaigns/your-energy-your-future/#slideshow_

170 BNEF, "Electric Car Price Tag Shrinks Along With Battery Cost," 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost

171 Sivak, M. and B. Schoettle, "Relative Costs of Driving Electric and Gasoline Vehicles in the Individual U.S. States," University of Michigan Transportation Research Institute, 2019.

172 Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost

Deloitte, "New Market. New Entrants. New Challenges. Battery Electric Vehicles," https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf

173 Phadke, Amol, Aditya Khandekar1, Margaret McCall, Nihan Karali1, and Deepak Rajagopal, "Long-haul battery electric trucks are technically feasible and economically compelling," 2019, http://eta-publications.lbl.gov/sites/default/files/working_paper_005_battery_electric_trucks_906_0.pdf

174 ICCT, "Estimating the Infrastructure Needs and Costs for the Launch of Zero-Emission Trucks," 2019, https://theicct.org/sites/default/files/publications/ICCT_EV_HDVs_Infrastructure_20190809.pdf

175 Tryggestad, Christerm, Namit Sharma, Jasper van de Staaij and Arjan Keizer, "New reality: Electric Trucks and their Implications on Energy Demand," 2019, https://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/

176 Billimoria, Sherri, Mike Henchen, Leia Guccione, and Leah Louis-Prescott, "The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings," 2018, https://rmi.org/insight/the-economics-of-electrifying-buildings/.

177 Billimora, S., L. Guccione, M. Henchen and L. Louis-Prescott, "The Economics of Electrifying Buildings," 2018, Rocky Mountain Institute.

178 EIA. One in four U.S. homes is all electric. May 1, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39293

179 Smart Electric Power Alliance, "Community Solar Program Design Models," 2018, https://sepapower.org/resource/community-solar-program-designs-2018-version/

180 Brown, S. and M. Yucel, 2013, "Shale Gas and Tight Oil Boom: US States' Economics Gains and Vulnerabilities," Council on Foreign Relations, Oct. 2013, https://www.files.ethz.ch/isn/171589/Energy_Brief_Brown_Yucel.pdf

181 Analysis Group, "The Economic Impacts of The Regional Greenhouse Gas Initiative On Nine Northeast And Mid-Atlantic States," 2018, https://www.analysisgroup.com/globalassets/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_april_2018.pdf

182 Analysis Group, "The Economic Impacts of The Regional Greenhouse Gas Initiative On Nine Northeast And Mid-Atlantic States," 2018, https://www.analysisgroup.com/globalassets/uploadedfiles/content/insights/publishing/analysis_group_rggi_report_april_2018.pdf

183 Muro, Mark, Adie Tomer, Ranjitha Shivaram, and Joseph Kane, "Advancing inclusion through Clean Energy Jobs," 2019, https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane_updated.pdf

184 "Occupational Outlook Handbook: Fastest Growing Occupations," accessed July 31, 2019, https://www.bls.gov/ooh/fastest-growing.htm

185 "Occupational Outlook Handbook: Fastest Growing Occupations," accessed July 31, 2019, https://www.bls.gov/ooh/fastest-growing.htm

186 Muro, Mark, Adie Tomer, Ranjitha Shivaram, and Joseph Kane, "Advancing Inclusion through Clean Energy Jobs," 2019, https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane.pdf

187 Muro, Mark, Adie Tomer, Ranjitha Shivaram, and Joseph Kane, "Advancing Inclusion through Clean Energy Jobs," 2019, https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane.pdf

188 NASEO and Energy Futures Initiative, "2019 US Energy and Employment Report- A Joint Project of NASEO and EFI," 2019, https://www.usenergyjobs.org/

189 Williams, Mike, "BlueGreen Alliance Testimony to Congress," 2019, https://www.bluegreenalliance.org/wp-content/uploads/2019/09/091019-Williams-Testimony-vFINAL.pdf.

190 E2, "Energy Efficiency Jobs in America," 2018, https://e4thefuture.org/wp-content/uploads/2018/09/EE-Jobs-in-America-2018.pdf.

