

Center for American Progress



A 100 Percent Clean Future

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Bidisha Bhattacharyya, Alan Yu, and Kristina Costa

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Introduction and summary

Climate change is the greatest challenge facing the United States—and the world—over the next decade and beyond. The impacts of climate change have already been deadly: More than 3,000 Americans have died in weather- and climate-related disasters in the past two years.¹ Public health experts warn that climate change threatens the quality of America's air and water.² Natural disasters have cost the United States more than \$450 billion in the past three years and are projected to cost \$54 trillion globally by 2040.³ By the end of the century, crop damage, lost labor, and extreme weather threaten to shrink the U.S. economy by as much as 10 percent, or \$500 billion—almost double the cost of the 2009 Great Recession.⁴ The U.S. military warns that climate change will multiply the national security threats facing the country. Climate change is a crisis that touches every element of our society. It exacerbates systemic economic and racial inequality and simultaneously threatens public health; national security; the safety and well-being of communities; and the strength of the economy.

A year ago, in October 2018, the issue took on new urgency when the Intergovernmental Panel on Climate Change (IPCC) issued a stark appraisal of the latest climate science: Humanity has only three decades to completely reinvent the global economy in order to eliminate net greenhouse gas pollution and hold global warming to 1.5 degrees Celsius above preindustrial levels.⁵ The differences between the previous target of 2 degrees and the new target of 1.5 degrees of global warming are startling, including greater harm to food and water supplies; major and potentially irreversible loss of ecosystems, such as the world's fragile coral reefs; a higher rate of sea level rise; and irreparable loss or collapse of ice sheets in Antarctica and Greenland.⁶ Every year of continued emissions raises the peak temperatures that carbon pollution will inflict, threatening destruction that can never be undone.

As the IPCC special report warned, the sheer scale of the challenge now facing the world has no precedent in all of human history. To meet this challenge, the president must organize the whole of government, and Congress must break through deeply entrenched gridlock to enact and execute a sweeping program of legislation. The United States has faced and overcome challenges that, at the time, were unprec-

edented, including working as a nation to go to the moon, electrifying rural America, and eradicating smallpox. The United States can and must address this crisis by putting people to work; building the necessary infrastructure to overcome the threat; and confronting the economic, racial, social injustices and inequalities that persist today.

Success is within reach, and it's now possible to visualize a 100 Percent Clean Future. The American public is demanding action, and it's time for political leaders to summon the courage to act. While the Trump administration has dismantled nearly all federal climate policy, state leadership has risen to the challenge with innovative and ambitious new policies. The combination of the following three pillars—100 percent clean, worker-focused, and environmental justice—should serve as a model for federal action, building on the initial efforts at the state level.

- **A 100 percent clean target.** Nine states across the country, along with the District of Columbia and Puerto Rico, have enacted policies to move toward a 100 Percent Clean Future by 2050 or earlier, including through clean electricity standards and aggressive economywide emission reduction targets.⁷
- **A worker-focused approach.** Many states have included initial plans for a worker-centered transition that would ensure the jobs necessary to build a clean future are good paying and high quality.
- **An environmental justice commitment.** Some states have also taken preliminary steps to develop policies that would advance environmental justice, including by identifying and cutting disproportionately high levels of toxic pollution in economically disadvantaged communities and communities of color.

It will take a combination of strong coalitions and knowledge from environmental justice experts, community advocates, labor partners, and others beyond the climate community to develop an innovative and equitable policy approach for major climate action that includes putting people to work, reducing pollution, and building healthy communities today—not just in the future. The coalitions to develop and support this ambitious policy approach have begun to organize. However, this is uncharted territory for many and will require a promise to see beyond historical differences in order to believe that progress is both possible and essential to solving the problems of today and tomorrow. Many of the candidates in the 2020 presidential election have framed their ambitious goals for climate action in a similar way.

While this initial progress is commendable, much more work remains to be done, especially to guarantee pollution reductions in economically disadvantaged communities and communities of color and to address the cumulative and deadly impacts of the history of pollution sources concentrated in these communities. Policy must take a comprehensive approach, including supporting access to affordable electricity, clean water, and good jobs in every community.

In this report, the Center for American Progress presents a framework for building a 100 Percent Clean Future that delivers on the goal of net-zero greenhouse emissions economywide by 2050 and net negative emissions thereafter to limit global warming to 1.5 degrees Celsius above preindustrial levels. This report outlines not only the policies that are needed to cut greenhouse gas emissions but also the coalitions and principles that will make them a reality. To accomplish this transition as quickly as the science demands, the report calls for strong economywide targets, sets sector-by-sector benchmarks for success, estimates the emission reductions these would deliver, and discusses how to spur the rest of the world to follow along. This report is divided into two parts:

- **Part 1 discusses the coalitions and principles needed to enact enduring and effective federal climate policy.** These conclusions are drawn from a review of the Trump administration's reversal of federal climate policy, the increasing clarity of scientific warnings, and the recent success of ambitious state climate policy. In particular, the report highlights the successful model of 100 percent clean targets, a worker-focused approach, and efforts to begin repairing environmental injustice.
- **Part 2 recommends a sustained, concerted, and urgent policy program.** This program aims to reduce greenhouse gas emissions by at least 43 percent below 2005 levels by 2030 and to reach net-zero greenhouse gas emissions no later than 2050, consistent with the requirements identified by the IPCC report on 1.5 degrees Celsius. The report makes policy recommendations for international, economywide, and sector-specific action, proposing specific benchmarks within each sector of the economy and quantifying the emission reductions these would deliver.

Part 1:

Strategies for enabling a 100 Percent Clean Future

In Part 1, CAP discusses the coalitions and principles needed to enact federal climate policy by outlining how the IPCC special report on 1.5 degrees Celsius has set a new goal of net-zero by 2050; proposing principles for federal climate policy to achieve this goal; reviewing models of climate policy success among the states; and summarizing an emerging consensus for federal action.

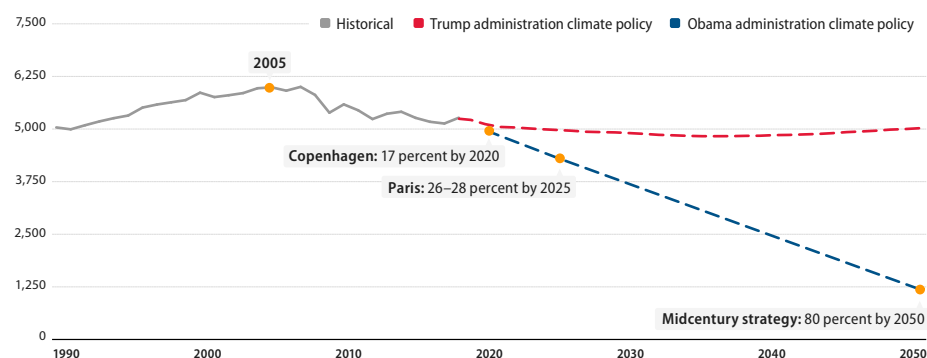
How the U.S. lost a decade of progress

Throughout President Barack Obama's terms in office, the United States led the rest of the world in aiming to limit global warming to 2 degrees Celsius above preindustrial levels. In this period, the United States made great strides; emissions fell 13 percent from 2005 to 2017 at the same time as the economy grew 21 percent.^{8 9} Policy drove down the cost of renewables, and deployment surged. The 2015 Paris agreement brought the world together to commit to nationally established emission reduction targets by all countries for the first time—a target that would be strengthened over the course of continued discussions to stabilize global temperatures.¹⁰ By the end of the Obama administration, the United States had prepared plans to reduce emissions by more than 80 percent below 2005 levels by 2050, consistent with a target of capping warming at 2 degrees Celsius. Though the country needed to be moving even faster at that point, it was moving in the right direction.

FIGURE 1

The Trump administration has returned to a pathway of increasing emissions

Energy-related carbon dioxide emissions, historical and projected, 1990–2050



Sources: U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>; U.S. Energy Information Administration, "August 2019 Monthly Energy Review" (Washington: 2019), available at <https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>; Climate Action Tracker, "Countries: USA Pledges and Targets," available at <https://climateactiontracker.org/countries/usa/pledges-and-targets/> (last accessed September 2019); The White House, "United States Mid-Century Strategy for Deep Decarbonization" (Washington: 2016), available at https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf.

Today, at a time when the United States should be accelerating its efforts to limit warming, the Trump administration has returned the country to a pathway of increasing emissions. After falling for three consecutive years, U.S. greenhouse gas emissions rose by over 3 percent in 2018.¹¹ The United States is now likely to miss its Paris pledge to cut emissions 26 percent to 28 percent below 2005 levels by 2025¹², as seen in Figure 1.

Trump's legacy of destructive climate policy

Hard-won progress on climate policy under the Obama administration was abandoned and actively sabotaged by the Trump administration. At every opportunity, Trump and his team have moved to line the pockets of fossil fuel industry executives at the expense of the health and safety of Americans.

In 2017, the Trump administration announced the intention to withdraw the United States from the Paris agreement, making the United States the only country that would not be at the table setting the rules for the world to follow on climate action.¹³

Domestically, the administration is trying to freeze national vehicle greenhouse gas and fuel economy standards over the objections of even the automakers,¹⁴ sticking drivers with higher fuel costs (a win for oil companies) and everyone with more air pollution. These rollbacks are so extreme that four automakers have struck a separate deal with California to largely implement the Obama standards.¹⁵

In parallel, the Trump administration has tried to undermine innovation in the clean energy industry and keep the economy stuck in the past by repeatedly attempting to defund federal research and development (R&D) programs that support American jobs. They scrapped commonsense limits on methane pollution from oil and gas production, including on public lands, where venting natural gas directly into the air means less economic benefit for the American people who are the true owners of the resources.¹⁶ ¹⁷ They replaced the first-ever limits on carbon pollution from power plants with a plan that would allow many plants to skate by

without any new emissions controls and could potentially even prompt emissions to increase from the sector.¹⁸ ¹⁹ The Trump administration proposed drilling for oil that the country does not need and which may not exist²⁰ in the pristine and long-protected Arctic National Wildlife Refuge. In addition, the administration ignored the objections from governors of both parties to push expanded offshore drilling in the Atlantic, Pacific, and Gulf Coast of Florida while also rolling back the worker protections and equipment safety standards developed to prevent another oil rig explosion like the Deepwater Horizon.²¹

This is just the damage that is public. The Trump administration's environmental cabinet is packed with political appointees—"Trump's dirty deputies"—who now regulate the polluting industries they once served.²² For example, Trump's EPA head, Andrew Wheeler, is a former coal lobbyist whose highest paying client was Murray Energy, a coal company run by coal magnate and Trump donor Bob Murray. Former EPA air chief Bill Wehrum, thought to be the architect of replacing the Clean Power Plan with a weak, industry-friendly rule, sued the Obama administration's EPA no fewer than 31 times in his former job as an industry lawyer in an effort to loosen pressure on polluters.²³ And Interior Secretary David Bernhardt, a former oil and gas lobbyist who has pushed for public lands and waters leasing at levels not seen in recent decades, has the most stated ethics conflicts of all Trump cabinet level appointees²⁴—a distinction that is impressive in a cabinet rife with conflicts of interest.

Science has set a new goal: net-zero by 2050

By 2018, the Trump administration's alarming reversals of climate policy had already made it apparent that restoring the country's previous momentum toward the Paris agreement's goals of "well below" 2 degrees Celsius of global warming would be a challenge. That challenge gained new urgency in October 2018 with the publication of the special report on 1.5 degrees Celsius from the IPCC.²⁵ This report brought into sharp focus the conclusion that 2 degrees of global warming is no longer an acceptable threshold.

The special report summarized the world's leading research on what will happen if the world continues to push global warming from the current 1 degree Celsius up by even just another half a degree, to 1.5 degrees Celsius above preindustrial levels. The differences between 1.5 degrees and 2 degrees Celsius of global warming are startling, including greater harm to the world's food and water supplies; major and potentially irreversible loss of ecosystems such as the world's fragile coral reefs; a higher rate of sea level rise; and irreparable loss or collapse of ice sheets in Antarctica and Greenland.²⁶ One of the most alarming differences is that failing to bring temperatures back down to 1.5 degrees Celsius this century would, in most projections, mean the world will still be warming in 2100, with untold consequences.²⁷

Stabilizing global temperatures at 1.5 degrees Celsius of warming is possible, but the IPCC report's authors warn that the scale of this transformation has "no documented historic precedent," requires "rapid and far-reaching transitions," and implies "deep emissions reductions in all sectors."²⁸ This amounts to a global call to action in perhaps the strongest terms employed by the scientific community to date.

The conclusions of the special report define a new target. To bring the current global warming trajectory back down to 1.5 degrees Celsius by the end of the century, global carbon dioxide emissions must fall 40 percent to 60 percent below 2010 levels by 2030; reach net-zero by 2050; and be net negative thereafter. The IPCC also noted that non-CO2 emissions, such as methane, need to be steeply reduced, though they may not reach net-zero globally.

To meet this target requires a significant acceleration in required emissions reductions, as the previous goal of 2 degrees Celsius meant only a 25 percent reduction in carbon dioxide emissions by 2030 and net-zero emissions only by 2070.²⁹ To put this in perspective, in 2009, at the start of President Obama's first term, the world would have had about 60 years to eliminate an annual emission rate of 48 billion tons of carbon dioxide-equivalent to stay below 2 degrees Celsius this century.³⁰ In 2021, at the start of the next presidential term, the world will only have about 30 years to eliminate an annual emission rate expected to have edged up from the current 53 billion tons if we are to return to 1.5 degrees Celsius.³¹ That is more than double the annual pace of reduction.

Bold new thinking and action is required if the world is to keep up with the targets set by the scientific community. After years of development, many policies and technologies are ready for immediate deployment, but no one yet has all the answers about how to accomplish a complete and timely transition. This is especially true when it comes to negative emission technologies, forecasting the threats to natural carbon sinks, and developing technologies for hard-to-decarbonize sectors such as manufacturing, all of which are areas where innovation is needed. When it comes to scientific research, technology deployment, infrastructure investment, and so much more, there is no time to spare in getting the country onto a path toward net-zero emissions.

How Trump has failed coal workers

Despite his promises to coal communities, President Donald Trump's reversing course on climate policy has not saved coal mining jobs. Since the beginning of the Trump administration, market forces, such as low-cost natural gas, have continued to drive the closure of coal-fired power plants. Utility companies have announced the retirement of 102 gigawatts (GW) of coal-fired power from the grid since 2010.³² Not only have coal plant retirements continued in the Trump administration, they have actually accelerated, increasing from an average of 6.8 GW per year between 2010 and 2016 to 8.8 GW per year since Trump took office.³³ The truth is that environmental regulations were never the cause of falling coal employment: 93 percent of the decline in coal demand arose from market factors, according to an analysis from Columbia University.³⁴ These market pressures help explain why even direct political pressure from Trump has not been sufficient to prevent coal plants from closing.³⁵ In June 2019, use of coal in the United States fell to a four-decade low.³⁶

Meanwhile, the Trump administration has pursued policies that actively hurt miners and their families while helping coal executives profit. In fact, many of these executives are significant Trump donors.³⁷ Trump and his allies in Congress allowed an excise tax that supports payments to miners suffering from black lung disease to fall by half at the end of 2018, while supporting billions of dollars in tax breaks for fossil fuel companies.³⁸ This comes at a time when black lung cases are on the rise. Sen. Joe Manchin (D-WV) has tweeted daily at President Trump since the lapse in early 2019, imploring him to support the American Miners Act that would fully fund retired miners' pensions and healthcare.³⁹

Trump appointed Bill Wehrum, a former coal industry lawyer, as his chief air regulator at the EPA. It was Wehrum, in his role as a coal lawyer, who argued in court against standards to protect miners and construction workers from dangerous silica dust, which can lead to silicosis and other respiratory diseases.⁴⁰ Instead of investing in communities and worker transitions in the wake of plant closures, Trump's first budget proposed eliminating the Appalachian Regional Commission and cutting other economic development and worker training projects in coal country.⁴¹ And then there's the Trump administration's repeated efforts to repeal the Affordable Care Act, which would have had a devastating effect on Appalachia. One analysis found that 670,000 people would have lost insurance in West Virginia and Kentucky alone and more than 70,000 jobs would have been eliminated.⁴²

Likewise, Senate Majority Leader Mitch McConnell (R-KY) from the coal state of Kentucky has also failed to support worker benefits, despite his state employing more than 6,000 miners, including his continued refusal to fully fund miners' pensions.⁴³ The Miners Pension Protection Act, which would transfer additional funding to the miners' pension fund to keep it solvent and ensure healthcare for retired miners,⁴⁴ has been introduced four times since 2015. Sen. McConnell has actively blocked it.⁴⁵

Principles for federal climate policy

Setting a target for greenhouse gas emission reductions is an act of leadership that relies on consideration of a combination of policy principles, available models, data, and feasibility. Failing to set a sufficiently ambitious interim target would fail to inspire the scope of changes needed, necessitate ever steeper reductions in later years, and magnify the damages of climate change. No target will be effective, however, if it pushes emissions-intensive agriculture and industry overseas (harming both the U.S. economy and global emissions) or provokes a political backlash that reverses policy changes.

People of all communities need to see the benefits of climate action in their own lives and have a voice in shaping their future. Those benefits extend beyond just the avoided disruption of climate change to include good jobs, clean water, and justice for the communities of color, tribal communities, and low-income communities that have lived with the cumulative impacts of decades of toxic pollution. As state-level and international examples illustrate, failing to center policy on the needs of workers and communities will undermine popular support for climate action, may even create backlash, and ultimately slow progress toward net-zero emissions.

For this report, the Center for American Progress synthesizes existing literature and modeling and evaluates the combined effect of various policies against a target of at least a 43 percent⁴⁶ reduction below 2005 levels in greenhouse gas emissions by 2030 and net-zero emissions no later than 2050. This is based on the interquartile range for cutting carbon dioxide emissions identified by the IPCC report on 1.5 degrees Celsius, restating the equivalent reduction against 2005 levels rather than 2010 levels, and also adding in all other greenhouse gas emissions.