191 NASEO and Energy Futures Initiative, "2019 US Energy and Employment Report- A Joint Project of NASEO and EFI," 2019, https://www.usenergyjobs.org/

192 "A Star Turn for Energy Efficiency Jobs," accessed July 29, 2019, https://www.americanprogress.org/issues/green/reports/2011/09/07/10332/a-star-turn-for-energy-efficiency-jobs/

193 "A Star Turn for Energy Efficiency Jobs," accessed July 29, 2019, https://www.americanprogress.org/issues/green/reports/2011/09/07/10332/a-star-turn-for-energy-efficiency-jobs/

194 Edison Electric Institute, "EEI celebrates 1 million electric vehicles on US roads," 2018, https://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20Celebrates%201%20Million%20Electric%20Vehicles%20on%20U-S-%20Roads.aspx

195 National Association of State Energy Officials & Energy Futures Initiative, "The 2019 US Energy and Employment Report," 2019, https://www.usenergyjobs.org/2019-report

196 United Auto Workers, "Taking the high Road: Strategies for a Fair EV Future," Fall 2018, https://www.eenews.net/assets/2019/07/19/document_gw_01.pdf

197 Winebrake, J., E. Green and E. Carr, "Plug-in electric vehicles: economic impacts and employment growth," Energy and Environmental Research Associates, LLC, 2017, https://caletc.com/wp-content/uploads/2019/05/EERA-PEV-Economic-Impacts-and-Employment-Growth.pdf

198 National Association of State Energy Officials & Energy Futures Initiative, "The 2019 US Energy and Employment Report," 2019, https://www.usenergyjobs.org/2019-report

199 Utility Dive, "US energy storage market grows nearly 45%, interconnects over 760 MWh in 2018: SEPA," 2019, https://www.utilitydive.com/news/us-energy-storage-market-grows-by-nearly-45-interconnects-over-760-mwh-in/560297/

200 Energy Storage Association, "35x25 A Vision of Energy Storage," 2017, https://www.energy.gov/sites/prod/files/2018/10/f56/3.2%20Storage%20Panel_Speakes-Backman_10-18-18.pdf

201 Eaton, "Blackout Tracker: United States Annual Report 2018," 2018, http://electricalsector.eaton.com/forms/BlackoutTrackerAnnualReport

202 Edison Electric Institute, Industry Data, https://www.eei.org/resourcesandmedia/industrydataanalysis/industrydata/Pages/default.aspx

203 U.S. Department of Commerce, "2017 Top Markets Report: Smart Grid," 2017, https://www.trade.gov/topmarkets/pdf/Smart_Grid_Top_Markets_Report_2017.pdf

204 U.S. Department of Energy, "Smart Grid System Report 2018 Report to Congress," 2018, https://www.energy.gov/sites/prod/files/2019/02/f59/Smart%20Grid%20System%20Report%20November%202018_1.pdf

205 Elena Ianchovichina and Harun Onder, "Dutch Disease: An economic illness easy to catch, difficult to cure," The Brookings Institution, October 31, 2017, https://www.brookings.edu/blog/future-development/2017/10/31/dutch-disease-an-economic-illness-easy-to-catch-difficult-to-cure/

206 Guilford, Gwynn, "The 100-year capitalist experiment that keeps Appalachia poor, sick, and stuck on coal," 2017, https://qz.com/1167671/the-100-year-capitalist-experiment-that-keeps-appalachia-poor-sick-and-stuck-on-coal/

207 Ken Ward Jr., "Covering West Virginia's Long History of Broken Promises," The Charleston Gazette-Mail, April 27, 2018, https://www.propublica.org/article/covering-west-virginias-long-history-of-broken-promises

208 Sean O'Leary, "Booms and Bust: Natural Gas," February 12, 2018, https://wvpolicy.org/booms-and-bust-natural-gas-update/

209 Sean O'Leary, "Booms and Bust: Natural Gas," February 12, 2018, https://wvpolicy.org/booms-and-bust-natural-gas-update/

210 Godby, Rob, Roger Coupal, and Mark Haggerty, "The Overlooked Importance of Federal Public Land Fiscal Policy," 2019, https://headwaterseconomics.org/public-lands/papl-godby/

211 Godby, Rob, Roger Coupal, and Mark Haggerty, "The Overlooked Importance of Federal Public Land Fiscal Policy," 2019, https://headwaterseconomics.org/public-lands/papl-godby/

212 Fourth National Climate Assessment, Volume II: Impacts, Risks, and Adaptation in the United States, https://nca2018.globalchange.gov/

213 Todd, Ben Dor, William Lester, Avery Livengood, Adam Davis, and Logan Yonavjak, "Estimating the Size and Impact of the Ecological Restoration Economy," PLOS ONE, Vol. 10, June 2015, pp 1-15, https://doi.org/10.1371/journal.pone.0128339

214 Lara Bryant, "Climate Change Wreaking Havoc on Farms; Cover Crops can Help," NRDC Blog, November 29, 2018, https://www.nrdc.org/experts/lara-bryant/climate-change-wreaking-havoc-farms-cover-crops-can-help

215 "Top 5 Benefits Of Regenerative Agriculture," accessed July 30, 2019, https://www.holganix.com/blog/top-5-benefits-of-regenerative-agriculture-infographic

216 "Regenerative Agriculture," accessed July 30, 2019, http://www.generalmills.com/en/Responsibility/Sustainability/Regenerative-agriculture

217 Soils4Climate, "Healthy Soils Legislation Table & Map – 2019 Session," accessed 25 October, 2019, https://docs.google.com/spreadsheets/d/1YgUd3pJLB9cjH21MfXVf4mJsJUf7_cS8W9dPTmolezk/edit#gid=716899618

218 E. Fargione, Joseph & Bassett, Steven & Boucher, Timothy & Bridgham, Scott & T. Conant, Richard & C. Cook-Patton, Susan & Ellis, Peter & Falcucci, Alessandra & Fourqurean, James & Gopalakrishna, Trisha & Gu, Huan & Henderson, Benjamin & Hurteau, Matthew & D. Kroeger, Kevin & Kroeger, Timm & Lark, Tyler & M. Leavitt, Sara & Lomax, Guy & Mcdonald, Robert & Griscom, Bronson, "Natural climate solutions for the United States," Science Advances, 4. eaat1869. 10.1126/sciadv.aat1869, 2018

219 Nature4Climate, "US State Mapper," accessed October 1, 2019, https://nature4climate.org/u-s-carbon-mapper/

220 Paul, M., Fremstad, A., Mason, J.W., "Decarbonizing the US Economy: Pathways Toward a Green New Deal," Roosevelt Institute, 2019, https://rooseveltinstitute.org/wp-content/uploads/2019/06/Roosevelt-Institute_Green-New-Deal_Digital-Final.pdf

221 Gasper, R., and T. Searchinger, "The Production and Use of Renewable Natural Gas as a Climate Strategy in the United States," World Resources Institute, 2018, http://www.wri.org/publication/renewable-natural-gas

222 Milbrandt, Anelia, Seiple, Timothy, Heimiller, Donna, Skaggs, Richard, and Coleman, Andre, "Wet waste-to-energy resources in the United States," 2018, Resources Conservation and Recycling, vol 137, Journal c, doi:10.1016/j.resconrec.2018.05.023.