The 2030 and 2050 targets identified in this report are extraordinarily ambitious, requiring reduction of emissions at a rate that is four times faster than the annual rate of reductions achieved between 2005 and 2017.⁴⁷ Achieving these targets will require a new set of policy principles. These are the 10 principles that underpin CAP's recommendations:

- 1. The goal is net-zero economywide emissions no later than 2050.** Stabilizing global warming will require achieving net-zero greenhouse gas emissions no later than 2050 and net-negative emissions thereafter. This is what is meant by a 100 Percent Clean Future, and it marks a profound shift in thinking. The United States and other countries need to avoid infrastructure and technologies that lock in fossil fuel dependency beyond 2050 except where carbon capture and sequestration is viable and necessary. In parallel to emission reductions, the rapid development and deployment of negative emission technologies must begin now to supplement earth's natural carbon sinks and pull historical greenhouse gas emissions back out of the atmosphere and oceans.
- 2. Interim emissions goals must be ambitious, achievable, and effective.** Interim emission reductions must put the country on the path to net-zero emissions by 2050 in a way that is politically durable and that creates a model for success that other countries will adopt. This report proposes cutting U.S. emissions at least 43 percent by 2030, which is the floor for action identified by the IPCC report on 1.5 degrees Celsius. Such an aggressive 10-year timetable means climate action must be the top priority for a new administration's legislative and executive agendas.
- 3. Climate action must put people first.** Building a 100 Percent Clean Future will create millions of new jobs, and policy must ensure that these jobs are located here in the United States and provide workers fair wages, good benefits, and a voice on the job. Workers and communities must be at the table in developing and implementing climate change solutions. Any plan must ensure a just and fair transition for workers and communities impacted by economic transformation to meaningful, high-quality job opportunities in their home communities.
- 4. All communities deserve to be pollution-free.** All people have the right to live with clean air, clean water, clean soil, and healthy food, free from dangerous toxic pollution. Realizing this will require confronting the historic environmental, economic, and racial inequality that has caused disproportionate harm to communities of color, tribal communities, and low-income communities. Greenhouse gas mitigation strategies that also reduce toxic pollution should be favored and climate mitigation must be part of a comprehensive agenda to address the cumulative impacts of decades of environmental injustice.

5. **U.S. innovation must lead the way.** Answering the challenge of climate change will require all of the ingenuity and creativity that America has to offer, and it will not happen fast enough unless the federal government drives forward an innovation agenda with more than triple the funding for research and development. In particular, development of new technology for harder-to-decarbonize sectors such as manufacturing and agriculture as well as negative emission technologies must be prioritized. Research is also needed to help communities become more resilient and adapt to continued climate changes even as emissions fall. But to be clear, innovation alone will not solve the climate crisis: Even the most miraculous new technologies will need policy support to spur deployment on fast enough timetables.
6. **There is no one silver bullet.** Given the short timetable for emissions cuts and the need to achieve full decarbonization, the climate agenda requires a broad program of complementary policies. Sector-specific deployment policies are needed to set in motion systemwide changes with long lag times, such as turning over the vehicle fleets, replacing buildings, and planting forests. Trillions of dollars in direct federal spending are needed to target R&D, support worker and community transitions, and build safe and healthy infrastructure and communities. A price on carbon pollution is necessary to spur conservation, efficiency, fuel switching, and innovation everywhere and all at once. Point-source emission controls and mandatory emission reductions in communities that have been historically overburdened by pollution are needed to reverse and repair the deadly consequences of concentrating high levels of pollution in those communities. Trading away regulatory authority or common law liability in exchange for a carbon fee, as has occasionally been suggested, is not consistent with a goal of 1.5 degrees Celsius.
7. **All emission-free solutions can play a role.** Approximately four-fifths of U.S. energy use is still supplied by fossil fuels,⁴⁸ and all of this will need to be decarbonized by midcentury. This means the United States must move forward on all fronts at once, allowing a role for every realistic emissions-free solution. Some technologies will require additional safeguards and considerations, but policy must not rule out the carbon reduction value of the existing nuclear fleet, the potential contributions of future advanced nuclear technologies, opportunities for carbon recycling and sequestration, and the need for negative emissions technologies.
8. **State leadership must be rewarded and reinforced—not preempted.** Given the need for sustained policy innovation, and in recognition of the ambitious groundwork already laid by states, federal policy will be best served by the ongoing work in the laboratories of democracy. The federal government should

avoid preempting state authorities to advance additional ambitious and equitable climate policies themselves, and federal policy should reward the early action the states have already taken.

9. **The United States must drive international climate action.** In addition to rejoining the Paris agreement, the United States must use all of its diplomatic, trade, and financial influence to drive global action. No other country has the same capacity and responsibility to lead as the United States.
10. **Climate policy must be built to last.** The Trump administration's concerted efforts to dismantle the Obama administration's legacy of climate progress show the dangerous potential for future political swings to undermine climate policy. The executive branch can accomplish a lot through administrative action, but to successfully act at the scale and speed required, Congress must also overcome its current disfunction and pass climate legislation. Policy changes must be legally durable and politically popular enough to withstand changes in administration, including by providing direct benefits to communities.

Americans support U.S. global action on climate change

CAP conducted public opinion polling⁴⁹ with research firm GBAO to collect empirical data on American public attitudes toward national security and foreign policy and to identify the principles that resonate with the general public beyond national security experts and opinion elites. The polling found that 93 percent of American voters support working together with allies to address shared global challenges such as climate change. Additionally, 90 percent of voters believe the United States cannot address these problems on its own and must work closely with allies to do so.

This support remains strong across partisan lines, with virtually all Democrats (96 percent), more than 9 in 10 Republicans (92 percent), and almost as many independents (87 percent) saying the United States is safer and stronger working with allies and partners to combat global challenges, including climate change.

Climate policy progress among the states

After President Trump announced his intention to withdraw the United States from the Paris agreement, states representing 55 percent of the U.S. population and 40 percent of U.S. greenhouse gas emissions committed to upholding the Paris agreement's climate goals. Since then, nine states, plus the District of Columbia and Puerto Rico, have announced ambitious plans to transition to a 100 Percent Clean

Future by midcentury, many with strong interim targets to get them on track. Nine of these states and territories have mandated 100 percent clean electricity by statute. Six—California, Hawaii, Colorado, New York, Maine, and New Jersey—have set ambitious economywide emissions reductions targets by 2050.



California: Passed legislation for 100 percent zero carbon electricity by 2045 and executive order for economywide carbon neutrality by 2045.⁵⁰



Colorado: Passed legislation requiring 90 percent emission reductions below 2005 levels economywide by 2050, setting a goal to eliminate emissions by 2050, and requiring large investor-owned utilities to reduce emissions by 80 percent below 2005 levels by 2030. Gov. Polis has put forth a plan to move to 100 percent clean electricity by 2040.⁵¹



Hawaii: Passed legislation for 100 percent renewable electricity by 2045 and economywide goal of being carbon-neutral by 2045.^{52,53}



Maine: Passed legislation for 100 percent renewable electricity by 2045 and economywide reductions of 80 percent by 2050.⁵⁴



Nevada: Passed legislation setting a goal of 100 percent carbon-free electricity by 2045.⁵⁵



New Mexico: Passed legislation requiring 100 percent carbon-free electricity by 2045.⁵⁶



New Jersey: Passed legislation to reduce emissions 80 percent below 2006 levels by 2050 and rejoined the Regional Greenhouse Gas Initiative in June 2019.⁵⁷



New York: Passed legislation requiring 100 percent carbon-free electricity by 2040 and goal of net-zero emissions economywide by 2050.⁵⁸



Washington: Passed legislation requiring 100 percent clean electricity by 2045.⁵⁹



District of Columbia: Passed legislation for 100 percent renewable electricity by 2032.⁶⁰



Puerto Rico: Passed legislation for 100 percent renewable energy by 2050.⁶¹

In considering a successful strategy for action at the federal level, the experiences of some states can help provide lessons for how to create strong coalitions around policy action. Several states have begun to pair 100 percent clean or renewable targets with policies to address toxic pollution in communities and help ensure that new clean jobs are good-paying, high-quality jobs.

While this initial progress is commendable, much more work remains to be done. Environmental justice advocates have raised concerns about how environmental justice and equity issues have been considered and incorporated in New York, New Jersey, and California, for example. At both the state and federal level, greater col-

laboration with environmental justice experts is needed to design climate policies that guarantee pollution reductions in economically disadvantaged communities and communities of color and to address the cumulative and deadly impacts of the history of pollution sources concentrated in these communities. More broadly, policy must take a comprehensive approach, including supporting access to affordable electricity, clean water, and good jobs in every community.

Below are examples of states that have enacted preliminary policies to advance environmental justice and create good, high-paying jobs. The focus here is simply on the enacted policies; this is not an endorsement of or commentary on the merits of any particular state's community or public engagement process, unique on-the-ground dynamics, or coalition activity.

California: In 2017, then-Gov. Jerry Brown (D) signed a bill to extend California's cap-and-trade program through 2030.⁶² In 2018, the legislature passed a law committing the state to 100 percent clean electricity by 2045 and Gov. Brown signed an executive order that same day committing California to economywide carbon neutrality by 2045.⁶³ Alongside expansion of California's cap-and-trade program in 2017, then-Gov. Brown signed AB-617, which requires the California Air Resources Board (CARB) to directly address air quality in communities most exposed to toxic and criteria air pollutants by consulting with environmental justice organizations, affected industries, and other stakeholder groups to prepare a statewide strategy for air quality.⁶⁴

Additionally, shortly after expansion of California's cap-and-trade program, then-Gov. Brown signed the Buy Clean California Act, the world's first legislative action to address carbon emissions from imported manufacturing materials and received strong support from labor unions, business and industry leaders, and environmental organizations.⁶⁵ The Newsom administration has strengthened labor protections in the state's climate program, committing \$35 million per year of California's cap-and-trade revenues in the 2019-2020 budget to two programs focused on ensuring that jobs created by clean energy investment programs are high-quality jobs. These include support for High Road Training Partnerships, which bring together employers, workers, community colleges, other training partners, and community groups to identify regional economic growth trends and investments needed in training to support high-quality jobs in these areas. Recognizing that nearly 60 percent of all jobs created by clean energy investment programs are in the construction trades, the budget also supports a high road construction career ladders program, providing pre-apprenticeships and apprenticeships into multicraft construction careers.

New York: In June 2019, New York Gov. Andrew Cuomo (D) signed the Climate Leadership and Community Protection Act, setting a legislative target of net-zero emissions economywide by 2050.⁶⁶ New York learned lessons from elsewhere and incorporated worker-focused and environmental justice provisions in the bill from the outset. The bill sets the economywide target and then leaves the policy development to be led by a 22-member Climate Action Council, which will appoint advisory panels on particular sectors and topics.⁶⁷ New York’s law states that a minimum of 35 percent of all state climate and clean energy spending, including funds from the Regional Greenhouse Gas Initiative, the state’s Clean Energy Fund, and any future initiatives established by this program go to disadvantaged communities. Additionally, the law creates a climate justice working group with representatives from environmental justice groups, vulnerable industries, and disadvantaged communities, to advise on how to ensure the transition reduces pollution that disproportionately affects low-income communities and communities of color.⁶⁸

The Climate Leadership and Community Protection Act requires the creation of a just-transition working group to advise on workforce training and job impacts. In addition, the New York State Public Service Commission’s offshore wind order includes commitments to project labor agreements and prevailing wages as contract requirements for awarded projects.⁶⁹ As a result of these provisions, labor has supported the offshore wind request for proposals—the projects selected for contract negotiation will feature jobs with salaries of approximately \$100,000.⁷⁰

Washington: In May 2019, Washington enacted one of the strongest state electricity sector legislative policies in the country with a target to phase out coal by 2025; achieve 80 percent clean power sector emissions by 2030; and reach 100 percent clean power by 2045.⁷¹ The bill was part of a comprehensive legislative package designed to significantly reduce greenhouse gas emissions across the economy, including complementary bills to increase energy efficiency in buildings, promote transportation electrification, and phase down hydrofluorocarbons (HFCs). Thanks to Gov. Jay Inslee’s (D) persistence, this package passed successfully despite several previously unsuccessful ballot initiatives to enact a carbon tax.

Implementation of the bill includes completion of a Cumulative Impact Analysis to identify the communities most vulnerable to climate and environmental health impacts. There are provisions for utilities to fund low-income energy assistance programs, such as direct bill reductions, weatherization, energy efficiency improvements, and “direct customer ownership in distributed energy resources.”⁷² The bill also includes a tiered system of 50 to 100 percent sales and use tax exemptions for

projects that meet certain labor requirements, including contracts with women, minority, or veteran-owned businesses, compensation of workers at prevailing wages determined by collective bargaining, and projects developed under a community workforce or project labor agreement.⁷³

Colorado: On May 30, 2019, Gov. Jared Polis (D) signed legislation to set binding statewide greenhouse gas reduction targets of 26 percent by 2025; 50 percent by 2030; and 90 percent by 2050.⁷⁴ Leading up to the signing of this law, the state's largest utility, Xcel Energy, announced a commitment to 100 percent carbon-free electricity by 2050 in Colorado.⁷⁵ This was one of the 11 bills the governor signed, encompassing provisions ranging from the integration of the social cost of carbon in utility decision-making and electric vehicle infrastructure to new building codes and energy efficiency standards for appliances.⁷⁶ The law requires tracking of conventional pollutants from regulated sources and implementation of strategies to reduce pollution in disproportionately impacted communities that have borne the costs of pollution.⁷⁷

The state enacted legislation to create a state Office of Just Transition, with support from the Colorado AFL-CIO.⁷⁸ The office is tasked with aligning and delivering targeted programming and funding to communities and workers impacted by a transition away from coal-fired electricity. The state also enacted plans for community assistance to any local government or school district that will lose revenue due to plant retirements.

An emerging consensus for federal action

In the past year, there has been an emerging consensus at the national level around principles for federal climate action centered on advancing economic, racial, and environmental justice goals and that underscore the importance of including affected voices, including workers and historically disadvantaged communities, in the creation of climate solutions. Coalition platforms have emerged as the result of many months of trust-building, cooperation, and negotiation between groups. And in the past several months, many presidential candidates have put forth ambitious climate change policy platforms.

While they differ in scope and specifics, these platforms and plans have embraced the IPCC target of limiting warming to 1.5 degrees Celsius. The IPCC notes that this goal requires net-zero greenhouse gas emissions globally by around 2050 and net negative emissions thereafter, meaning that a combination of natural carbon sinks and negative emission technologies will be needed to draw historical emissions out of the atmosphere and oceans. The related concept of “pollution free” incorporates all pollution, not only greenhouse gases, and emphasizes that pollution sources must be eliminated and not merely offset by negative emissions elsewhere.

Building upon these platforms and others will be critical to successful climate action at the national level.

Green New Deal

On February 7, 2019, the Sunrise Movement, a coalition of young climate activists around the country, and the Justice Democrats worked with Sen. Ed Markey (D-MA) and Rep. Alexandria Ocasio Cortez (D-NY) to put forth H.Res 109—Recognizing the Duty of the Government to create a Green New Deal.⁷⁹ The resolution calls for a nationwide 10-year mobilization to put the United States on the path to net-zero emissions by 2050. It calls for an inclusive process engaging communities and stakeholder groups, with a focus on American workers and frontline and vulnerable communities.

Solidarity for climate action

On June 24, 2019, the BlueGreen Alliance (BGA) released “Solidarity for Climate Action”—a set of policy principles that reflect a consensus between the eight major labor unions and six prominent national green groups—that represents the first comprehensive plan to address climate change put forward by some of America’s largest unions.⁸⁰ BGA’s platform presents a vision and policy principles to achieve a target of net-zero greenhouse gas emissions by 2050 and advocates for efforts to increase union representation throughout the United States to tackle income inequality that permeates throughout the American economy.

Equitable and Just National Climate Platform

On July 18, 2019, U.S. environmental justice and national environmental groups together released the “Equitable and Just National Climate Platform” through a process that was co-led by the Center for Earth, Energy and Democracy (CEED), CAP, and the Natural Resources Defense Council (NRDC), with support from the Midwest Environmental Justice Network and the New Jersey Environmental Justice Alliance. The platform highlights a shared vision for national climate action that confronts racial, economic, and environmental injustice as it enacts deep cuts in climate and local pollution and accelerates a clean energy future that benefits all communities. The more than 200 signatories believe that the United States must commit to ambitious emission reduction goals and contribute equitably to global efforts to stabilize the climate system by limiting global warming to 1.5 degrees Celsius. The platform calls for the United States to be on this path by 2030 as well as for a policy agenda that builds a more inclusive economy and cuts local pollution in overburdened communities.

Economically disadvantaged communities, tribal communities, and communities of color have historically been marginalized in the development of national climate policies. Confronting the legacies of systemic racism and injustice will require a much closer collaboration with environmental justice advocates to incorporate their perspective and expertise. While there are broad areas of agreement, these communities have well-founded concerns about market-based policy mechanisms, nuclear waste, and carbon capture and sequestration. These and other questions of policy design require stronger dialogue and collaboration to ensure the agenda for climate action achieves pollution-free communities to protect and advance the right of all people “to breathe clean air, live free of dangerous levels of toxic pollution, access healthy food, and share the benefits of a prosperous and vibrant clean economy.”⁸¹

Presidential campaigns

On the campaign trail, many presidential candidates have prioritized bold new goals for climate action that reflect the scale and urgency of the challenge. The proposals signal increasing alignment on achieving net-zero emissions by midcentury, prioritizing a worker-centered transition and environmental justice, and rejoining the Paris agreement. Building on this emerging consensus, candidates have identified a wide range of specific policy levers for climate action across all domestic sectors which together lay the groundwork for an ambitious and effective policy agenda.

Matching principles to policies

The state-level policy successes and the principles in the coalition platforms discussed previously provide solid groundwork upon which to build national policies to aggressively reduce emissions, ensure a path to a worker-centered transition to a clean economy, and reduce or eliminate pollution that has disproportionately affected economically disadvantaged communities and communities of color.

This alignment is extremely encouraging but is just a start. Much more work must now be done to intentionally design policies that achieve racial and environmental justice, build an inclusive economy, and chart a pathway to a stable climate. It is important for coalitions and policymakers to consider the pros and cons of different approaches to carbon pollution mitigation through the lenses of effectiveness; racial, economic, and environmental justice; job creation; and traditional pollution reduction.

What combination of economywide and sector-specific policies will have the fastest timeline for enactment, implementation, and pollution reduction? Can market mechanisms and nonmarket mechanisms be combined in a way that both accelerates overall greenhouse gas emission reductions and guarantees local pollution reductions for all communities, especially those that have historically been overburdened by high levels of pollution? What incentives or other conditions could be applied to the U.S. manufacturing sector to bolster high-quality job creation at home while decarbonizing industries? Can new trade and industrial policies create job and export opportunities for the manufacturing sector at the same time as it decarbonizes?

The next section of this report focuses specifically on the emissions mitigation policies in each sector that will be necessary to achieve net-zero emissions by 2050. This is just one piece of a broader agenda to mitigate emissions; adapt to climate change; advance environmental, economic, and racial justice goals; and create high-quality jobs.

Part 2:

Policies for emission reductions by sector

In Part 2, the Center for American Progress surveys the emission sources in each sector of the economy; proposes specific benchmarks to measure success; and recommends a broad program of international, economywide, and sector-specific policies to deliver on an interim emissions reduction target of at least 43 percent below 2005 levels by 2030 and to achieve net-zero greenhouse gas emissions no later than 2050 and net negative emissions thereafter. This is consistent with the interquartile range for cutting carbon dioxide emissions identified by the IPCC report on 1.5 degrees Celsius.

As discussed in Part 1, mitigation policies are just one part of the larger program that is needed to address the needs of workers and communities disproportionately affected by historic pollution. This paper does not provide a comprehensive treatment of this larger program—which requires the ongoing leadership of the environmental justice and labor movements—but aims to present mitigation policies that are consistent with the broader objectives. Similarly, while this report does not offer a specific investment plan, these policies will need to be supported by trillions of dollars in direct federal spending. Opportunities for job creation and stronger, healthier communities are suggested throughout the following sections for policymakers to further explore and develop in collaboration with environmental justice and labor experts.

Benchmarks for building a 100 Percent Clean Future

The vision for a 100 Percent Clean Future is centered on pollution-free energy, widespread prosperity, and stable global temperatures. By 2050, millions of American workers will be in high-quality jobs, driving the clean energy economy. Homes, schools, and playgrounds in every community, especially those that have historically suffered from pollution, will get the healthy air, clean water, and stable climate that they deserve. Abundant clean electricity sources will serve a responsive network of all-electric appliances and zero-emission vehicles. Communities will be connected by a seamless system of transit and human-centered, smog-free streets. Farmers will be rewarded for restoring degraded soil. American exports of cleanly manufactured goods will dominate the world market. And industrial process emissions will be isolated and diverted into rehabilitated pipelines to be sequestered in shale formations that once supplied fossil fuels.

In this report, CAP outlines a framework for climate change mitigation that prescribes strong economywide greenhouse gas emission targets broken down into sector-by-sector benchmarks, each supported by a wide range of complementary policies. These six sector-specific benchmarks are enough to achieve roughly 90 percent of the emission reductions required by 2030 and 2050. The estimated greenhouse gas emission reductions associated with each of these benchmarks are described in Table 1 and illustrated in Figure 1.

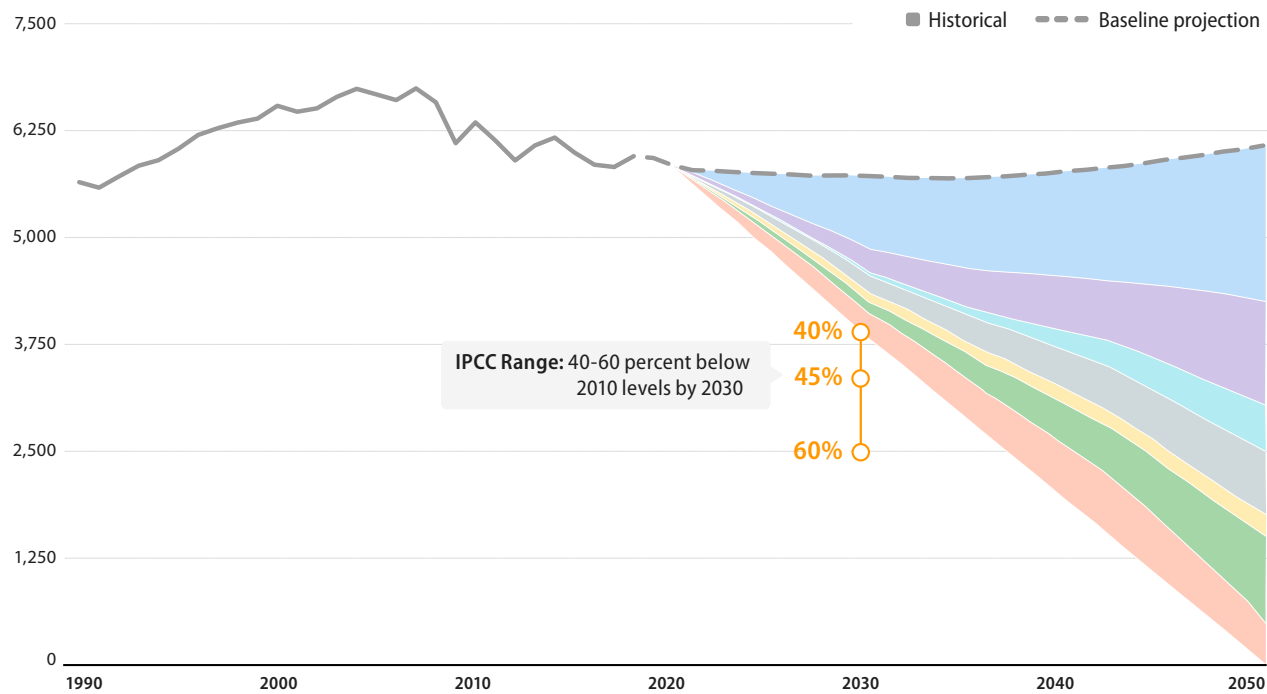
- **Clean electricity.** Achieve at least 65 percent clean generation by 2030 and 100 percent no later than 2050.
- **Electric vehicles and smart growth.** Reduce urban vehicle miles traveled 18 percent below baseline in 2030; reach 100 percent zero-emission sales for new light-duty vehicles no later than 2035; and reach 100 percent zero-emission sales for new medium- and heavy-duty vehicles no later than 2040.
- **Electric appliances and buildings.** Ensure all new buildings and appliance sales are electric and highly efficient by 2035.

- **Clean manufacturing.** Reduce manufacturing sector emissions at least 15 percent by 2030 and set in motion a longer-term technology development and deployment agenda for deep decarbonization.
- **Agriculture and waste.** Invest \$120 billion by 2030 to drive emission reductions, carbon sequestration, and innovation in agriculture.
- **Lands and negative emissions technologies.** Protect 30 percent of America's lands and oceans and adopt climate-smart practices on an additional 100 million acres of farmland and rangeland by 2030. Deploy natural and technological solutions to sequester 1 gigaton of carbon dioxide by 2050.

Additional policies beyond these benchmarks will be necessary to meet the economywide greenhouse gas reduction goals. The report recommends an innovation agenda for research and development, the formation of a National Climate Council within the White House, a price on carbon, and an international strategy of diplomacy, trade, and finance. Additional policies are discussed throughout this paper that contribute to emission reductions above and beyond the six benchmarks, and a section on further improvements identifies even more options for cutting emissions.

FIGURE 2
100 percent clean future benchmarks

Approximate emission reductions from baseline



Change in greenhouse gas emissions by 100 percent clean benchmarks,
as a share of 2005 emissions level

| | 2030 | 2050 |
|--|-------------|--------------|
| Reductions achieved, 2005–2017 | -13% | -13% |
| Projection of current trends, 2018–2050 | -2% | +4% |
| Clean electricity | -13% | -27% |
| Electric vehicles and smart growth | -4% | -18% |
| Electric appliances | -1% | -8% |
| Smart manufacturing | -3% | -11% |
| Agriculture and waste | -2% | -4% |
| Lands and negative emissions technologies | -2% | -15% |
| Further improvements | -5% | -7% |
| Economywide | -43% | -100% |

Source: See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

The role of carbon pricing

Forcing polluters to pay for the harm they cause is the textbook approach to cutting pollution, but no policy to set a price on carbon will by itself be enough to achieve net-zero greenhouse gas emissions, make all communities pollution-free, and drive international action.

Carbon price models show that substantial emissions reductions are possible, especially in the electricity sector, where even just a \$15 per ton fee would cut coal use 68 percent by 2030 and a \$25 per ton fee would cut coal use 89 percent.⁸² However, carbon pricing does not drive the long-term infrastructure and fleet turnover changes that need to begin immediately in the transportation, buildings, manufacturing and land-use sectors. Even in the electricity sector, a carbon price could lock in natural gas infrastructure—boosting consumption 14 percent to 17 percent in the prior examples⁸³—which would complicate the pathway to net-zero by 2050 if not supported by additional policy. Furthermore, a price on carbon does not guarantee pollution reductions in every community and, by itself, could actually increase pollution in neighborhoods that have historically borne the brunt of pollution from refineries, power plants, and highways.^{84 85} Ultimately, the long-term effectiveness of carbon pricing relies on sending a clear signal to guide investment, but as international examples in Australia and Alberta have demonstrated, the reliability of this signal is undermined by the risk of abrupt swings in policy.

Carbon pricing can still be effective as a complementary policy because it can encompass the entire economy—spurring conservation, efficiency, fuel switching, and innovation everywhere and all at once, beyond the scope of targeted sectoral policies. Pricing can also take effect without waiting for years of litigation about administrative procedure and can continuously encourage the invention of ever better systems of emission reduction in every sector. In addition, carbon prices raise revenues that can support other important programs. Even if the Senate continues to allow the abuse of the filibuster, a carbon fee is a clear-cut candidate for enactment under budget reconciliation instructions, which require just 51 votes for passage.

In order to ensure that the program of federal climate policy leads to durable, popular, and sustainable emissions reductions that guarantee the elimination of fossil-fuel related pollution in every community, CAP recommends a combination of a broad price on carbon, a border adjustment tariff, point source emission controls, direct federal investments in infrastructure and research, sector-specific policies, and more. As the IPCC special report on 1.5 degrees Celsius articulated, “While an explicit carbon pricing mechanism is central to prompt mitigation scenarios compatible with 1.5 °C pathways, a complementary mix of stringent policies is required.”⁸⁶ Additional elements of this larger program are discussed in the following sections.

An innovation agenda

For the United States to meet its decarbonization goals and become a global leader in clean technologies, the federal government must significantly increase its climate and energy R&D budgets. In light of a 1.5 degrees target, a working paper by the UNFCCC suggests member countries invest in R&D for climate technologies at levels above the original Mission Innovation goal of doubling investments.⁸⁷ Promisingly, the fiscal year 2020 Energy and Water Development Appropriations Bill that advanced with full bipartisan consensus in the Senate Appropriations Committee in September 2019 proposed increasing energy programs at the Department of Energy by more than 11 percent year over year,⁸⁸ demonstrating the appetite for ambitious congressional funding.

In FY 2016, the federal government spent \$6.4 billion on clean energy R&D across 12 agencies⁸⁹ and \$15.6 billion on climate science and data collection.⁹⁰ With the new 1.5-degree target, the Center for American Progress recommends that Congress triple federal funding for clean energy R&D and climate science across the 13 federal agencies that make up the U.S. Global Change Research Program over five years. Sustaining this higher funding level beyond that would amount to roughly \$570 billion over 10 years between FYs 2021 and 2030. CAP also supports the recommendation of the National Academies of Sciences for up to \$10 billion* in research and development in sequestration technologies and natural carbon sinks over 10 years.⁹¹

To be clear, innovation alone will not solve the climate crisis: Even the most miraculous new technologies will need policy support to spur deployment on fast enough timetables. But to meet the challenges of climate change adaptation, hard-to-decarbonize sectors, and net negative emissions by midcentury, the United States must fund more data collection, policy modeling, scientific analysis, and technology development.

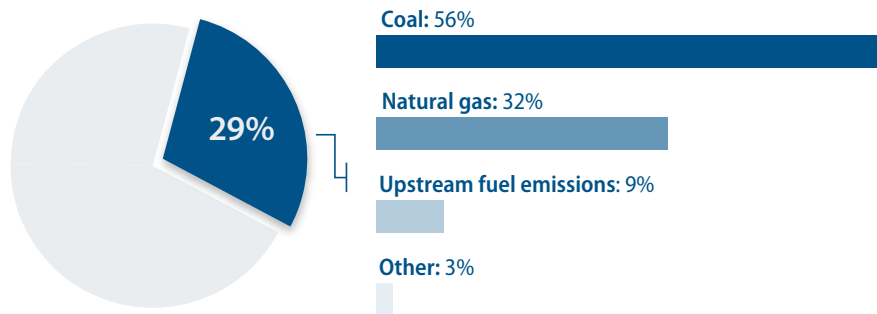
Electricity sector

Benchmark: Achieve at least 65 percent clean electricity generation by 2030 and 100 percent no later than 2050. This would cut economywide emissions by an estimated 13 percent of 2005 levels in 2030 and 27 percent in 2050.

FIGURE 3

U.S. electricity sector

Proportion of economywide emissions and sector-specific breakdown in 2020



Source: Authors' estimates based primarily on U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>. See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

The combustion of coal and natural gas at electric power plants today causes about 29 percent of U.S. greenhouse gas emissions, together with associated emissions from the extraction and transportation of those fuels. These same sources also emit mercury, volatile organic compounds, heavy metals, and particulate matter that contaminate the air, water, and soil of local communities and impair entire regions downwind.⁹² Coal-fired power plants⁹³ and natural gas drilling sites,⁹⁴ in particular, are disproportionately sited near economically marginalized communities and communities of color. Policies that transition away from fossil fuels will address greenhouse gases as well as these other pollutants, but other pollution from this sector, including nuclear waste, will require a separate set of policies.

This sector is already in the midst of a major transformation. In response to wildfire threats, cybersecurity risks, new technologies, and an aging fleet of nuclear reactors, the electricity sector will reinvent itself over the next 30 years. Federal policy will

help determine how. Fossil fuels are already declining as a share of electricity generation. Since 2007, fossil fuels have dropped from 72 percent to 63 percent of electrical generation, on their way to 56 percent by 2050, according to the Energy Information Administration's (EIA) projection of current policy. Even as fossil fuels decline overall, natural gas has significantly eroded the market share of coal. Since 2003, coal has dropped from 51 to 27 percent of electrical generation.⁹⁵ Of all sectors of the economy, the electricity sector is most ready for a complete transition away from fossil fuels, both economically and politically.

This shows up in the jobs numbers. Within electricity generation, clean electricity jobs outnumber fossil fuel power plant jobs by a 3-to-1 margin.⁹⁶ Jobs in wind and solar installation are the two fastest growing occupations in the whole economy.⁹⁷ A Stanford study showed that if every conventional energy source were replaced with renewables, it would result in a net job growth of 2 million jobs in construction and operations.^{98 99} Complementary policies will be needed to ensure that the new jobs in this sector are high-paying unionized jobs and that workers in fossil fuel industries are supported through pension guarantees, access to healthcare, and training for new jobs in their own communities.

Electricity costs generally impose a disproportionate financial burden on low-income communities.¹⁰⁰ In a future where an increasing share of the economy's energy use is electric, the affordability of electricity will be all the more important. Policies such as income-based subsidies, solar cooperatives, and energy efficiency programs intentionally designed to serve low-income residents can help alleviate this burden and support community wealth building.

In a 100 Percent Clean Future, electricity will be clean, reliable, and affordable. Everything that can run on electricity will, whether directly from the grid or a battery or indirectly through hydrogen created by electrolysis. Electricity generation will depend on renewable resources, balanced by a mix of demand response, energy storage, expanded transmission networks, natural gas with carbon capture and sequestration, or other potential innovations, such as load-following nuclear, as determined by market forces and state-by-state regulatory decisions. The electricity system will be unconstrained by fuel costs, have no single points of failure, and be built from the ground up to ensure cybersecurity.

This report recommends several federal policies to spur the transition to emissions-free sources for electricity generation, discussed below.

- **Clean electricity standard.** Several states have had success in enacting mandates for clean electricity. Some standards require compliance using only renewables, but many states have found it possible to enact stronger standards by broadening compliance to any emissions-free source. Altogether, nine states or territories have enacted 100 percent clean or renewable electricity standards by 2050 or sooner.¹⁰¹ Clean electricity standards have been more widely adopted by the states than economywide policies, perhaps because they focus voters on solutions rather than the price of action. With a clean electricity standard, it is possible to guide long-term investment and guarantee at least 65 percent emissions-free electricity by 2030 and 100 percent by 2050 or sooner.¹⁰² Substantial additional emission reductions could be achieved if it is possible to accelerate the deployment of clean electricity even faster.
- **Directed spending.** Investment and production tax incentives have demonstrated extraordinary success in accelerating the deployment of renewable energy in the past decade. These tax incentives could be extended and expanded through reconciliation or as part of must-pass legislation to include energy storage and any other innovative technologies that support decarbonization. As a way of further targeting these tax incentives for renewable energy, CAP has argued for extending them in the form of grants in lieu of taxes, patterned on Section 1603 of the American Recovery and Reinvestment Act, which could reduce emissions 504 million metric tons (MMT) CO₂e in 2030 relative to the baseline at a cost of less than \$15 per ton.¹⁰³
- **Carbon price.** The electricity sector would be very responsive to a price on carbon. The EIA's Annual Energy Outlook for 2018 found that a carbon price of \$25 per ton would cut electricity sector emissions 55 percent by 2030 relative to their reference case, for example.¹⁰⁴ Even a price of just \$15 per ton is expected to cut coal-fired power plant generation by two-thirds from 2020 to 2030¹⁰⁵.
- **Emissions controls for power plants.** The EPA has the authority and mandate to impose strict emissions requirements on pollution from fossil fuel-fired power plants, including new and existing natural gas and coal power plants. While it is unlikely that new coal power plants will be built, natural gas generation is projected to grow. In the absence of such requirements, if natural gas prices continue to be low through the mid-2020s, the Rhodium Group research firm warns that they pose a serious threat to climate goals over time.¹⁰⁶ Even under a \$25 per ton price on carbon, the EIA estimates that natural gas would grow as a share of electricity to 42 percent by 2030,¹⁰⁷ displacing not only coal but also nuclear and delaying the deployment of renewables and energy storage. Strong emissions controls such as carbon capture and sequestration for new power plants at the outset would eliminate the risk of locking in new natural gas infrastructure that would need to be retired prematurely or retrofitted by midcentury.

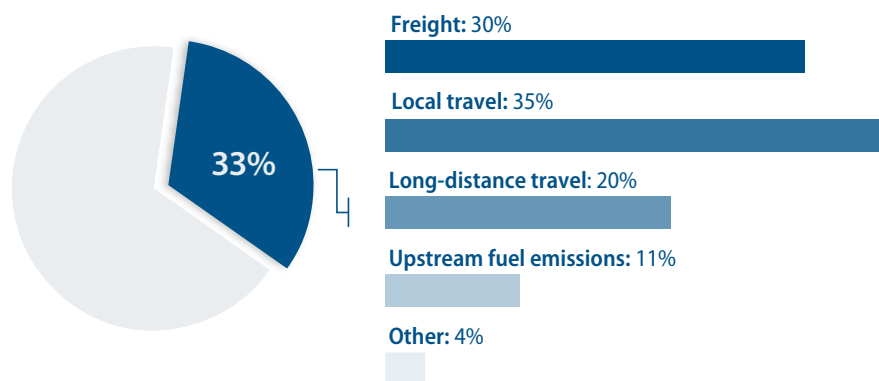
Transportation sector

Benchmark: Reduce urban vehicle miles traveled 18 percent below baseline in 2030; reach 100 percent zero-emission sales for new light-duty vehicles no later than 2035; and reach 100 percent zero-emission sales for new medium- and heavy-duty vehicles no later than 2040. This would cut economywide emissions by an estimated 4 percent of 2005 levels in 2030 and 18 percent in 2050.