223 Bates White Economic Consulting, "Renewable Natural Gas Supply and Demand for Transportation," 2019, https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/5ce6c195ec212d3893613c23/1558626712387/BW+RNG+Report+Final+2019.04.05.pdf

224 EPA, "RIN Trades and Price Information," accessed September 23, 2019, https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information

225 Tomich, M. and Mintz, Marianne, "Cow Power: a case study of renewable compressed natural gas as a transportation fuel," Argonne National Laboratory, 2019, https://afdc.energy.gov/files/u/publication/cow_power_case_study.pdf

226 CDFA, "California awards $69.9 million for dairy digester projects," Biomass Magazine, 2018, http://biomassmagazine.com/articles/15447/california-awards-69-9-million-for-dairy-digester-projects

227 Oregon State Department of Environmental Quality, "Overview of Clean Fuels Program," accessed September, 23, 2019, https://www.oregon.gov/deq/FilterDocs/cfpoverview.pdf

228 California Bioenergy, "Projects," accessed October 25, 2019, https://calbioenergy.com/projects/

229 Roeslein Alternative Energy, "Company Overview," accessed September 23, 2019, www.roesleinAE.com

230 EPA, "Project Profile: Ruckman Farm," accessed September 23, 2019, https://www.epa.gov/agstar/project-profile-ruckman-farm

231 Butler, Branden, "Prairie Power: Roeslein Alternative Energy moves toward horizon 2," Missouri Prairie Journal, vol. 40, no. 2, 2019.

232 Jesse Newman and Jacob Bunge, "'This One Here is Gonna Kick my Butt' – Farm Belt Bankruptcies are Soaring," The Wall Street Journal, February 6, 2019, https://www.wsj.com/articles/this-one-here-is-gonna-kick-my-buttfarm-belt-bankruptcies-are-soaring-11549468759

233 American Wind Energy Association, "Wind Power Pays $222 Million a Year to Rural Landowners," Press Release, March 22, 2016, https://www.awea.org/resources/news/2016/wind-power-pays-$222-million-a-year-to-rural-lando

234 Evan Vaughan, "American Farmers are Harvesting the Wind," American Wind Energy Association Blog, October 12, 2016, https://www.aweablog.org/american-farmers-harvesting-wind/

235 "AWEA Annual Market Report: Top 11 Wind Power Trends in 2018," accessed July 31, 2019, https://www.aweablog.org/awea-annual-market-report-top-11-wind-power-trends-2018

236 IRENA, "Renewable Energy and Jobs Annual Review 2018," 2018, https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_RE_Jobs_Annual_Review_2018.pdf

237 Natural Resources Defense Council, "Clean Energy Sweeps Across Rural America," 2018, https://www.nrdc.org/sites/default/files/rural-clean-energy-report.pdf

238 U.S. Environmental Protection Agency, Office of Water, "Regulatory Impact Analysis for the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category," EPA-821-R-15-004, 10-3, September 29, 2015, available at: https://www.epa.gov/sites/production/files/2015-11/documents/steam-electric_regulatory-impact-analysis_09-29-2015.pdf

239 Health Effects Institute, "State of Global Air 2019," 2019, Boston MA, https://www.stateofglobalair.org/

240 American Lung Association (2019), "State of the Air 2019," available at: https://www.lung.org/assets/documents/healthy-air/state-of-the-air/sota-2019-full.pdf

241 Sean Reilly, "EPA about-face lets emissions soar at some coal plants," Environment and Energy Publishing, LLC., September 26, 2019, https://www.eenews.net/stories/1061172075

242 Health Effects Institute, "State of Global Air 2019," 2019, Boston MA, https://www.stateofglobalair.org/

243 Goodkind, A.L., Tessum, C.W., Coggins, J.S., Hill, J.D., Marshall, J.D., "Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions," Proceedings of the National Academy of Sciences Apr 2019, 116 (18) 8775-8780; DOI: 10.1073/pnas.1816102116 (2019)

244 Sierra Club, Beyond Coal, "Moving Beyond Coal, By the Numbers," 2019, https://content.sierraclub.org/coal/victories

245 This is the high scenario under the COBRA model

246 Goodkind, A.L., Tessum, C.W., Coggins, J.S., Hill, J.D., Marshall, J.D., "Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions," Proceedings of the National Academy of Sciences Apr 2019, 116 (18) 8775-8780; DOI: 10.1073/pnas.1816102116