FIGURE 4

U.S. transportation sector

Proportion of economywide emissions and sector-specific breakdown in 2020



Source: Authors' estimates based primarily on U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>. See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

The combustion of gasoline, diesel, and other fossil fuels in transportation, military, and construction vehicles today causes about one-third of U.S. greenhouse gas emissions, together with associated emissions from the extraction and transportation of those fuels. As a sector, this constitutes the largest share of greenhouse gas emissions in the U.S. economy. The combustion of these fuels contributes to smog; releases carcinogens such as benzene; and contaminates the air, water, and soil¹⁰⁸ of the communities near highways, railyards, and ports,¹⁰⁹ which are disproportionately low-income and communities of color.¹¹⁰ Phasing out the use of petroleum will address greenhouse gases as well as toxic pollutants, but additional policies will be required to clean up legacy pollution, including the neurotoxin lead that for decades was added to gasoline and still contaminates soil today.

Because vehicles are long-lived assets, vehicle fleets take a long time to turn over and incorporate new technologies. The built environment is even slower to change; buildings built before the year 2000 will still represent roughly half of all buildings in the United States in 2030,¹¹¹ for example, locking in patterns of land use sprawl and transportation demand.

TABLE 1
Emissions vary by mode of transportation

Comparison of transportation metrics and MMT CO₂* in 2017

| | Million person-trips | | Emissions | |
|---|----------------------|-------------|--------------|-------------|
| Urban or suburban driving | 254,373 | 69% | 622 | 51% |
| Rural driving | 43,626 | 12% | 106 | 9% |
| Walking or biking | 42,522 | 12% | 0 | -- |
| Bus or rail | 17,225 | 5% | 15 | 1% |
| Boating or ferries | 176 | <1% | 16 | 1% |
| Local travel (≤ 40 miles) | 357,923 | 97% | 760 | 63% |
| Driving | 10,432 | 3% | 306 | 25% |
| Bus or rail | 532 | <1% | 0.47 | <1% |
| Air travel | 639 | <1% | 144 | 12% |
| Long-distance travel (> 40 miles) | 11,604 | 3% | 451 | 37% |
| Travel | 369,528 | 100% | 1,212 | 100% |
| | Billion ton-miles | | Emissions | |
| Trucking | 2,023 | 48% | 450 | 75% |
| Freight rail | 1,674 | 40% | 36 | 6% |
| Shipping | 489 | 12% | 79 | 13% |
| Air cargo | 14 | <1% | 34 | 6% |
| Freight | 4,201 | 100% | 600 | 100% |

* Emissions are measured in MMT CO₂e, or million metric tons of carbon dioxide equivalent.

Source: Authors' interpretation of Federal Highway Administration, "National Household Travel Survey 2017 Data" (Washington: U.S. Department of Transportation, 2018), available at <https://nhts.ornl.gov/>; U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>; and Bureau of Transportation Statistics, "Freight Transportation: Description of BTS Freight Data Program," available at <https://www.bts.gov/topics/freight-transportation> (last accessed September 2019).

The emissions impact of transportation varies greatly by mode, as is evident in Table 1. For example, rail transports 80 percent as much freight as trucks with only 8 percent as much carbon pollution. When it comes to the movement of people, long-distance travel by car or airplane represents only 3 percent of trips but more than 37 percent of emissions. Walking, bicycling, transit and commuter rail today provide nearly one-sixth of all local trips with hardly any emissions.

With 100 percent clean energy, people will still make these trips and receive these shipments as part of a healthy economy and a vibrant society but will be able to do so without producing emissions. There are a variety of strategies to accomplish that shift—primarily, vehicle electrification and smart growth—but not every strategy fits every context. Solutions need to be tailored to suit the diverse transportation needs underlying this pattern of emissions.

This section discusses policy options for the transportation sector in three categories: vehicle electrification, smart growth, and industry-specific policies.

Policy options for vehicle electrification

There are more than 1 million zero-emission vehicles (ZEVs) in the U.S. fleet already today, with another 1 million more expected to be added by 2021.¹¹² However, even as production accelerates, it will take considerable time to replace the 270 million cars, trucks, motorcycles, and buses in the fleet. The average light-duty vehicle lasts for 12 years, and phasing out the last of the oldest models takes even longer. According to data from National Renewable Energy Laboratory’s (NREL) Electrification Futures study, even if every new car or SUV sold were an electric vehicle, it would take 10 years for the fleet to reach 70 percent electric and 15 years for the fleet to reach 90 percent electric.¹¹³ This transition needs to be completed around 2050, so there is no time to waste.

Replacing every vehicle in the country on an accelerated timetable will create jobs, which federal policy and early investment can help ensure will be domestic, unionized jobs drawn from a well-trained workforce. Even more jobs will be created in building out the nationwide network of charging infrastructure.¹¹⁴

This report recommends several federal policies to accelerate the deployment of zero-emission vehicles.

- **ZEV sales standard.** A California-led program requiring automakers to gradually increase the ZEV share of new vehicle sales has been adopted by nine other states and is now on firmer footing after several automakers agreed to respect California’s program, even in the face of the Trump administration’s efforts to assert preemption.¹¹⁵ By 2026, the sales of zero-emission vehicles are projected to reach more than one million annually, or approximately 12 percent of all new vehicles sold nationwide by 2026.¹¹⁶ A federal ZEV standard for new car sales would build on state-level successes and ensure that the benchmark set by the states is the floor

for deployment, leading to 100 percent new light-duty vehicle sales by 2035. If this transition can be accelerated, significant additional emission reductions are possible. During this transition, fuel economy standards for internal combustion engines should continue to be strengthened. Ambitious new vehicle standards would employ existing technologies and support electrification, which could reduce per vehicle emissions by half from 2016 levels by 2030, according to the International Council on Clean Transportation.¹¹⁷

- **Cash-In for Clean Cars.** At the current rate of vehicle replacements, about 10 percent of the fleet in 2050 would still run on fossil fuels even if all sales were fully zero-emission as early as 2035. That is why the United States must enact policies that also accelerate the removal of inefficient, fossil-based vehicles from the road. An accelerated fossil fuel trade-in program would take the form of an improved ZEV tax incentive that requires the trade-in and scrapping of an old on-road fossil fuel-based car or truck at the time of sale of a ZEV. If designed correctly, this could help low-income households afford new and used vehicles as well as domestic automakers that benefit from accelerated production volumes. According to the Department of Transportation, there are more than 50 million light-duty vehicles on the road that are older than 15 years,¹¹⁸ At the time of sale, these vehicles averaged only 22 to 23 miles per gallon, with the lowest fifth percentile averaging 17 to 19 miles per gallon.¹¹⁹ CAP estimates that providing incentives equivalent to \$9 billion annually, targeted at accelerating the scrapping of the least efficient vehicles, could result in emissions reduction of 81 MMT CO₂e annually by 2030, not accounting for the added benefit of promoting greater ZEV sales. This program could plausibly be enacted as part of a must-pass legislation or reconciliation.
- **ZEV tax credits.** Today's tax credits for the purchase of zero-emission vehicles phase out for individual manufacturers once they have sold their first 200,000 vehicles, which penalizes the companies who are moving fastest to expand production. General Motors and Tesla have already hit this limit.¹²⁰ Several bills in Congress have been proposed to increase or eliminate this cap, which would support uninterrupted production at this early phase in the technology's deployment.
- **Plug-in electric vehicles (PEVs) charging infrastructure.** Americans will need a convenient, accessible, and reliable network of grid-integrated EV charging infrastructure. There are currently around 22,000 Level 2 and DC Fast electric charging stations in the United States, compared to over 111,000 traditional gas stations.^{121 122} A 2018 CAP report found that the United States would need to install more than 330,000 additional charging outlets to support the 14 million PEVs required to reach the country's Paris agreement-mandated nationally determined contribution

(NDC).¹²³ The rate of public charging infrastructure deployment must be even more ambitious to meet the 1.5 degrees Celsius goal. In a paper published in September 2019, CAP recommended a 30 percent grant-in-lieu investment tax credit for the installation of EV charging infrastructure through 2025, declining to 15 percent by 2030.¹²⁴ This should be supported by complementary incentives to upgrade electric panels in homes; equip parking spaces in areas without private garages; and prepare distribution systems in rural areas. The federal government should proactively plan and fund the installation network to encourage efficient corridors and equitable access for rural areas and historically underserved communities.

Policy options for smart growth

In most of the country, the only choice for getting around is to drive. But for the 97 percent of trips that are local (less than 40 miles),¹²⁵ smart transportation and housing development can multiply the opportunities to access jobs, stores, and homes using transit, commuter rail, sidewalks, and protected bike lanes, with fewer and shorter trips by automobile. Smart growth is an approach to development that encourages a mix of building types and uses; diverse housing and transportation options; development within existing neighborhoods; and community engagement.¹²⁶ This offers freedom of choice in travel, reduced traffic congestion, healthier local communities, and significant greenhouse gas emission reductions.

Reducing vehicle miles traveled is an important emissions reduction strategy. Even in a scenario of complete electrification of vehicles by 2050, only 5 percent of the fleet will likely be electrified by 2030,¹²⁷ which means that any reduction of vehicle miles traveled will translate directly into a reduction in petroleum consumption. Reducing the demand for energy from the transportation sector will also ease the burden of increasing electricity on the grid. Moreover, smart growth makes lasting changes in the built environment that cannot be undone with the stroke of a pen or a change in fuel prices.

According to a conservative estimate from the Transportation Research Board, smart growth can reduce vehicle miles traveled nationwide 8 percent by 2030 and 11 percent by 2050 below the business-as-usual baseline.¹²⁸ Because these changes would happen primarily for local trips in urbanized areas, this reduction implies an 18 percent reduction in vehicle miles traveled in urbanized areas by 2030 and a 25 percent reduction by 2050.¹²⁹ There is good reason to believe that even greater improvements may be possible.¹³⁰

It is important to note that smart growth does not mean forcing every community into a single mold. Quite the opposite—smart growth means breaking the mold of zoning restrictions, parking minimums, and highway dependency so that regions can plan new investments based around people rather than motor vehicles. In small towns, it means restoring main streets to their role as commercial and social centers for the community. In the suburbs, it means connecting children to their schools with sidewalks and offering carpooling or rail service so that commuters can beat the traffic on the way to work. In cities, it means increasing in-fill development to keep housing prices down; building a network of protected bicycle lanes and pedestrian street crossings; revitalizing mixed-use zoning to make neighborhoods balanced; and world-class transit service.

Moreover, urban reinvestment that fails to increase the availability of affordable housing cannot be considered smart growth. Displacing residents from dense, transit-served neighborhoods to marginal, auto-dependent areas will increase emissions,¹³¹ and disrupting communities or dislocating families in any way will exacerbate poverty and break social bonds. Policy at all levels must prioritize inclusive local economic development that supports and strengthens communities.

While smart growth is largely a function of state and local decision making, there are several important federal policies that can help to encourage smart growth, described below.

- **Equalize funding for new roads and transit.** The federal government currently subsidizes 80 percent to 100 percent of the cost of a new highway, almost solely at the discretion of state departments of transportation. In contrast, new transit projects require a multiyear administrative review with multiple approvals by Congress and a restriction of no more than 50 percent federal funding. Highway funding is subsidized by general fund transfers, which have kept the Highway Trust Fund afloat since 2008 as gas tax revenues fail to meet the federal government's obligations, even just for the maintenance and repair of existing roads and bridges. Total new highway capacity in urbanized areas should receive no more federal support than new transit service, and each new highway capacity project should receive at least as much scrutiny in terms of their impact on safety, land use, and emissions as new transit projects do. Without this scrutiny, new highway capacity will continue to induce new highway traffic.¹³²
- **Federal funding for smart growth.** The federal government provides the states with more than \$40 billion annually for highway programs, with very few strings attached. States and metropolitan planning organizations should be rewarded for gradual reductions in vehicle miles traveled and gradual improvements in access

to destinations, which is a better measure of system performance than vehicle throughput. At the same time, federal funding should allow states more flexibility to control vehicle miles traveled with user fees and congestion prices, provided that any surplus revenues are dedicated to transit service in the same corridor.

Policy options for specific transportation industries

Certain transportation industries will not be fully decarbonized by vehicle electrification and smart growth strategies. These include aviation (3.1 percent of U.S. greenhouse gas emissions); shipping (1.4 percent); construction (0.8 percent); military transportation (0.7 percent); freight rail (0.6 percent); and, to some degree, long-haul trucking (7.8 percent). These industries will require thoughtful industry-specific decarbonization policies. Further research and regulatory analysis is required to create comprehensive roadmaps for these transportation industries, and there are several federal policy levers that need to be considered.

- **Aviation.** Demand for long-distance transportation will need to be satisfied by an alternative to petroleum-based jet fuel—not by ending air travel. Hybrid electric systems are expected to make inroads and pure-electric aircraft may prove viable for smaller planes traveling on short routes.^{133 134} However, the most promising pathway for decarbonization is the substitution of advanced carbon-free liquid fuels for jet fuel.¹³⁵ Several airlines have already announced plans for commercial operations with biofuels.¹³⁶ The Clean Air Act requires the direct regulation of this industry to accomplish these changes, given EPA's endangerment finding in 2016.¹³⁷ To maximize the global impact of these regulations, the United States should push the International Civil Aviation Organization to develop post-2028 international emissions standards for aircraft¹³⁸ with a requirement for direct emissions reductions without offsets.
- **Shipping.** The shipping industry's size, operational flexibility, and access to capital create numerous opportunities for major, near-term emission reductions. According to a study from the International Transportation Forum (ITF),¹³⁹ it may be possible to cut global shipping emissions by over 90 percent below projected emissions by 2035 through a combination of ship design, operational efficiencies, and low-carbon fuels. This includes building ships with light-weight materials, more slender designs, and better propulsion; lowering operating speeds and reducing wait times at ports; and the use of advanced biofuels, methanol, ammonia, or hydrogen. To maximize global impact, the United States should push the International Maritime Organization to implement the recommendations of the ITF study. In addition, the

EPA and the Departments of Transportation and Labor should study local “green port” initiatives¹⁴⁰ to promote best practices for electrification, on-dock rail, and maximizing the reduction of local air pollutants for surrounding communities.

- **Construction.** This report considers all construction emissions here, though the sources include petroleum-based fuels used in both construction vehicles and on-site diesel generators. Approximately one-third of these emissions are from the construction of buildings; one-quarter from civil engineering; and the remainder from specialty trades such as plumbers, electricians, and site preparation contractors.¹⁴¹ Potential emission reduction strategies include reducing idling; switching to biodiesel; replacing diesel generators with grid electricity or solar generators; and continued research and development of more efficient hydraulic systems.¹⁴²
- **Military Transportation.** Under the Obama administration, the Department of Energy, the Department of Agriculture, and the Navy worked with private industry starting in 2011 to support the development of a commercial biofuels industry to reduce the risks of petroleum dependence for both the Department of Defense and the private transportation sector.¹⁴³ Under the authorities of the Defense Production Act, the Navy conducted a feasibility demonstration of drop-in biofuels at the end of 2012 and the 2016 “Great Green Fleet” exercise, which featured ships and aircraft powered in part by biofuels.¹⁴⁴ These are good examples of administrative action to drive the development and adoption of new technologies.
- **Freight Rail.** Although freight rail currently runs on diesel, it is substantially more efficient than trucking, carrying 40 percent of the U.S. freight ton miles with only 6 percent of U.S. freight emissions. Redirecting a higher share of freight shipments to rail would save emissions. This could be supported through the construction of on-dock rail at ports to seamlessly transfer containerized goods from ships;¹⁴⁵ rebuilding rail network links; and restoring highway user fees to a level that is once again sufficient to support the Highway Trust Fund without requiring perennial bailouts from taxpayers. In the long-term, further research is required to understand the potential for full decarbonization of freight rail, perhaps through advanced carbon-free liquid fuels; overhead catenaries to provide electricity; or technologies similar to the battery-powered electric multiple unit train sets that are increasingly popular with passenger rail.
- **Trucking.** There is substantial potential to electrify the trucking industry through the same policies discussed earlier. The NREL Electrification Futures study found that the high-deployment scenario for electric heavy-duty trucks could reach 13 percent of sales and cut fleet emissions by 6 percent by 2030. The remaining energy demand

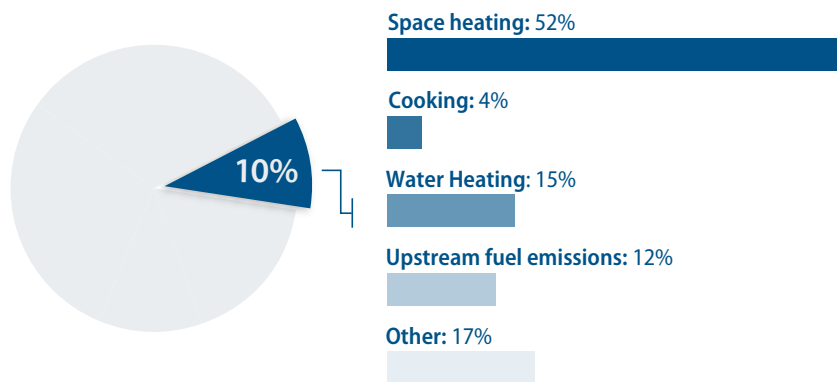
that is not electrified could be supplied by advanced carbon-free fuels or transferred to rail. The NREL maximum electrification potential scenario showed that reaching 100 percent ZEV sales would cut fleet emissions roughly 90 percent within 10 years, implying near full decarbonization if ZEV trucks can reach 100 percent of sales by 2040. One deficit-neutral policy change that could hasten this transition and benefit independent truck owner-operators would be to eliminate—for zero-emission trucks—the 12 percent excise tax currently applied to a new truck’s sale price and replace the lost revenue for the Highway Trust Fund by raising the diesel tax.¹⁴⁶

Buildings sector

Benchmark: The Center for American Progress recommends ensuring that all new buildings and appliance sales are electric and highly efficient by 2035. This would cut economywide emissions by an estimated 1 percent of 2005 levels in 2030 and 8 percent in 2050.

FIGURE 5
U.S. buildings sector

Proportion of economywide emissions and sector-specific breakdown in 2020



Source: Authors' estimates based primarily on U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>. See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

Houses, stores, offices, restaurants, and all other buildings together consume about 38 percent of the energy used in the United States and produce 10 percent of U.S. greenhouse gas emissions. This discrepancy is because almost half of the energy used by the buildings sector is already electrified, including nearly all air conditioning, ventilation, lighting, refrigeration, washing machines, and electronics.