247 Health Effects Institute, "State of Global Air 2019", 2019, Boston MA, https://www.stateofglobalair.org/

248 U.S. Environmental Protection Agency, "Coal Ash (Coal Combustion Residuals, or CCR)," accessed October 1, 2019, https://www.epa.gov/coalash

249 U.S. Environmental Protection Agency, "Coal Ash (Coal Combustion Residuals, or CCR)," accessed October 1, 2019, https://www.epa.gov/coalash

250 Ashley B. Ramsey, Anthony M. Faiia, Anna Szynkiewicz, "Eight years after the coal ash spill – Fate of trace metals in the contaminated river sediments near Kingston, eastern Tennessee," Applied Geochemistry vol. 104 (158-167), 2019, DOI: 10.1016/j.apgeochem.2019.03.08

251 Environmental Integrity Project, "Coal's Poisonous Legacy: Groundwater Contaminated by Coal Across the U.S.," March 4, 2019, http://www.environmentalintegrity.org/wp-content/uploads/2019/04/National-Coal-Ash-Report-4.30.2019.pdf

252 Luber, George et al., "Climate Change and Extreme Heat Events," American Journal of Preventive Medicine, November 2008, Volume 35, Issue 5, 429 - 435, https://doi.org/10.1016/j.amepre.2008.08.021

253 Crimmins, A., et al., "The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment," U.S. Global Change Research Program, Washington, DC, 2016, http://dx.doi.org/10.7930/J0R49N

254 Health Care Without Harm, "Health Care Climate Challenge," 2018, http://www.healthcareclimatechallenge.org/

255 Health Care Without Harm, "Health Care Climate Council," accessed October 1, 2019, https://noharm-uscanada.org/healthcareclimatecouncil

256 Hyman, L., "The New Deal wasn't what you think," The Atlantic, March 6, 2019, https://www.theatlantic.com/ideas/archive/2019/03/surprising-truth-about-roosevelts-new-deal/584209/

257 Paul, M., Fremstad, A., Mason, J.W., "Decarbonizing the US Economy: Pathways Toward a Green New Deal," Roosevelt Institute, 2019, https://rooseveltinstitute.org/wp-content/uploads/2019/06/Roosevelt-Institute_Green-New-Deal_Digital-Final.pdf

258 NREL's Rapid Advancement Scenario: Jadun, Paige, Colin McMillan, Daniel Steinberg, Matteo Muratori, Laura Vimmerstedt, and Trieu Mai, "Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050," Golden, CO: National Renewable Energy Laboratory, NREL/TP-6A20-70485, 2017, https://www.nrel.gov/docs/fy18osti/70485.pdf

259 ARPA-E, "ARPA-E Impacts: A Sampling of Project Outcomes, Volume III," 2018, https://arpa-e.energy.gov/sites/default/files/documents/files/ARPA-E-Impact-Book-Volume-3-Final-May10.pdf

260 Paul, M., Fremstad, A., Mason, J.W., "Decarbonizing the US Economy: Pathways Toward a Green New Deal," Roosevelt Institute, 2019, https://rooseveltinstitute.org/wp-content/uploads/2019/06/Roosevelt-Institute_Green-New-Deal_Digital-Final.pdf

261 Tooze, A., "Why central banks need to step up on global warming," Foreign Policy, July 20, 2019.

262 Federal Reserve Bank of St. Louis, FRED Economic Data, https://fred.stlouisfed.org/graph/?g=ZYO

263 Asia-Pacific Economic Cooperation, "APEC Energy Demand and Supply Outlook 7th Edition Volume II," 2019.

264 Arndt, C., Hartley, F., Ireland, G. et al., "Curr Sustainable Renewable Energy Rep" (2018) 5: 240, https://doi.org/10.1007/s40518-018-0121-9

265 U.S. Energy Information Agency, State Energy Data System, accessed Nov 2019, https://www.eia.gov/state/seds/

266 Whitley, S., Chen, H., Doukas, A., Gençsü, I., Gerasimchuk, I., Touchette, Y., Worrall, L. "G7 fossil fuel subsidy scorecard: Tracking the phase-out of fiscal support and public finance for oil, gas and coal." Oil Change International, Overseas Development Institute, Global Subsidies Initiative, National Resources Defense Council, 2018.