Much more can be done to reduce emissions in the buildings sector. Electricity is used for only 11 percent of space heating, 27 percent of water heating, 23 percent of cooking, and 85 percent of clothes drying. All other energy uses in the buildings sector, such as district heating for commercial buildings, together run about two-thirds on electricity. The remaining energy demand, along with associated greenhouse gas emissions, is supplied mainly by natural gas, propane, and home heating oil.¹⁴⁷

Electric appliances have the potential to virtually eliminate these older, fossil-fuel based alternatives. This includes highly efficient heat pumps that provide air conditioning in the summer and heating in the winter; programmable or even tankless electric water heaters; and induction cooktops. Full adoption of electric appliances would eliminate natural gas utility bills in residential and commercial buildings altogether, and each of these appliances has advantages over its fossil-fueled alternatives. However, transitioning the nation's appliance stock will take time.

Energy efficiency is an important strategy to complement electrification because it provides additional emission reduction benefits until the sector is fully electrified, which will likely be after 2050, when the long-lived building stock fully turns over. Energy efficiency reduces costs for consumers and lessens the load growth for the electricity sector. Better building envelope insulation and proliferation of technologies such as LED light bulbs and efficient appliances are already helping this sector to realize its energy efficiency potential. Additional improvements to manage the timing of energy demand, such as through programmable thermostats and water heaters, can reduce the peak electricity demand even further and complement ever-higher penetration of intermittent renewable power sources on the grid. Cool, green, and white roofs have the potential to abate the heat island effect and reduce electricity demand in buildings.^{148 149} Altogether, adoption of existing technologies could cut building emissions up to 50 percent if fully deployed.¹⁵⁰ On the job creation side, energy efficiency is already the source of the largest job gains of all energy sectors and holds immense promise for further job creation with the implementation of ambitious policies to meet this potential.¹⁵¹ Implementing these high standards and retrofitting old buildings will make the entire housing stock not only more efficient but healthier and more affordable for all communities.

The buildings sector also holds the potential to support the carbon sequestration efforts discussed elsewhere in this paper by switching to sustainably sourced wood and other low-carbon building materials, thus spurring demand for climate-smart forestry practices.

Retrofitting all existing buildings and instituting new buildings codes also creates a once-in-a-generation opportunity to correct the legacy pollution within buildings. Replacing natural gas with electricity will reduce sources of carbon monoxide and formaldehyde, improving indoor air quality.¹⁵² Financial support for retrofitting existing buildings will also support the remediation of lead paint and pipes, asbestos insulation, and other hazardous materials and promote adequate ventilation.^{153 154}

This report recommends several policies to promote energy efficiency and electrification in the buildings sector.

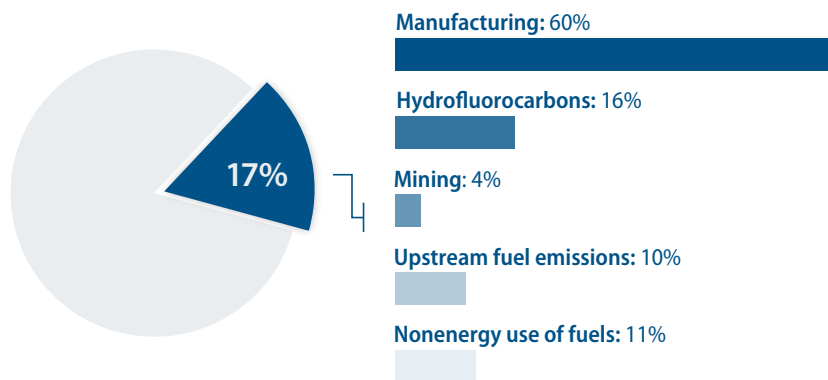
- **Federal building electrification and energy efficiency mandate.** Although federal buildings make up a small share of total floor space in the United States, an executive order mandating complete electrification; full energy efficiency retrofits for existing buildings; and a net-zero design for all future construction would provide model solutions for the rest of the sector.
- **A National Energy Efficiency Resource Standard (EERS).** A national EERS is a prescribed energy savings goal, set as an annual percent reduction or a multiyear reduction target to be met by utilities. A national EERS reduction target on electricity and natural gas sales readily corresponds to quantifiable savings in carbon emissions, air pollution, and energy bills. In addition, a national EERS holds the potential for job creation, as it would expand the market for energy efficiency goods and services by crystallizing the long-term market outlook. For example, a national EERS proposal introduced to Congress this year calls for 22 percent retail electricity savings and 14 percent retail natural gas savings by 2035.¹⁵⁵ The American Council for an Energy-Efficient Economy estimates that, if passed and implemented, the EERS would result in carbon emission avoidance equivalent to the annual energy use of 700 million homes as well as an addition of 400,000 jobs.^{156 157} In addition, the next administration must restore lighting and appliance standard setting at the Department of Energy.
- **Incentives for better building codes.** Building codes generally fall under the purview of state and municipal jurisdictions, but the federal government can encourage the adoption of codes that support stricter efficiency standards, electrification, and low-carbon building materials such as cross-laminated timber. The U.S. Department of Energy's State Energy Program (SEP) should provide technical assistance to states in writing more ambitious building codes.
- **Funding for Building Electrification and Efficiency.** The Energy Efficiency and Conservation Block Grant Program, funded by the American Recovery and Reinvestment Act (ARRA) and operated by the Department of Energy until 2015,¹⁵⁸ should be reinstated and expanded to encourage distributed renewables and electrification. Funding could be set aside for the fastest improving states to encourage a race to the top for energy efficiency and building electrification.

Manufacturing sector

Benchmark: Reduce manufacturing sector emissions at least 15 percent by 2030 and set in motion a longer-term technology development and deployment agenda for deep decarbonization. This would cut economywide emissions by an estimated 3 percent of 2005 levels in 2030 and 11 percent in 2050.

FIGURE 6
U.S. manufacturing sector

Proportion of economywide emissions and sector-specific breakdown in 2020



Source: Authors' estimates based primarily on U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>. See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

Compared to power, transportation, and buildings, the industrial sector is home to a much more diverse range of processes, materials, and applications that contribute to climate change. This section considers emissions from fuel combustion as well as energy feedstocks and process emissions from the production of chemicals, plastics, metals, glass, cement, paper, machinery, vehicles, electronics, fertilizer, food products, and more. Together with the upstream emissions from the associated supply of fossil fuels, these activities constitute more than one-sixth of U.S. greenhouse gas emissions. Industrial processes also produce toxic waste, particulate matter, volatile organic compounds, and other pollutants, some but not all of which are associated with fossil fuels.¹⁵⁹

More than 12.8 million Americans work in manufacturing, but this represents a shrinking share of overall U.S. employment.¹⁶⁰ Increasing automation has allowed manufacturing firms to boost output without hiring more workers.¹⁶¹ And the offshoring of jobs to low-wage countries, such as China, has contributed significantly to the shrinking U.S. manufacturing base.¹⁶² Building a clean manufacturing sector is an opportunity to restore American manufacturing jobs, and policy must ensure these are good-paying, high-quality jobs.

Despite these trends, the federal government and states have invested relatively little in technology development and policy effort to reinvent the industrial sector. For example, while clean energy R&D budgets at the Department of Energy have hovered around \$4 billion per year, the FY 2019 budget for the Advanced Manufacturing Office is just \$320 million.¹⁶³

Unlike other sectors, where comprehensive suites of competitive zero-emission technologies exist and need additional policy supports to accelerate deployment, there is a relatively limited set of existing technology solutions for manufacturing and the industrial sector more broadly. Electrification; energy efficiency; the use of alternative feedstocks such as biofuels and hydrogen; and carbon capture, utilization, and storage all hold promise, “but much greater diversity of processes and high levels of process integration make solutions more complex,” as the Lawrence Berkeley National Laboratory wrote in a study of electrification solutions for industry.¹⁶⁴ This means that failing to robustly support the development and deployment of clean manufacturing alternatives would lead to offshoring—putting American workers out of a job; increasing countries’ dependence on Chinese-made technologies; and driving up global carbon pollution.

As the United States reinvents the manufacturing sector and its processes to cut greenhouse gas emissions, it must also cut other industrial pollution from existing plants and ensure that new sources of industrial pollution will not be concentrated in communities of color.

With the right actions now on trade and industrial policy, the United States manufacturing sector will employ millions of Americans in high-wage, high-skill jobs, making clean energy technologies for use at home and abroad by 2050. Energy efficiency and on-site renewable energy generation will help reduce the industrial sector’s demands on the electric grid, even as more equipment is electrified inside manufacturing plants. Goods invented and made in America will dominate the \$23 trillion clean energy market, helping countries around the world achieve their

own clean energy transitions¹⁶⁵ without the cyberespionage fears that recently have accompanied Chinese company Huawei's dominance of 5G mobile telecommunications infrastructure.¹⁶⁶ Pipeline workers who today build and maintain oil and gas pipelines will be working on hydrogen and pipelines for the sequestration of captured carbon dioxide, making similarly high wages and continuing to enjoy union protections. Multinational corporations will have embraced circular production models, recycling and reusing materials to reduce strains on natural resources.

There are several policy strategies that could be implemented immediately to deliver longer-term emission reductions from the manufacturing sector.

- **Launch an all-of-government clean industry initiative. The next decade is critical** for accelerating research and development of clean manufacturing technologies, testing and scaling zero-emission solutions for the industrial sector so that major emissions reductions from the sector can be achieved in the 2030 to 2050 period. As part of must-pass legislation, the next Congress should create and fund a new assistant secretary of energy for manufacturing and industry, who would oversee an ambitious research, development, and deployment initiative, including partnerships with manufacturers to pilot and deploy low-carbon manufacturing and industrial technologies. Areas of focus for such a research, development, and deployment agenda should include developing low-cost decarbonized industrial technologies, such as low-cost, low-capacity factor hydrogen electrolysis powered by intermittent renewable energy; utilization of captured atmospheric carbon to reduce the life cycle emissions of carbon-intensive materials such as cement; feedstock substitutions for greenhouse gas intensive processes; near-term deployment of electric and hybrid boilers for low-heat processes; and development of next-generation materials substitutes. Industry adoption of products, technologies, and materials developed with support from federal research and development dollars could be promoted through Economic Development Assistance grants from the Department of Commerce and targeted manufacturing supports within the Department of Energy, including the loan and loan guarantee programs. Such a program—combining financing support, supportive partnerships with manufacturers, and ambitious research and development—should enable both near- and long-term emissions reductions from industry.
- **Phase down HFCs and accelerate production of HFC alternatives.** In 2016, countries including the United States finalized the Kigali Amendment to the Montreal Protocol to freeze and then phase down hydrofluorocarbons HFCs worldwide 85 percent by 2036. Because HFCs trap 10,000 times more heat than carbon dioxide, eliminating them worldwide could prevent as much as half a degree Celsius of global

warming by the end of the century. American industry has been urging ratification of this agreement, and there is strong bipartisan support to proceed, including from 13 Republican senators.¹⁶⁷ In 2017, the U.S. Court of Appeals struck down the EPA's Significant New Alternatives Program (SNAP) rules for HFCs, which aimed to reduce HFC emissions by 30 percent, or up to 162 MMT CO₂e per year.¹⁶⁸ However, American industry and a broad bipartisan coalition seek to get the United States back on track. This should include submitting the Kigali Amendment to the Senate for ratification and Congress making more explicit EPA's authority to regulate HFCs through report language or other measures. And the EPA and Department of Energy should pursue additional regulatory pathways to cut HFCs at least 50 percent by 2030, in line with the Kigali Amendment, which envisions 85 percent HFC reductions by 2036.¹⁶⁹ At the same time, through the clean industry initiative and federal building retrofit programs, the Department of Energy and EPA should support programs to find and dispose of existing stocks of HFCs and support accelerated production of climate-safe HFC alternatives. A recent report from CAP found that \$10 billion to create a reverse credit auction at EPA to incentivize private operators to destroy HFC stocks, combined with requiring government contractors to recover and destroy HFCs from appliances when retrofitting public and residential buildings, would result in up to 80 MMT CO₂e reductions by 2030.¹⁷⁰

- **Incentivize high-efficiency equipment and deep factory retrofits.** In manufacturing sectors that are less dependent on high-heat processes such as food and beverages, increased electrification, energy efficiency, and building efficiency can help reduce emissions from industry, even in the 2020 to 2030 time period. For instance, for processes that require heat below 100 degrees Celsius, electric heat pumps can be substituted for boilers—which are in fact more efficient.¹⁷¹ Hybrid boilers—which can alternate between natural gas or biogas feedstocks and electric power—are also a promising near-term solution for reducing emissions from low- and medium-heat industrial processes and can even serve as energy storage solutions to facilitate grid integration of renewables.¹⁷² Installation of heat pumps and hybrid boilers could be supported through Department of Energy loans or through a new grant program, as CAP proposed recently. A 10-year, \$20 billion grant program to support innovative low-carbon manufacturing would yield emissions reductions of up to 67 MMT CO₂e in 2030; a longer-running program would yield commensurately higher reductions as technologies mature through the research and development program described in the preceding section. This program could plausibly be enacted with bipartisan support.

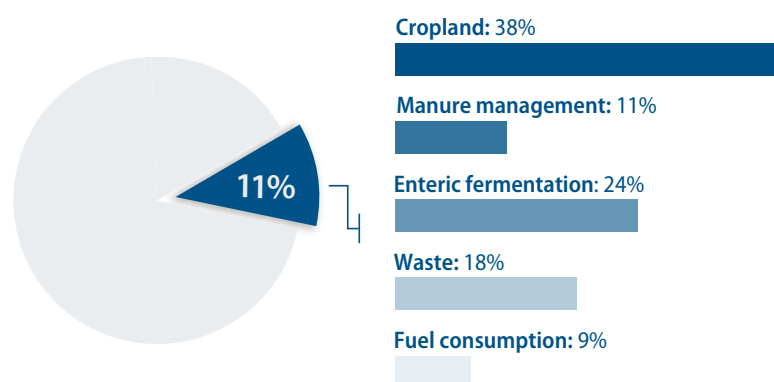
- **Create federal buy-clean procurement standards.** The federal government is a major direct purchaser of goods and services, and federal grant expenditures increase the government’s purchasing power even more. Since 1978, Buy America provisions have imposed domestic content requirements on federally supported infrastructure projects, such as highways and transit projects.¹⁷³ In 2017, California became the first state to institute buy-clean standards, which require government agencies to take into account suppliers’ emissions profiles when purchasing materials such as steel and glass for infrastructure projects.¹⁷⁴ Instituting national buy-clean standards to benefit more cleanly produced steel, aluminum, cement, glass, plastics, and other core materials in federal and federally supported procurement would help reward low-emission manufacturers and support jobs in the United States.¹⁷⁵ A federal buy-clean program could plausibly be enacted as part of must-pass legislation and should be designed to encourage deeply decarbonized materials where available rather than simply prohibiting purchase of the most carbon-intensive products. It should set different levels of stringency for different materials—depending on the market availability and cost of process changes and clean manufacturing equipment. The EPA and the Department of Energy should have joint responsibility for increasing the stringency of federal buy-clean standards over time based on technological feasibility and the best available science.
- **Support U.S. clean manufacturing with export promotion and border adjustments.** As much as 10 gigatons of carbon pollution falls in what researchers have called the “carbon loophole” of international trade—emissions from manufacturing outsourced to other countries.¹⁷⁶ The United States’ carbon footprint is even larger than official tallies when the life cycle emissions of goods produced overseas for consumption in the United States are considered. The next progressive administration must ensure that U.S. producers who invest in energy efficiency, clean energy, equipment electrification, feedstock substitution, carbon capture, and other solutions to reduce greenhouse gas emissions are not penalized by global trade rules or economywide carbon pricing. Border adjustments, as discussed in the international section of this report, should be targeted at greenhouse gas-intensive, trade-exposed industries—such as aluminum and steel production—to prevent and even reverse carbon leakage as a result of international trade. In addition, U.S. manufacturers who are making clean energy and energy efficiency products—or who retool their operations to significantly reduce greenhouse gas emissions resulting from manufacturing of conventional goods—should receive prioritized federal support through entities such as the Export-Import Bank and the U.S. Trade and Development Agency—to export their goods to the global market.

Agriculture and waste sector

Benchmark: Invest \$120 billion by 2030 to drive emission reductions, carbon sequestration, and innovation in agriculture. This would cut economywide emissions by an estimated 2 percent of 2005 levels in 2030 and 4 percent in 2050.

FIGURE 7
U.S. agriculture and waste sectors

Proportion of economywide emissions and sector-specific breakdown in 2020



Source: Authors' estimates based primarily on U.S. Energy Information Administration, "Annual Energy Outlook 2019 with projections to 2050" (Washington: 2019), available at <https://www.eia.gov/outlooks/aeo/>. See the Appendix in "A 100 Percent Clean Future" for complete notes on methodology, available at <https://www.americanprogress.org/?p=475605>.

American farmers and ranchers are at the forefront of facing the effects of climate change. Farmers in the West have experienced record droughts, while farmers in the Midwest have experienced unprecedented flooding. Investing in the agricultural sector will both reduce direct emissions and enlist farmers in actively sequestering carbon.

Agriculture emits approximately 600 MMT CO₂e per year, about one-tenth of total U.S. annual greenhouse gas emissions. Of this, 48 percent are nitrous oxide emissions from nitrogen fertilizer, and 42 percent comes from livestock methane emissions from manure management and enteric fermentation. The remaining 10 percent comes largely from on-farm fuel consumption from farm equipment together with upstream emissions from the supply of those fuels. On the other end of the value chain, another 130 MMT CO₂e per year comes from the breakdown of these

agricultural products and other wastes in landfills and wastewater treatment facilities. When waste decomposes in landfills, it produces biogas comprised of a mix of methane, carbon dioxide, and a small amount of nonmethane organic compounds.

These sectors also produce other types of pollutants with harmful impacts on human health, often disproportionately affecting low-income communities and communities of color. Farm workers are routinely exposed to high levels of pesticides, which can cause a range of health issues from skin irritations to serious and potentially deadly poisoning.¹⁷⁷ Ammonia from nitrogen fertilizers and manure combine with other air pollutants to create fine particulates that cause heart and lung disease.¹⁷⁸ Leakage from manure lagoons, poultry manure, and runoff from the spreading of untreated waste on land can pollute surface and groundwater sources. Excessive nitrogen and phosphorus from farm fields wash off into waterways and cause eutrophication of water bodies, which kills fish and other aquatic life.¹⁷⁹

Much of this pollution can be managed more effectively. More efficient fertilizer application with today's technologies could reduce emissions by up to 50 MMT CO₂e per year¹⁸⁰ and would improve air and water quality. Covering landfills and capturing methane from manure can reduce emissions by up to 22 MMT per year, avoiding manure runoff that has contributed to problems such as the dead zone in the Gulf of Mexico.¹⁸¹ Wastewater emissions can be reduced through aerobic wastewater treatment plants on an individual or centralized scale and installing anaerobic wastewater treatment plants with cogeneration.