267 Paul, M., Fremstad, A., Mason, J.W., "Decarbonizing the US Economy: Pathways Toward a Green New Deal," Roosevelt Institute, 2019, https://rooseveltinstitute.org/wp-content/uploads/2019/06/Roosevelt-Institute_Green-New-Deal_Digital-Final.pdf

268 Tooze, A, "Why central banks need to step up on global warming," Foreign Policy, July 20, 2019.

269 Task Force on Climate-related Financial Disclosures, "Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures," 2017, https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf

270 US Energy Information Agency. State Energy Data System. Accessed September 2019. https://www.eia.gov/state/seds/

271 Diaz, D., & Moore, F., "Quantifying the economic risks of climate change," Nature Climate Change, 7, 774, 2017, doi:10.1038/nclimate3411

272 Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., . . . Houser, T., "Estimating economic damage from climate change in the United States," Science, 356(6345), 1362-1369, 2017, doi:10.1126/science.aal4369

273 EPA, "Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment," U.S. Environmental Protection Agency, EPA 430-R-17-001, 2017.

274 Martinich, J., B.J. DeAngelo, D. Diaz, B. Ekwurzel, G. Franco, C. Frisch, J. McFarland, and B. O'Neill, "Reducing Risks Through Emissions Mitigation. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II," 2018, [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)], U.S. Global Change Research Program, Washington, DC, USA, pp. 1346–1386. doi: 10.7930/NCA4.2018.CH29

275 Hallegatte, Stéphane, Jun Rentschler, and Julie Rozenberg, "Lifelines: The Resilient Infrastructure Opportunity," 2019, Sustainable Infrastructure Series, Washington, DC: World Bank, doi:10.1596/978-1-4648-1430-3.

276 Global Commission on Adaptation, "Adapt Now: a Global Call for Leadership on climate Resilience," Global Center on Adaptation and World Resources Institute, 2019, https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf

277 J.D. Morris, "Judge's wifire proposal could cost as much as $150 billion," San Fransisco Chronicle, https://www.sfchronicle.com/california-wildfires/article/PG-E-Judge-s-wildfire-proposal-could-cost-as-13556257.php

278 Chris Edwards, "Reforming Federal Farm Policies," Cato Institute, April 2018, https://www.cato.org/publications/tax-budget-bulletin/reforming-federal-farm-policies#_idTextAnchor001

279 USDA Economic Research Service, "Conservation: Title II," accessed November 20, 2019, https://www.ers.usda.gov/agriculture-improvement-act-of-2018-highlights-and-implications/conservation/

280 Lilliston, Ben, "Will the Farm Bill Deliver for the Climate?" Institute for Agriculture & Trade Policy (blog), 2018, https://www.iatp.org/blog/will-farm-bill-deliver-climate.

281 North Carolina Clean Energy Technology Center, Database of State Incentives for Renewables & Efficiency, 2019, https://www.dsireusa.org/

282 Renewable Energy Policy Network for the 21st Century (REN21), "Renewables in Cities: 2019 Global Status Report," 2019, http://www.ren21.net/cities/wp-content/uploads/2019/05/REC-GSR-Low-Res.pdf

283 American Green Bank Consortium and Coalition for Green Capital, "Green Banks in the United States: 2018 Annual Industry Report," 2019.