Making these changes will require strong investment over the next decade. CAP recommends an investment of \$120 billion over 10 years, doubling the amount of funding for agricultural conservation, research, and renewable energy in the 2018 farm bill.¹⁸² If the United States invests boldly in the next decade, it will put the country on a trajectory to significantly reduce emissions from agriculture; increase soil health and yields; and sequester carbon in farmland. By 2050, farmers will have a wide array of affordable solutions to vastly reduce the use of nitrogen fertilizers and improve soil health and yields. Emissions from manure and waste will be captured, converted into fuel, and used on-site or piped to industrial facilities for use in processes that are difficult to electrify. The need for fossil fuel use on farms will be dramatically reduced by farm equipment that runs on electricity, hydrogen, or advanced carbon-free fuels. Backed by strong federal investment in agricultural research and financial incentives, farmers will be able to actively manage the carbon content and health of their soils to boost productivity, reduce on-farm costs, and supply healthy food for global markets.

There are several federal policies that could support reduction of emissions in the agriculture and waste sectors. This section lays out policies targeted toward reduction of direct greenhouse gas emissions from agriculture. The next section will discuss policies to increase soil health and carbon sequestration in cropland and rangeland.

- **Invest in agricultural innovation.** The federal government can significantly increase the agriculture sector's contribution to emissions reduction through ambitious investment in coordinated federal research. Funding should focus on regenerative agriculture techniques to improve soil health and yields and development and deployment of alternatives to nitrogen fertilizer. In parallel, the USDA should study and pilot interventions that reduce enteric fermentation emissions from livestock such as diet changes, feed additives, selective breeding, and intensive grazing techniques.¹⁸³ The federal government should also support the development and deployment of promising next generation farm equipment, such as tractors that run on electricity, hydrogen, or advanced carbon-free fuels. The USDA should fund the development, deployment, and increasing adoption of precision agriculture technologies that leverage data and machine learning to inform decision-making and reduce input use.
- **Reduce nitrous oxide emissions through technical assistance and financial incentives.** Federal investments and technical assistance can equip farmers to dramatically reduce nitrogen fertilizer use. Congress can authorize mandatory funding to the USDA's Conservation Stewardship Program (CSP) and Environmental Quality Incentives Program (EQIP) to defray the costs and accelerate deployment of precision agriculture technologies to much more efficiently apply fertilizer where and when it is needed. USDA extension offices can vet these technologies and make region-specific recommendations for farmers to increase adoption. As part of participation in the crop insurance program, which covers 90 percent of U.S. cropland, the USDA can incentivize (through higher payments) reporting of data on input use and crop yields. Collection and dissemination of such data can provide farmers with information to alleviate concerns about reduced fertilizer use affecting yields.
- **Reduce methane emissions from livestock.** The federal government should require anaerobic digesters—equipment that prevents the release of methane and creates a fuel—on large dairy and livestock operations and deploy incentives and direct payments to defray costs for all operations. There are currently 248 anaerobic digesters on farms in the United States, and the USDA estimates that installation is technically feasible at 8,000 large dairy and hog operations total.¹⁸⁴ The main barrier is the high upfront capital costs. Congress should appropriate funds to the USDA to provide grants through the Rural Energy for America Program (REAP) and

EQIP to accelerate installation of methane digesters by 2030 and renew the expired investment tax credit for methane digesters.

- **Expand energy efficiency and renewable energy on farms.** REAP provides grants and loan guarantees for farmers to install solar, wind, and make on-farm energy efficiency improvements. Given its popularity and strong bipartisan support, Congress should fully fund the discretionary amount for the REAP program each year and double the size of the program in the next farm bill to allow funding for all qualifying projects.
- **Reduce emissions from landfills and wastewater treatment.** In 2016, the Obama administration announced long-overdue New Source Performance Standards to require capture of methane emissions for new and modified municipal solid waste landfills. However, as part of a larger executive order, the Trump administration issued a stay of the 2016 rule, promptly triggering a lawsuit by eight states that had already submitted plans for EPA review under the new rule. A future administration should immediately implement the 2016 rules for landfill methane emissions. Additionally, there is a major opportunity to abate landfill emissions by reducing the one-third of all food produced in the United States that goes to waste and ends up in landfills. This can be significantly reduced through a combination of policy incentives and technology deployment to increase efficiencies along the food value chain. For wastewater treatment plants, emissions can be reduced through technologies such as aerobic wastewater treatment plants and anaerobic plants with cogeneration.

Lands and negative emissions technologies

Benchmark: Protect 30 percent of America's lands and oceans and adopt climate-smart practices on an additional 100 million acres of farmland and rangeland by 2030. Deploy natural and technological solutions to sequester 1 gigaton of carbon dioxide by 2050. This would cut economywide emissions by an estimated 2 percent of 2005 levels in 2030 and 15 percent in 2050.

Even with aggressive emissions mitigation across sectors, increased sequestration will be necessary for offsetting emissions that are economically or technologically difficult to abate by midcentury and, more importantly, for achieving net negative emissions after 2050 to stabilize warming at 1.5 degrees C by the end of the century. Sequestration encompasses natural sequestration from lands and oceans as well as technology-based sequestration through direct air capture or geological sequestration.

The good news is that the National Academies of Sciences estimates that there is current global capacity to safely and economically sequester an additional 9.1 to 10.8 gigatons of carbon dioxide globally per year through a combination of natural sequestration in lands and oceans and technological solutions.¹⁸⁵ Of this amount, 1 gigaton per year of sequestration capacity lies in the United States.

Achieving this target is possible with a concerted effort to protect and restore natural lands and coastal ecosystems; restore the health of agricultural soils; and invest rapidly in research and development over the next decade to enable solutions, such as direct air capture and geological sequestration, to become available.

Natural Sequestration Solutions

In the United States, lands and coastal areas sequester approximately 700 MMT CO₂e per year on net, which is approximately one-tenth of total emissions, with forests accounting for nearly the entire amount.¹⁸⁶ Unfortunately, several global models predict that lands could go from being a carbon sink to a carbon source, on net, due to climate-related factors such as more intense wildfires and deforestation as the global population increases to 10 billion by 2050. The United States is losing

a football field worth of natural area every 30 seconds due to development. Parts of the arctic permafrost, which by some estimates hold double the amount of carbon currently in the earth's atmosphere, are melting 70 years earlier than expected. Coastal ecosystems, which can capture and store significantly more carbon per acre than terrestrial forests, have been lost to coastal development and pollution, turning them from carbon sinks into sources.

It is imperative to implement policies to protect and expand the U.S. carbon sink. Of the 1 gigaton of additional annual sequestration that the National Academies of Sciences says is possible, half comes from forestry and better management of agricultural soils. To accelerate the conservation and restoration of forests, wetlands, and other natural systems that will play the most important role in absorbing and sequestering carbon, the United States should establish and pursue a national goal of protecting 30 percent of all lands and oceans by 2030. This national conservation goal—which is discussed in greater detail in CAP's "How Much Nature Should America Keep" report—is critical to confronting both the climate and conservation crises that the country is facing.¹⁸⁷

Additionally, farmers and ranchers have a long tradition of land stewardship that will be immensely valuable to the fight against climate change. Some farmers are already proving agricultural soil carbon sequestration practices to be some of the least costly and most swiftly deployed options for carbon sequestration currently available.

As in other sectors, targeted strategies beyond carbon pricing are necessary to speed up deployment of sequestration before 2030. This section outlines policy ideas that would ramp up greenhouse gas mitigation and sequestration through the protection and restoration of America's lands and oceans and support for agricultural solutions.

- **Establish a national goal of protecting 30 percent of U.S. lands and oceans by 2030.** Currently, only 12 percent of U.S. lands and 26 percent of U.S. oceans are permanently conserved as national parks, wildlife refuges, wilderness areas, and other protected areas.¹⁸⁸ Meanwhile, sprawling cities, energy infrastructure, and other development is consuming a football field worth of natural area every 30 seconds.¹⁸⁹ To slow the loss of natural areas—which are essential carbon sinks—U.S. policymakers should do far more to help local communities; tribal nations; economically disadvantaged communities; communities of color; and all Americans to protect the lands, waters, and wildlife that are most important and most at risk. For example, the United States could, by 2030, protect at least 15 million acres of forests at risk of development and reforest up to 40 million to 50 million acres of

historically forested lands.¹⁹⁰ Doing so, with a particular focus on protecting and restoring lands with high ecological and carbon sequestration value, would sequester tens of millions of tons of carbon.

- **Invest heavily in research, development, and deployment for sequestration to enhance the U.S. and global carbon sink.** As recommended by the National Academies of Science, Congress should authorize \$1.5 billion* in coordinated federal research, development, and deployment for sequestration from lands and oceans over the next 20 years.¹⁹¹ R&D will need to focus on factors including land competition with food and biodiversity preservation, energy requirements, high cost, permanence, monitoring and verification, and insufficient scientific or technological understanding.

In forestry, R&D is required in areas including improved field data and remote sensing to allow for more accurate measurement of the U.S. carbon sink and demonstration projects to improve collection and disposal of wood products after use. In agriculture, this includes better data collection and predictive analytics on agricultural soil carbon capture and storage; development and testing of crop varieties that can enhance soil carbon storage through the Department of Energy/ ARPA-E ROOTS program; and studying the soil carbon impacts of biochar.¹⁹² In coastal areas, it includes investment in basic research, mapping current and future coastal wetlands, better data, and support for blue carbon demonstration projects and deployment.

- **Invest in reforestation.** Reforestation, or growth of new forests, is critical to maintaining and expanding the U.S. carbon sink. Policymakers should invest in reforestation of up to 40 million to 50 million acres of historically forested lands by 2050.¹⁹³ This includes planting trees on the estimated 8.3 million acres of public lands managed by the USDA and the Department of Interior that are in need of reforestation.¹⁹⁴ Policies should include incentives for private landowners to reforest land, including support for new markets that use sustainable wood products, create jobs, and build an economic case for climate-smart forestry.
- **Revive the Civilian Conservation Corps (CCC).** Congress should revive the New Deal Civilian Conservation Corps to employ millions of young Americans to restore and plant new forests and restore coastal ecosystems. California's Conservation Corps, for example, has been running successfully since 1976 and should be scaled up nationally. This revived CCC could help restore forests on public lands to reduce the risk of catastrophic wildfire and clear the reforestation backlog on federal lands.¹⁹⁵ It can also help revitalize cities through planting as many as 435 million additional trees in urban areas.¹⁹⁶

- **Protect at-risk lands with high carbon sequestration potential.** Some of the lands with the highest carbon sequestration potential in the country are at risk of development. One example is the old-growth temperate rainforests in the Tongass National Forest, which store over 1 million tons of carbon each year. However, the Trump administration is attempting to open this area to widespread clear-cut logging of old growth stands,¹⁹⁷ despite the high costs and limited economic returns of these types of timber sales in the region.¹⁹⁸ Protecting the Tongass, and at least 15 million acres of forests at risk of development by 2030, would safeguard some of our most important carbon stores.
- **Restore forests and grasslands.** A century of human activities, including intensive logging and fire suppression, have contributed to more intense wildfires across the United States. Forest restoration—managing lands to reflect their natural ecological state—will be necessary to reduce catastrophic wildfire risk, protect forests that serve as valuable carbon sinks, and improve the carbon sequestration potential of natural areas. To achieve scientifically grounded forest restoration objectives, land managers will need to use tools such as prescribed fire to burn some biomass in the forest and invasive species removal. Cheatgrass, for example, is outcompeting native species on the sagebrush steppe in the West and contributing to increased wildfire risk. Addressing restoration needs on both public and private lands should be prioritized in budgets for the Department of the Interior and the USDA’s conservation programs.
- **Restore coastal ecosystems.** Coastal ecosystems—which include mangrove forests, seagrass meadows, and salt marshes—can capture and store significantly more carbon per acre than terrestrial forests, defend coastlines from storms and flooding, and serve as key habitat for commercially important fish and shellfish. Unfortunately, coastal development and pollution has led to the loss of more than half of these vital blue carbon ecosystems globally, turning them from carbon sinks into sources and eliminating their ability to protect the coastline from storms and flooding. Congress should prioritize the restoration of coastal ecosystems by fully funding the NOAA Coastal and Estuarine Land Conservation Program and directing the Army Corps of Engineers to prioritize natural infrastructure and carbon storage in Water Resources Reform and Development Act (WRRDA) project decisions.

- **Leverage the USDA's conservation programs for land retirement and easements.**

Congress should amend the USDA's conservation programs to prioritize carbon storage potential and reduce risk of land conversion. The conservation easement tax incentive, the Agricultural Conservation Easement Program (ACEP), and the Forest Legacy Program enrollment criteria should prioritize properties with the greatest carbon storage potential. Easement programs can also prioritize retirement of frequently flooded farmland. The Conservation Reserve Program (CRP) acreage cap should be increased to historic levels of 32 million to 36 million acres¹⁹⁹ and, given historic reenrollment trends, the USDA should target 50 percent of land coming out of CRP contracts to be moved into permanent conservation easements.²⁰⁰ Farmers and private forest owners should be compensated for additional, verifiable, permanent carbon sequestration. Congress should direct the USDA to develop a soil carbon accounting mechanism and build a publicly available soil carbon database to enable verification of carbon sequestration.

- **Compensate farmers for climate-smart practices on 100 million acres of active cropland and rangeland.** By 2030, the U.S. should set a goal of planting cover crops and adopting no-till methods on at least half (100 million acres) of the U.S. cropland not already using cover crops. This can sequester approximately 50 MMT CO₂e per year.²⁰¹ Alley cropping (growing trees in alleys between rows on cropland) could sequester another 82 MMT per year, and with R&D, biochar incorporation has potential for another 95 MMT.²⁰² Congress should expand the USDA CSP program and prioritize practices that enhance soil carbon sequestration on land under production, such as planting cover crops, no-till soil management, alley cropping and agroforestry, and windbreaks. The USDA can also leverage crop insurance and FSA lending programs to encourage more widespread adoption of these soil carbon practices. No-till or cover crop practices should be incentivized for lands exiting Conservation Reserve Program (CRP) contracts and moving back into production. The USDA could incentivize adoption of improved grazing programs through government cost-sharing initiatives, such as EQIP and CSP, along with the Regional Conservation Partnership Program, to convert an additional 9 million acres of grazing lands to more sustainable management.
- **Incentivize smart-growth policies.** As discussed in the transportation section, denser development ensures more efficient land-use, freeing up land for agricultural production and reforestation. A substantial share of the land required to maintain or increase the U.S. lands sector sink could be freed up through smarter, densified development.

Technology-based sequestration solutions

In parallel to natural carbon sequestration solutions, negative emissions technologies will play a critical role in achieving net-zero emissions by midcentury and negative emissions after that. Half of the 1 gigaton of sequestration estimated by the National Academies of Sciences comes from negative emissions technologies, including bioenergy with carbon sequestration (BECCS) and direct air capture technology (DAC). Bringing these solutions online at scale will require heavy investment in research, development, and deployment.

BECCS uses plant biomass to produce electricity or liquid fuels, with sequestration of the CO₂ emissions in geologic formations. Investment in R&D on BECCS should address questions around cost; availability of biomass given needs for food and fiber production and for biodiversity; and the feasibility of effectively capturing waste biomass.

DAC involves capturing CO₂ from the ambient air through chemical processes and injecting it into a storage reservoir. While this technology theoretically has unlimited sequestration potential, it is currently cost-prohibitive and very energy intensive. There are currently 11 DAC operational plants around the world, the largest with a capacity to capture 4,000 tons of CO₂ per year. According to a Rhodium Group analysis, the United States will need to build an estimated capacity of 9 MMT CO₂/year by 2030 and between 560 to 1850 MMT CO₂ annually by midcentury.²⁰³

DAC faces fewer political or environmental barriers than other potential sequestration options. However, high capital costs and the need for a low-carbon electricity source to power these facilities make them uncompetitive compared to other capture and sequestration options such as BECCS. Exactly how much DAC will be required will depend on the success of deploying other sequestration such as afforestation/reforestation, ocean blue carbon, and BECCS.

Policy solutions to accelerate deployment of negative emissions technologies include the following:

- **Invest heavily in research, development, and deployment.** The National Academies of Sciences recommends investing approximately \$7 billion* over the next 10 years in R&D on technology solutions for sequestration. For BECCS, R&D is required to address the feasibility of capturing waste biomass at scale, the availability of land, and mitigation of potential adverse environmental impacts. For DAC, R&D must address energy requirements and cost. For both, R&D must address how to safely and permanently sequester the emissions in geologic formations, such as saline aquifers. Finally, additional research should focus on ways to put carbon to use in products such as building materials and cement.

- **Targeted policies for direct air capture**

In order for DAC to become viable, in addition to implementing the R&D plan proposed by the National Academies of Sciences, the federal government can implement policies to stimulate demand and decrease the non-cost barriers. To drive demand and get the first generation of DAC plants to break even, the Department of Defense and the General Services Administration can use their procurement processes to ramp up demand for DAC-based fuels and direct carbon removal. Congress can amend the Section 45Q tax credit in several ways to focus on DAC, such as extending the commence-construction deadline to 2030; lengthening the credit payout period; among other solutions. The government can also establish a federal mandate for DAC-based fuels. There is also a need for actions to overcome non-cost barriers to DAC, such as developing monitoring capacity and mapping geological formations to identify suitable areas for storage.²⁰⁴

Pollution-free public lands and oceans

The federal government manages more than one-fourth of all lands and most of the ocean in the United States.²⁰⁵ While these lands should be carbon sinks, the federal government's legacy coal, oil, and gas programs have turned these publicly owned lands and oceans into a net emitter of greenhouse gas pollution. From 2005 to 2014, production and consumption of fossil fuels extracted from federal lands and oceans accounted for nearly 24 percent of all U.S. greenhouse gas emissions annually—a total volume that exceeds the annual greenhouse gas pollution of all but four countries in the world.^{206, 207}

In the same 2005 to 2014 study period, the U.S. Geological Survey found that the life cycle emissions from energy extracted from federal lands and waters contributed 1,332.1 MMT CO₂e of greenhouse gas pollution each year, whereas the natural systems of these lands captured carbon at a rate of 343 MMT CO₂e annually.²⁰⁸ In other words, energy extraction on the federal estate has been contributing roughly four times more greenhouse gas emissions than federal lands have been absorbing naturally. Increasingly severe wildfires, clear-cut logging, and other land use changes further worsen the picture.

This report recommends that Congress or the administration direct federal agencies to play a leading role in addressing the climate crisis by helping the country protect 30 percent of its lands and oceans by 2030 and by meeting a goal of net-zero emissions on public lands and waters by 2030. This net-zero by 2030 target would put the United States on a path to pollution-free public lands and waters by 2050.

Policy solutions

To meet a net-zero goal for public lands by 2030, policymakers will need emissions reductions tools as well as to increase the capacity of public lands and waters to absorb pollution and supply clean power. Below are actions that the Interior Department and other federal natural resource managers can take to clean up the federal energy program and capitalize on the opportunities that public lands and waters can offer for clean energy production and pollution reduction:

- **Stop the fire sales of public lands.** From January 2017 to April 2019, the Trump administration offered the oil and gas industry the opportunity to buy drilling rights at below market costs on nearly 378 million acres of public lands and waters,²⁰⁹ which could result in 854 million to 4.7 billion MT CO₂e of greenhouse emissions.²¹⁰ Congress or a new presidential administration should implement an immediate pause on the sale of coal, oil, and gas leases until federal agencies adopt and implement an aggressive carbon emissions reduction plan for federal lands and waters.