284 Renewable Energy Policy Network for the 21st Century (REN21), "Renewables in Cities: 2019 Global Status Report," 2019, http://www.ren21.net/cities/wp-content/uploads/2019/05/REC-GSR-Low-Res.pdf

285 Renewable Energy Policy Network for the 21st Century (REN21), "Renewables in Cities: 2019 Global Status Report," 2019, http://www.ren21.net/cities/wp-content/uploads/2019/05/REC-GSR-Low-Res.pdf

286 The Milken Institute, "Financing Models to Expand Access to Electric Vehicles in California," 2017, https://www.milkeninstitute.org/reports/financing-models-expand-access-electric-vehicles-california

287 The Milken Institute, "Financing Models to Expand Access to Electric Vehicles in California," 2017, https://www.milkeninstitute.org/reports/financing-models-expand-access-electric-vehicles-california

288 Renewable Energy Policy Network for the 21st Century (REN21), "Renewables in Cities: 2019 Global Status Report," 2019, http://www.ren21.net/cities/wp-content/uploads/2019/05/REC-GSR-Low-Res.pdf

289 Billimoria, Sherri, Mike Henchen, Leia Guccione, and Leah Louis-Prescott, The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings, Rocky Mountain Institute, 2018, http://www.rmi.org/insights/reports/economics-electrifying-buildings/

290 PACE Nation, "Pace Market Data," accessed October 1, 2019, https://pacenation.us/pace-market-data/

291 Bloomberg New Energy Finance, "Electric Vehicle Outlook 2019," Bloomberg L.P., May 15, 2019.

292 Jeff Brady, "Finding New Opportunity for Old Coal Fired Plant Sites," National Public Radio, May 23, 2019, https://www.npr.org/2019/05/23/724454774/finding-new-opportunity-for-old-coal-fired-power-plant-sites

293 Rocky Mountain Institute, "Sunshine for Mines: A Second Life for Legacy Mining Sites," November 2017, https://d231jw5ce53gcq.cloudfront.net/wp-content/uploads/2017/11/RMI_SecondLifeLegacyMiningSites.pdf

294 Elizabeth McGowan, "Federal funds to help turn Virginia coal mine into solar farm," March 8, 2019, https://energynews.us/2019/03/08/southeast/virginia-solar-farm-among-10-projects-to-receive-mineland-reuse-funds/

295 Associated Press, "Major solar project proposed for former Washington coal mine," March 15, 2018, https://www.seattletimes.com/seattle-news/major-solar-project-proposed-for-former-washington-coal-mine/

296 Froese, M, "Former Massachusetts Coal Plant to Serve as Offshore Wind Hub," Windpower Engineering & Development, May 14, 2019, https://www.windpowerengineering.com/former-massachusetts-coal-plant-to-serve-as-offshore-wind-hub/

297 Bryce Gray, "Facing likely closures, owner of Southern Illinois coal power plants supports bill to help repurpose sites for solar, energy storage projects," St. Louis Post-Dispatch, April 13, 2019, https://www.stltoday.com/business/local/facing-likely-closures-owner-of-southern-illinois-coal-power-plants/article_351b523a-9b64-58c4-b68d-e0805bb8a824.html

298 National Association of State Energy Officials and Energy Futures Initiative, "The 2019 US energy and Employment Report," 2019, https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f3708fa0d6036d7120d8f/1551849054549/USEER+2019+US+Energy+Employment+Report.pdf

299 National Association of State Energy Officials and Energy Futures Initiative, "The 2019 US energy and Employment Report," 2019, https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f3708fa0d6036d7120d8f/1551849054549/USEER+2019+US+Energy+Employment+Report.pdf

300 Deanna Nord, "Renewable Energy = Economic Development and Jobs," November 29, 2018, accessed July 29, 2019, http://www.americanbusinessmag.com/2018/11/renewable-energy-economic-development-and-jobs

301 Research on job training shows that the results are mixed. A 2008 Department of Labor study that looked at retraining programs involving 160,000 laid off workers in 12 states concluded, "It appears possible that ultimate gains from participation are small or nonexistent." Another study from the Hamilton Project found that to be successful, retraining programs must be highly targeted at the workers most likely to benefit. In general, that means younger workers with some postsecondary education who are motivated to follow through, and who are able and wiling to relocate to places with more job opportunities. Robert LaLonde and Daniel Sullivan, "Retraining Displaced Workers," The Hamilton Project, 2010. See also, Jeffrey Selingo, "The False Promises of Worker Retraining," The Atlantic, January 8, 2018.

302 HB19-1314, Just Transition from Coal-Based Electrical Energy Economy, accessed July 30, 2019, https://leg.colorado.gov/bills/hb19-1314

303 Minnesota Legislature, Office of the Revisor of Statutes, "HF 700," 2019, https://www.revisor.mn.gov/bills/text.php?number=HF700&type=bill&version=0&session=ls91&session_year=2019&session_number=0

304 Herman Trabish, "Securitization Fever: Renewables Advocates Seize Wall Street's Innovative Way to End Coal," Utility Dive, May 28, 2019, https://www.utilitydive.com/news/securitization-fever-renewables-advocates-seize-wall-streets-innovative-w/555089/

305 Emma Foehringer Merchant, "New Mexico's 100% Clean Energy Law Praised for Worker Retraining, but Community Concerns Remain," Greentech Media, March 29, 2019.

306 Sonia Aggarwal, "Redirecting Trump's Coal and Nuclear Bailout to Fund Economic Redevelopment," Greentech Media, August 23, 2018, https://www.greentechmedia.com/articles/read/redirecting-trumps-coal-and-nuclear-bailout-to-fund-economic-transition#gs.sjlucg

307 Elizabeth McGowan, "Rising from the ashes, a Buffalo suburb ends its dependence on coal," Grist, July 11, 2017, https://grist.org/justice/a-working-class-buffalo-suburb-retired-a-coal-plant-the-right-way/

308 Town of Tonawanda, "Tonawanda Tomorrow: Growing the Town's economic future," 2017, http://tonawandatomorrow.org/wp-content/uploads/sites/24/2017/08/TonawandaTomorrowPlanJune15SinglePages.pdf

309 U.S. Global Change Research Program, "2014 National Climate Assessment," 2014, https://nca2014.globalchange.gov/report

310 Ross, L., Drehobl, A. Stickles, B., "The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency," American Council for an Energy-Efficient Economy, July 18, 2018, https://aceee.org/research-report/u1806

311 Mikati, I., et al., "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status," American Journal of Public Health, April 2018, https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2017.304297

312 Smart Electric Power Alliance, "Community Solar Program Design Models," 2018, https://sepapower.org/resource/community-solar-program-designs-2018-version/

313 American Fuel and Petrochemical Manufacturers, energyAPI, NACS, PMAA, and SIGMA, "To the Honorable Mitch McConnell and the Honorable Paul Ryan," November 19, 2018, https://www.api.org/~/media/Files/News/Letters-Comments/2018/No-EV-Tax-Credit-Extension-Letter.pdf

314 U.S. Energy Information Administration, "Electrified vehicles continue to see slow growth and less use than conventional vehicles," May 22, 2018, https://www.eia.gov/todayinenergy/detail.php?id=36312&src=email

315 Sunter, D., Castellanos, S., Kammen, D., "Disparities in Rooftop Photovoltaics deployment in the United States by race and ethnicity," Nature Sustainability, January 2019, https://rael.berkeley.edu/wp-content/uploads/2019/01/Sunter-Castellanos-Kammen-Nature-SustainablityDisparitiesPVDeploymentRaceEthnicity.pdf

316 California Air Resources Board, "Clean Cars 4 All: About," accessed October 1, 2019, https://ww2.arb.ca.gov/our-work/programs/clean-cars-4-all/about

317 E. Gregory Barnes, "Electric Vehicle Grid Integration Pilot Program ('Power Your Drive') Fourth Semiannual Report of San Diego Gas and Electric Company," March 20, 2018, https://www.sdge.com/sites/default/files/documents/FINAL_Power_Your_Drive_Semi_Annual_Rpt.pdf

318 Congressional Research Service, "The Regional Greenhouse Gas Initiative: Background, Impacts, and Selected Issues" R41836, July 2019, https://fas.org/sgp/crs/misc/R41836.pdf

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