- **Cut methane pollution.** Oil and gas companies already own the rights to drill on approximately 25.5 million acres of federal lands²¹¹ and nearly 23.7 million acres of federal waters,²¹² accounting for the potential extraction and combustion of tens of billions of MT CO₂e of greenhouse gas emissions.²¹³ Policymakers should aim to reduce venting and flaring of methane at natural gas extraction sites as well as incentivize the capture of methane waste leaking from coal mines.
- **Eliminate production subsidies and implement other fiscal reforms.** The United States should eliminate subsidies for fossil fuel extraction on federal lands, including royalty loopholes and deductions that cheat taxpayers, states, and local communities. Congress should also enact long-overdue reforms to the oil and gas leasing process, including ending noncompetitive leasing,²¹⁴ taking lease extensions off autopilot, and increasing federal royalty rates and associated leasing fees.²¹⁵
- **Require companies to clean up and pay for the costs of their pollution.** Federal agencies should require fossil fuel companies operating on public lands and waters to minimize or avoid greenhouse gas pollution. For pollution that is unavoidable, these agencies should either require active mitigation or charge an additional fee to compensate for pollution damage.
- **Reliably measure and limit emissions from public lands.** In June 2019, the Trump administration released weak and ineffective guidance for how to consider climate impacts that result from federal decision-making—including leasing for oil, gas, and coal development.²¹⁶ This guidance should be updated and strengthened to ensure that carbon pollution from public lands and waters is measured, tracked, and managed.
- **Expand renewable energy development.** Public lands and waters contain vast solar, wind, and geothermal energy potential, but only account for about 5 percent of the nation's renewable power generation at present.²¹⁷ The Interior Department can create new jobs and reduce carbon emissions with responsible siting of additional utility-scale solar; wind and geothermal projects on public lands and waters; helping to meet the renewable energy goals laid out elsewhere in this paper.
- **Expand the capacity of the nation's forests, grasslands, and coasts to capture and sequester carbon.** Public lands offer a clear, cost-effective opportunity to tap into natural carbon sinks through restoration of ecosystems such as wetlands, prairies, and forests. For example, an estimated 8.3 million acres of public lands managed by the U.S. Departments of Agriculture and the Interior need reforestation. Planting trees on these lands would capture approximately 13 MMT of additional CO₂e annually by 2030.²¹⁸

International action

The ambition of the 100 Percent Clean Future plan has important global implications. In the absence of proactive effort, the United States is on track by 2050 to burn through about 33 percent of the world's remaining carbon budget,²¹⁹ though the U.S. constitutes only 4 percent of the world's population. Reducing domestic emissions will significantly delay climate change.

But climate change is a global problem that requires global cooperation, and action at home by itself is not enough to stabilize global temperatures. Ambitious U.S. domestic action can serve as a strategic tool to catalyze international action. To translate new domestic climate policies into global influence, the United States must execute an international strategy to advance both global action and U.S. national interests, which include global emission reductions, U.S. economic competitiveness, and a stable international order. But after four years of the Trump administration's climate policy malpractice, the United States will be digging itself out of a political credibility hole. It will take strong demonstrated domestic and international initiative to restore U.S. influence to drive a U.S. international climate strategy.

The Paris agreement still provides the right framework for coordinating international steps to strengthen national climate policies. Although it does not impose binding targets, Paris offers a foundation of nearly unanimous global commitment to continuous cooperation, an achievement that took years of diplomacy, creative policy development, and political leadership to secure, and which the United States should embrace again immediately. However, diplomatic efforts through Paris alone will not be enough to spur global emission cuts fast enough. The United States must use all of its diplomatic, trade, and financial influence with allies, rivals, international corporations, and institutions to drive global action. No other country has the same capacity and responsibility to lead as the United States.

This section of the paper recommends numerous diplomatic, trade, and financial policies as part of an international climate strategy to leverage the unique strengths of the United States and accomplish net-zero global greenhouse gas emissions no later than

2050. This must be done in ways that reduce poverty and inequality and improve the health and well-being for people throughout the world, and as an interim step, must reach universal achievement of the U.N. Sustainable Development Goals by 2030.

Diplomacy as an international climate strategy

President Trump has done his best to sabotage global climate cooperation, most notably when he announced in 2017 his plan to withdraw from the Paris agreement.²²⁰ A new administration should immediately rejoin the Paris accord, a process that would take only one month. However, this is just step one. Restoring U.S. global influence on climate change through a set of targeted actions will be critical if the world is to have a chance in preventing the worst impacts of climate change.

There are several federal policies that would better leverage U.S. diplomatic strategy to further climate change goals.

- **Prioritize climate on all fronts.** Climate change considerations must be central to U.S. foreign policymaking. The president should inform foreign leaders that climate change will be a priority issue in all U.S. bilateral relationships and instruct the NSC, national security departments and agencies, and ambassadors overseas to set climate change as a priority issue for all foreign policy engagements and the U.S. national security strategy.
- **Set a new NDC.** After years of climate policy rollbacks by the current administration, the United States is unlikely to meet its 2025 NDC.²²¹ Furthermore, if true to form, the Trump administration will not submit a 2030 NDC when it is due in 2020, creating pressure for a new administration to announce an emissions target when it declares its return to the Paris agreement. But a new administration's first NDC will be a very important decision and policy declaration. Following a day one announcement on returning to the Paris agreement, the new administration should move promptly to establish a credible 2030 target, drawing on this report's recommendations, and clarifying what it can achieve with existing authorities and potential congressional action.
- **Implement a global electricity decarbonization initiative.** A U.S. president should launch an initiative for coordinated global action at scale to decarbonize power systems worldwide in 30 years.²²² Key elements of this initiative should include a worldwide commitment to end public financing for coal-fired plants by 2025, build no new coal plants by 2030, and build no new fossil fuel-fired plants by 2035.

Other elements are a global initiative to accelerate integration of low-cost clean electricity sources; turbocharged capacity-building for countries to implement these rapid transitions; a blueprint to catalyze decommissioning of existing fossil plants by 2050; and a government and private-sector commitment to mobilize required resources under a public-private framework. The initiative could build on the important diplomatic and leadership of U.N. Secretary General Antonio Manuel de Oliveira Guterres²²³ and the progress achieved by several countries, states, cities (including several from the United States), and businesses under the Powering Past Coal Alliance.²²⁴ Success would require the United States, the United Nations, and China to partner on this effort, given China is the largest source of financing for fossil fuel projects in developing countries.²²⁵

- **Return to multilateral diplomacy.** The U.N. Framework Convention on Climate Change (UNFCCC) process will continue to play a critical role in climate diplomacy, requiring the United States to reestablish trust and influence with counterparts. The United States has also led in a number of other multilateral initiatives that have played important roles in tandem with the UNFCCC process. Many have gone in the wrong direction or become dormant under the Trump administration. Advancing U.S. global climate interests must include prioritizing attention and resources in these initiatives. Secretary Mike Pompeo's erasure of climate change from the Arctic Council was a national embarrassment and betrayal of U.S. national security. A new administration should return climate change to the centerpiece of Arctic Council policy, programmatic and research cooperation, and nominate a new special representative for the Arctic to lead the U.S. climate agenda at the council. A new administration should resuscitate the Major Economies Forum (MEF) for the world's 17 largest economies and focus members' action on a few prioritized, high-level initiatives, such as the global electricity decarbonization initiative or undertaking the proposed revamping of the international trade and finance systems outlined below. As discussed in earlier parts of the report, the United States has the opportunity to achieve meaningful domestic emissions reductions in several global initiatives, including under the Montreal Protocol, the International Civil Aviation Organization (ICAO), and the International Maritime Organization (IMO), and leverage those accomplishments to drive actions by others. The United States must also restore the G-7 and G-20 as strategic platforms to address climate.
- **Prioritize and elevate U.S. bilateral partnerships.** After President Trump's parting legacy of damage to U.S. interests and reputation overseas, it will take much work and time by a new administration to repair the trust and influence necessary to win over key countries to a U.S. vision to combat climate change. If the next president succeeds in restoring U.S. global influence, the status of the United States as the

preferred partner to tackle the most difficult global challenges could return America to a central role internationally on climate change. It is clear that to make significant and sustainable progress at the global level, a new administration will have to prioritize its engagement with China, India, and the EU, in particular, in a future U.S. international climate strategy. And White House leadership will be critical to achieving U.S. goals globally. (See text boxes below)

- **Invest in and leverage women's empowerment in order to combat climate change.**

Climate change poses significant risks to women's health and well-being. For example, issues around food insecurity, natural resource depletion, gender-based violence, and poor access to medical care and family planning services are exacerbated by climate change and have a disproportionate impact on women and girls.^{226 227 228} It is vital that policies focused on combating climate change are also focused on women's empowerment.²²⁹ Studies have found that when women are empowered, per capita carbon footprints are reduced. For instance, countries in which more women occupy political leadership roles tend to have lower CO2 emissions.²³⁰ This can be achieved by, among other things, improving access to education; comprehensive family planning and reproductive health services; economic security through quality jobs and high wages; and leadership and governance opportunities. The United States must lead by example by promoting high standards for reproductive and maternal rights and bodily autonomy and repealing regressive policies such as the Hyde Amendment and the Mexico City Policy.²³¹ These priorities can inform the U.S. diplomatic approach on the Sustainable Development Goals and on climate change. The next administration should also immediately resume and increase funding and support to international family planning organizations²³² and the U.N. Population Fund (UNFPA)²³³ as well as enhance investments in other tools that promote women and girls' economic empowerment. If the U.S. wants to craft the best solutions to expand peace and security in this new climate era, it must give women a seat at the decision-making table.

- **Bolster climate science capacity, collaboration and data collection.** The United States has long been the world's leader in climate science and climate data collection. U.S. federal funding supports much of this work, including international collaborations, which contribute to improved U.S. understanding and planning to address domestic climate risks. The international community relies on data collected from American satellites, buoys, and other remote sensing technologies. Under the Trump administration, climate science and technology funding has been under attack, which has hampered advances in understanding and foreign collaborations. To bolster global capacity to confront future climate science challenges, the next administration must continue to identify and fund promising areas of climate science and technology and address the losses of career federal scientists under the

current administration. CAP proposes tripling investment in climate science over the next five years above an FY 16 baseline of \$15.6 billion across relevant U.S. Global Change Research Program activities. A new administration will also have a less visible but important task to restore U.S. funding to the IPCC (and UNFCCC) at the pre-Trump levels of \$10M annually. The Trump administration and Congress zeroed out FY 17 funding for the two bodies; funding was upped to \$3M in FY18 but has never fully recovered.²³⁴

An updated approach to China

It is incumbent upon the United States and China—as the world’s two largest economies and greenhouse gas emitters—to reengage each other and to lead internationally on climate.²³⁵ The two demonstrated indispensable leadership at Paris, but the changed nature of the relationship will also mean change in how the two countries approach climate. To compound the challenge, Trump’s abdication on climate action undermines U.S. political leverage in winning stronger climate action by China. Nevertheless, an updated approach to China on climate should focus on China’s domestic actions and how it addresses the climate impacts of its foreign activities, specifically in the Belt and Road Initiative (BRI).

- The U.S. and China should launch a senior-level, policy and technical exchange on NDC performance. The United States should press China for action beyond its NDC, including faster implementation of its reform plan to accelerate China’s coal-to-renewables transition.²³⁶
- The administration should prioritize senior-level engagement with China on the global decarbonization initiative, which would require transformational policy changes by China to cease public financing in the near term; wind down coal plant construction at home and under BRI in the medium term; as well as decommission its domestic coal plant fleet over the long term. China’s 20 percent nonfossil target by 2030 puts it on a decarbonization path, but it is inadequate to satisfy the IPCC 1.5 degree imperative.

- On BRI, the administration should take up President Xi Jinping on his pledge to reform and “green” BRI policies and guidance to Chinese companies and banks and propose a multilateral dialogue to support China to align BRI project performance standards with the highest international environmental standards.²³⁷
- In parallel to a China-focused BRI strategy, the United States and other interested governments should launch an initiative²³⁸ to strengthen policy and technical capacities of recipient countries/regions for engaging China in negotiating project performance standards and seeking transparency on Chinese project terms among recipient countries.

President Trump argues China is getting a free ride under the Paris agreement. Under its NDC, China’s CO2 emissions grow before peaking by 2030, though a recent study indicates China may be on track to peak emissions up to 10 years sooner.²³⁹ This progress reflects China’s wide-ranging policy changes and ambitious public investments, as demonstrated in its NDC goal, to boost the share of nonfossil energy to 20 percent of its energy mix and to slash the carbon intensity of its economy (CO2/unit of GDP), which has fallen more than fourfold since 1980.²⁴⁰ China’s long game investment in clean energy technology development at the same time President Trump disinvests in the same represents a critical economic competitiveness threat to the United States.²⁴¹

Reviving climate cooperation with India

A global solution to combating climate change requires strong U.S.-India cooperation on supporting India, the world's fourth-largest emitter, in its sustainable development strategy. The good news is the two countries start from a strong foundation. The United States and India enjoyed a robust climate and clean energy partnership during the Obama administration, including the U.S.-India Partnership to Advance Clean Energy (PACE) program and President Obama and Prime Minister Modi's direct work on the Paris agreement. The Trump administration has ceased climate engagement with India and prioritized oil and gas in bilateral energy work. A new administration should revive the U.S. climate and clean energy agenda with India and then expand it.

- India will be a key player in any global electricity decarbonization plan. The United States and India should create a public-private panel to analyze and advise on the economic, technical, and social challenges to India's coal-to-clean energy transition and launch a cooperative program in policy, financing, and technical areas.
- India's ambitious clean energy deployment strategy continues to require extensive capital investment. U.S. and Indian

agencies should put clean energy finance mobilization on the priority list of the bilateral climate agenda. Importantly, India's dire water security challenges create a circumstance for public-private cooperation to mobilize finance.

- The United States and India could establish India as a regional center of excellence for power system transformation in order to disseminate best practices and support South and Southeast Asian countries to meet and exceed NDC goals.
- The United States should increase its policy, financial, and technical involvement in the India-led International Solar Alliance, whose core objective is to undertake joint efforts to reduce the costs of finance and technology and mobilize more than one trillion dollars by 2030 to finance global-scale deployment of solar energy.
- The two governments should rejuvenate the previously strong cooperation in joint clean energy research and broaden to new areas such as the water-energy nexus, as noted above. As work on building cooling technologies grows, the two sides should work to accelerate India's transition away from HFC use.

Trade as an international climate strategy

A new administration will have an opening to reset the international trade architecture as a vehicle to advance, rather than thwart, climate and worker priorities. This undertaking will require the United States to repair its standing and influence within the World Trade Organization (WTO); align partners to examine the WTO's overall function given broader global trade developments; include a review of ways in which trade rules can get out of the way on Paris implementation; and affirmative ways trade can help address climate. If done correctly, trade policy can be a tool to convince trading partners to raise their climate change ambition, support U.S. commercial competitiveness, and protect U.S. workers. This would require removing existing provisions within multilateral and bilateral trade agreements that hinder governments from acting on climate within their own borders and using trade tools to spur further climate action internationally.

There are several federal policies that could leverage trade policy to further climate change action internationally.

- **Investor-state dispute settlement (ISDS).** Fossil fuel and other interests have used ISDS provisions to block environmental and climate-related regulations and laws to advance corporate interest over common goods objectives.²⁴² The United States should remove ISDS from trade agreements and replace them with narrowly focused investor protection provisions on expropriation or discrimination.²⁴³
- **Domestic clean energy incentives.** In June, the WTO found in favor of a complaint by India that seven U.S. states' buy-local clean energy programs violated "national treatment" principles,²⁴⁴ a decision that could undermine domestic clean energy businesses and jobs. But under WTO rules, a trade-related environmental measure could be excepted from General Agreement on Tariffs and Trade (GATT) rules if the measure is "necessary for the protection of human, animal or plant life or health." Buy local programs can demonstrate to domestic stakeholders the local benefits of the energy transformations required to counter climate change. Interestingly, the United States filed and won a WTO case in 2016 against India for a buy local solar initiative.²⁴⁵ The United States should partner with India to seek an overall change in WTO treatment on this issue.
- **Border Adjustment Tariff (BAT).** As policymakers consider measures, such as carbon fees, to spur domestic greenhouse gas reductions, BAT mechanisms have moved to the forefront of policy options to help protect U.S. jobs and economic competitiveness. In addition to ensuring that a price on carbon will not push carbon-intensive activities to less regulated markets, many see a BAT also as a potential tool to motivate trading partners to strengthen their domestic climate performance. In order to simplify administration and maintain consistency with existing WTO rules, an effective BAT can be designed to cover just more than 40 energy-intensive, trade-exposed (EITE) sectors (for example, steel, aluminum, chemicals, glass, paper) that comprise 50 percent of total U.S. manufacturing emissions and 6 percent of manufacturing employment, according to a 2009 EPA analysis.²⁴⁶ New EU Commission President Ursula von der Layen has called for the EU to implement a BAT system in tandem with the EU raising its emissions reduction ambition.²⁴⁷ Early U.S.-EU coordination to harmonize a seamless system of carbon price border adjustments could smooth trade flows between these two major trade markets and drive climate action in all other countries.²⁴⁸
- **Global clean production certification system.** The United States and other leading medium and heavy industry countries should partner to launch a global forum to create a taxonomy of clean energy production standards and an accompanying

voluntary certification system for high carbon-intensity products. Such a certification and labeling system could incentivize improved production practices in domestic and foreign manufacturing sectors. The Energy Star program offers an interesting model. Once the certification system is sufficiently robust and global capacity for clean production has developed, the United States could graduate to a trade or procurement regime based on law or regulation.

- **Use trade to combat deforestation.** A new administration and Congress should determine how the United States should use trade policy to incentivize sustainable land use practices and counter alarming deforestation trends in hotspots such as the Amazon and Southeast Asia. Policymakers could look to the Lacey Act and EU trade agreements as potential models.²⁴⁹
- **Climate standards in U.S. bilateral trade agreements.** A new administration should stipulate that all U.S. trade agreements—bilateral and multilateral—include environmental, climate, and labor standards, which would be effectively enforceable, rather than their current status as side agreement matters.
- **Climate performance criteria in foreign direct investment (FDI).** Similar to the Committee on Foreign Investment in the United States (CFIUS) review process, Congress should provide new authorities to condition U.S. approval of potential FDI transactions into the United States against a standard for an investing party's climate performance in its broader investment activities. In addition, the United States should prohibit any foreign investments on climate damaging projects or acquisitions in the United States. Investment limitations would be a strong and controversial instrument but would send an unequivocal signal of the need for immediate emission reductions. CFIUS-like review would likely prompt potential investors to change behavior.
- **Fossil fuel subsidy reform.** The Trump administration has turned its back on seeking the elimination of fossil fuel subsidies, one of the most effective means to drive down greenhouse gas emissions and level the competitive field for noncarbon energy sources. The IMF estimates that worldwide energy subsidies in 2015 totaled \$4.7 trillion (6.3 percent of world GDP).²⁵⁰ If governments set fuel prices at fully efficient levels, global CO₂ emissions would have been 28 percent lower, fossil fuel air pollution deaths 46 percent lower, revenues higher by 3.8 percent of global GDP, and net economic benefits (environmental benefits less economic costs) would have amounted to 1.7 percent of global GDP. The new administration should reengage both on the domestic and international fronts, specifically under the G-20 and Asia-Pacific Economic Cooperation (APEC) in their respective fossil fuel subsidy reform initiatives.²⁵¹

Finance as an international climate strategy

The World Bank estimates the world will need to spend up to \$90 trillion from 2015 to 2030 in order to replace ageing infrastructure in advanced economies and to accommodate higher growth and structural change in emerging market and developing countries.²⁵² Public finance can play a catalyzing role, but private-sector finance will be the key to meet the scale of the finance challenge. The United States has a disproportionate influence over how private-sector finance will contribute, both through domestic regulations and influence over international financial institutions.

There are several policies that could better unlock finance for climate change projects worldwide.

- **Integrate climate into corporate financial governance.** Trump's climate denialism is creating a dangerous blind spot for the U.S. financial sector, irresponsibly putting U.S. companies, workers, and investors at risk. One concrete step would be for the Federal Reserve to join the Network on Greening the Financial System (NGFS), a network of central banks and supervisors that are driving improved climate risk management within their financial sectors. An increased Fed role on climate would catalyze climate risk assessment and management throughout the U.S. financial sector and could shape market incentives to channel investment to climate-related opportunities. In tandem, the Securities and Exchange Commission should require U.S.-listed companies to adopt and implement Task Force on Climate-related Financial Disclosures (TCFD) recommendations on climate-related financial reporting. Implementation of TCFD protocols has the potential to accelerate the wind down of fossil fuel-related investment, for example.
- **Decarbonize U.S. trade finance programs.** To mobilize U.S. private climate project finance, a new administration should: 1) overhaul the Overseas Private Investment Corporation—transforming into the U.S. International Development Finance Corporation (USDFC) in October²⁵³—and Ex-Im Bank's energy-related financing policies; and 2) turbocharge their financing resources and authorities. The administration should declare a blanket prohibition on U.S. financing for overseas fossil fuel projects, from mining to power generation. Operating with boosted resources and closing fossil fuel support, the USDFC and Ex-Im can then fully focus their energy agendas to support a clean energy mission and the U.N Sustainable Development Goals.
- **Decarbonize foreign trade finance programs.** To complement its reform of U.S. public finance policy on fossil fuel financing and achieve a main objective under the global decarbonization initiative, the new administration should immediately press other

Organisation for Economic Cooperation and Development (OECD)-member governments to adopt the same policy. To achieve meaningful change on fossil fuel financing, the United States and others will have to press China, which is not subject to OECD guidelines, to adopt the same approach.

- **Make good on the U.S. commitment to the Green Climate Fund (GCF).** President Trump's failure to honor the \$2 billion U.S. contribution to the GCF was a strike to the global effort to support developing countries and to international confidence in U.S. reliability on combating climate change.²⁵⁴ To repair the damage, a future administration should make whole the \$2 billion pledge balance. Furthermore, the United States should join other donors, who are doubling their contributions to the GCF. For the United States, a \$6 billion pledge over three years would fund 100 new projects and catalyze nearly \$15 billion in cofinancing.

Further improvements

The emissions reduction estimates presented in this report are not the product of comprehensive, integrated modeling, but are instead drawn from a variety of estimates published in other contexts. In general, CAP sought the most reliable and sector-specific published reports to furnish these estimates. To avoid double counting, this report quantifies the impact only of the six sector-specific benchmarks discussed above. Substantial additional emission reductions are possible if more ambitious benchmarks can be supported and from additional policies, as described below. Taken together, these additional policies need to reduce economywide emissions by an estimated 5 percent of 2005 levels in 2030 and 7 percent in 2050.

- In the electricity sector: Complementary policies to encourage transmission, demand management, and storage have the potential to significantly improve the efficiency of electricity generation, but the potential emissions reductions are not quantified in this report.
- In the transportation sector: Reduction opportunities are discussed in this report but not quantified for innovations in freight, aviation, shipping, and other subsectors.
- In the buildings sector: Additional reduction opportunities may be possible from district heating and complementary policies for efficiency that are not quantified in this report.
- In the manufacturing sector: The R&D program recommended in this report is likely to yield significant new industrial process improvements whose effects are not estimated here.
- In the agriculture sector: Steeper reductions are possible from adoption of electric farm equipment, methane digesters, and development and deployment of innovations to reduce nitrogen use and enteric fermentation.
- In sequestration: High technology development and deployment scenarios could result in higher amounts of carbon sequestration.

There is not currently a satisfactory level of modeling of specific emissions reductions pathways in the context of the new goal of 1.5 degrees Celsius set by the IPCC. The emissions reduction estimates presented in this paper are not the product of comprehensive modeling but are instead drawn from a variety of estimates published in other contexts. The emission estimates are tied to the sectoral benchmarks and not to the discrete, marginal effects of each policy. A description of this methodology can be found in the appendix.

Modeling, research, and analysis of the cumulative impacts and disproportionate distribution of local pollution has also been inadequately funded to date and has not been incorporated well enough into greenhouse gas mitigation modeling. This deficiency unnecessarily adds to the challenge of incorporating environmental justice and equity into climate policy and hinders the effort to reduce pollution of all types in overburdened communities where pollution sources have historically been concentrated.

CAP calls for additional modeling and scientific analysis to validate emission reduction pathways in the United States under a variety of technological, economic, and political conditions, including analysis of the geographic and racial distributional impacts and the effects on various forms of pollution, so that policymakers can understand with increased confidence which suite of emissions reduction policies will work together to best accomplish a 100 Percent Clean Future.

The need for a national climate council

To achieve the wide-ranging outcomes described above, a structural change within the White House will likely be necessary. The scope and urgency of the climate crisis, as well as the need to sustain a program of policy innovation for decades, will require a coordinated, holistic effort drawing on the expertise and resources of the entire federal government. Responsibilities for addressing the nation's climate change challenge reach beyond the purview of the EPA, Department of Energy, Department of the Interior, and the USDA to include those government entities focused on the economy, public health, trade, national security, research, affordable housing, emergency response, finance, and intelligence. Effective and enduring solutions at the federal level will require sustained senior-level leadership, a unified vision, and constant coordination.

To achieve such an outcome, the president should create a new White House component called the National Climate Council that is run by a director with the title of assistant to the president for climate policy. The council should be comprised of cabinet-level leadership and tasked with directing, coordinating, and delivering measurable climate outcomes across the federal government. This council is modeled on the National Security and National Economic Councils, which are supported by specialized staff.

A new president will have no time to waste in setting the country on the path to achieving a 100 Percent Clean Future. Therefore, the first action of the National Climate Council should be to set the 100 percent clean target and appropriate benchmarks across the federal government against which progress will be measured. The new White House component will also need to work closely with the U.S. Congress to enact legislation, including to codify the 100 Percent Clean Future target, that will be needed to be successful in carrying out the policy recommendations listed throughout this report.

Individual call to action

As with any major social change, it takes individuals demanding action and doing their part to address the problem. The Green New Deal, the Sunrise Movement, and the Global Climate Strikes show that activists are energized and forcing leaders to step up to the challenge. Not everyone is ready to be an activist, but many people want to get involved and make choices that can be a powerful part of the solution.

Whether choosing to purchase products with sustainable supply chains, investing in climate-conscious funds, making your home and appliances more energy efficient, buying an electric vehicle, or taking public transportation, lifestyle and consumption choices equip every American to become part of the climate solution today.

With a smart phone in everyone's pocket, a simple game application should be developed for teachers, parents, and pretty much anyone interested in tracking what they can do to protect the planet. Each consumer choice or individual action could give you points until you reach your own net-zero status.

Unlike other recommendations in this report, this is an excellent opportunity for the private sector to jump in and offer a helpful tool to engage as much of society as is interested in driving the necessary change. When John F. Kennedy called for America to land on the moon, he asked science and education to join in the challenge, and it ²⁵⁵ captivated the imagination of millions. This is just a small opportunity to make the large number of Americans who care about climate change part of building a 100 Percent Clean Future.

Throughout this report there are many actions that individuals will need to take, including planting trees in their communities, making sure their next vehicle is an electric vehicle, making consumer choices that are more sustainable, and installing solar panels on their roofs. Companies and social networking sites can encourage these early adopters by offering ways to highlight and quantify the effects of proactive individual choices. Other businesses or retailers could offer incentives or discounts at particular point levels. The most important thing any individual can do is vote to put pressure on policymakers to act on climate change to stabilize global temperatures, but in between elections, this is one way to stay focused on simple solutions. No individual alone will significantly affect the climate, but like victory gardens in World War II, personal and community commitments help create a sense of common purpose to support a sustained program of policy change.

Conclusion

The science is clear. The costs of inaction are increasing daily. There is a growing consensus that the United States must act to limit warming to 1.5 degrees Celsius.

Moving to a 100 percent clean economy by 2050 will require strong leadership at the national level to transform the American economy, create millions of high-quality jobs, and clean up the pollution affecting disadvantaged communities today. If the next administration and Congress can repair the damage by the Trump administration and make climate change a top priority, success in getting the United States and the world on the right pathway is within reach. This will mean learning from state and local successes, building strong coalitions, and putting the needs of workers and historically disadvantaged communities at the center of the process.

America's future is in the balance. If the country acts, it means a safer, healthier, more equitable, and more prosperous future for all Americans and their families. It means clean air and water for everyone and millions of high-wage jobs all across the country; developing innovative green technologies to export to the rest of the world; and building infrastructure that will power America and make communities healthier and safer. This is a future to embrace and welcome; it will improve people's lives today and ensure prosperity for generations of Americans to come.

About the authors

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Appendix and methodology

This appendix provides brief notes of explanation on the major calculations and assumptions made throughout the report.

Baseline projections

- **Baseline for energy-related carbon dioxide.** This report uses the EIA Annual Energy Outlook 2019 Reference Case,²⁵⁶ published January 2019, for projections of energy-related carbon dioxide emissions from 2017 through 2050.
- **Definition of sectors.** For the purposes of this analysis, certain line items within the EIA reference case are assigned to different sectors. EIA assigns the emissions associated with electricity generation to their end-use sectors, but this report considers the direct emissions of the electricity sector and the end-use sectors separately. EIA's commercial and residential buildings sectors are both treated as a combined buildings sector in this discussion. EIA considers emissions from construction under the industrial sector, but this report discusses them under the transportation sector. EIA considers emissions from agriculture under the industrial sector, but this paper discusses them as a separate agriculture sector. EIA considers the emissions associated from refining and coal mining under the industrial sector and from lubricants and pipelines under the transportation sector but they are treated in this paper separately as fossil fuel supply-related emissions. This report discusses all other components of EIA's industrial sector, including statistical discrepancies and noncoal mining, alongside manufacturing.
- **Baseline for all other direct greenhouse gas emissions.** The EPA publishes economywide estimates of all greenhouse gases, most recently in 2019,²⁵⁷ but does not project a future baseline similar to EIA's. For this report, carbon dioxide emissions from nonenergy use of fuels is considered alongside manufacturing and is projected through 2050 by maintaining the same annualized rate of growth observed from 1990 to 2017. Non-CO2 emissions from stationary combustion, incineration of waste, and electrical transmission are assigned to the electric sector, and projected

through 2050 following EIA's projection for electricity-related CO₂ emissions. Non-CO₂ emissions from mobile sources are assigned to the transportation sector and projected through 2050 following EIA's projection for transportation-related CO₂ emissions. Non-CO₂ emissions from fossil fuel mines, wells, and systems are treated in this paper separately as fossil fuel supply-related emissions and projected through 2050 following EIA's projection for quads of energy consumption by fuel. A substantial spike in methane emissions in the last decade indicates that global non-CO₂ accounting may be significantly underestimating fossil fuel supply-related emissions.²⁵⁸ Non-CO₂ emissions from manufacturing and agriculture are projected through 2030 following the rates of growth reported by the Rhodium Group in its proprietary climate deck service²⁵⁹ and through 2050 by continuing the same average rate of annual growth thereafter.

- **Separating coal mining from all other mining.** Emissions from coal mining activities, which do not include fugitive methane emissions,²⁶⁰ were obtained from EPA's Greenhouse Gas Inventory Data Explorer. In EPA's breakdown of emissions from energy production and use,²⁶¹ coal mining activities accounted for 62 MMT CO₂e in 2017. To calculate the proportions of CO₂ and non-CO₂, we used the CO₂ emissions factor for the mining industry in Exhibit 2 of the Department of Energy Industrial Technologies Program's 2007 report titled "Mining Industry Energy Bandwidth Study" and then derived a coal mining CO₂ emissions factor as a part of total mining activity. This emissions factor was then applied to EIA emissions data for total mining. This paper estimates that coal mining activity was responsible for 40 MMT CO₂ and 22 MMT CO₂e of non-CO₂ emissions.
- **Associated fossil fuel supply-related emissions.** In this report the CO₂ and non-CO₂ emissions from fossil fuel supply-related emissions, which amount to approximately one-tenth of total greenhouse gas emissions in 2017, are presented within the end-use sectors in proportion to each sector's total consumption of the relevant fuel.
- **Baseline for land use, land use change, and forestry.** The emissions sequestered on net through land use, land use change, and forestry (LULUCF) are difficult to account for historically and even more difficult to project. It is likely that increased wildfires and melting permafrost, among other changes, will significantly degrade the carbon sink provided by this sector, which, in 2017, was 714 MMT CO₂e.^{262 263 264} In this report LULUCF emissions are projected through 2050 by the same annualized rate of change observed from 1990 to 2017. This calculation implies a 2050 carbon sink of 615 MMTCO₂e, which may significantly overstate the amount of sequestration that would actually remain available under current trends without significant forest management interventions.

Estimated emissions effects of sectoral benchmarks

- **Vehicle and appliance electrification.** To estimate the effect of reaching 100 percent zero-emission sales in 2035 for light-duty vehicles and appliances or systems used in buildings and industry, this paper used estimates of energy consumption by fuel type from the High Electrification Scenario of the Electrification Futures Study of the National Renewable Energy Laboratory (NREL)²⁶⁵ through 2035. Beyond 2035, this paper compared the High Electrification Scenario and a version of the Maximum Electrification Potential Scenario with the effects lagged from 2018 to 2035, choosing the more optimistic estimate in each year. The same methodology was used for medium- and heavy-duty vehicles but using 2040 in place of 2035.
- **Smart growth.** To estimate the effect of reducing vehicle miles traveled in urbanized areas by 18 percent by 2030, which the Transportation Research Board's report on Driving and the Built Environment²⁶⁶ implied was equivalent to an 8 percent reduction in total vehicle miles traveled, this paper reduces emissions in proportion to the vehicle miles traveled reduction after first reducing the total demand for fossil fuels as a result of vehicle electrification.
- **Electricity sector.** To estimate the combined effects of reaching 65 percent clean electricity generation by 2030 as well as increasing electricity load from the increasing electrification in other sectors, this paper first increased emissions from the electricity sector in proportion to the additional electricity demand resulting from vehicle and appliance electrification, as described above, and then reduced emissions by the difference in share of clean electricity generation from the baseline. The share of clean electricity generation is assumed to grow at a constant rate from 2021 to reach 65 percent in 2030 and from 2031 to reach 100 percent in 2100.
- **Agriculture and waste sector.** For methane and nitrous oxide emissions from these sectors, this paper used the marginal abatement cost curves for agriculture published by the EPA²⁶⁷ and applied the potential share of emissions abated at \$20, \$50, and \$100 per ton to the baseline for 2030, 2040, and 2050, respectively. For CO₂, this paper assumed that emissions would be reduced at the same rate as heavy-duty vehicles but with a five-year lag.
- **Manufacturing sector.** The target of reducing emissions at least 15 percent by 2030 from the manufacturing sector combines emissions reductions described above drawn from the NREL Electrification Futures Study; implementation of the Kigali targets for HFC reduction of 50 percent in 2030, 85 percent in 2036, and 100 percent in 2050; and estimates made in the Center for American Progress' recently published infrastructure paper.²⁶⁸

- **Sequestration.** In its report on Negative Emissions Technologies and Reliable Sequestration,²⁶⁹ the National Academies of Sciences estimated that an additional 1.02 gigatons of annual carbon dioxide sequestration is safely achievable without specifying a baseline or timetable. This paper assumes that this level of additional sequestration is achieved in 2050 against the baseline land sector carbon sink, described above. To estimate the additional sequestration effect of conserving 30 percent of lands by 2030—which assumes 75 million acres of permanently protected reforested or afforested lands; reforestation on nonstocked but already protected lands; and avoided deforestation of at-risk natural areas through extensions of permanent protections—this paper assumes a rate of 1 MMT CO₂ sequestered per acre for natural areas, informed by the same 2016 USDA report, as well as peer-reviewed articles from researchers at USFS and George Mason University.²⁷⁰ To estimate the effect of moving an additional 100 million acres of farmland into climate-smart agriculture practices by 2030, this paper assumes a rate of 0.5 MMT CO₂ sequestered per acre, informed by the 2016 USDA report on Building Blocks for Climate Smart Agriculture and Forestry.²⁷¹ Additional research on these topics was explicitly recommended by the National Academies’ report.

***Correction, November 4, 2019:** This report has been corrected to accurately state the National Academies of Sciences’ proposed federal investments in sequestration technologies.

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The Center for American Progress is an independent, nonpartisan policy institute that is dedicated to improving the lives of all Americans, through bold, progressive ideas, as well as strong leadership and concerted action. Our aim is not just to change the conversation, but to change the country.

Our Values

As progressives, we believe America should be a land of boundless opportunity, where people can climb the ladder of economic mobility. We believe we owe it to future generations to protect the planet and promote peace and shared global prosperity.

And we believe an effective government can earn the trust of the American people, champion the common good over narrow self-interest, and harness the strength of our diversity.

Our Approach

We develop new policy ideas, challenge the media to cover the issues that truly matter, and shape the national debate. With policy teams in major issue areas, American Progress can think creatively at the cross-section of traditional boundaries to develop ideas for policymakers that lead to real change. By employing an extensive communications and outreach effort that we adapt to a rapidly changing media landscape, we move our ideas aggressively in the national policy debate.

