



CLIMATE
INNOVATION
2050

Getting To Zero:

A U.S. CLIMATE AGENDA



GETTING TO ZERO: A U.S. CLIMATE AGENDA

We've worked with leading companies across key sectors to outline the policies needed over the coming decade to put the United States on the path to carbon neutrality by 2050.

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Introduction

There is growing momentum in the United States toward a more robust response to climate change. States, cities, and companies across the country are stepping up their efforts. A growing majority of Americans favor stronger climate efforts. And debate is again underway in Washington on comprehensive long-term solutions.

This report offers a comprehensive agenda for aligning the U.S. economy with the historic imperative of ensuring future generations a safe and stable climate. This agenda includes:

- A long-term federal framework, including an economy-wide carbon pricing program
- Complementary federal, state and local measures addressing key sectors: power, transportation, industry, buildings, land use, and oil and gas
- Recommendations to drive innovation, mobilize finance, ensure a just transition, and advance especially critical technologies
- Steps that companies should take to help lead the climate effort

Getting to Zero: A U.S. Climate Agenda is a product of C2ES's [Climate Innovation 2050](#) initiative, which brings together leading companies from all the major sectors to address the decarbonization challenge.

We invite you to take a closer look at the steps needed to put the United States on the path to carbon neutrality.

[Read the full report.](#)



The Decarbonization Challenge

Decarbonizing the U.S. and global economies represents perhaps the most ambitious and complex societal transformation ever undertaken. A successful strategy must be grounded in a firm understanding of the strong scientific rationale for this mission; the scale, scope, and urgency of this transformation; and the fundamental features of the decarbonization challenge.

What Science Tells Us: Mounting scientific evidence details the rising toll of climate change and the urgency of decarbonizing the global economy no later than 2050 to avoid its worst potential impacts.

Key Elements of Decarbonization: The core strategies for achieving net zero emissions are increasing energy efficiency, decarbonizing the power sector, switching to electricity and other low- and zero-carbon fuels, reducing non-CO₂ climate pollutants, and using both nature and technology to remove carbon from the atmosphere.

An Innovation Challenge: A U.S. climate strategy must dedicate the public resources and foster the public-private collaboration needed to accelerate innovation across a wide of range of decarbonization technologies. But innovation alone is not enough. Translating innovation into carbon neutrality is contingent on sufficient policy drivers.

All Must Do their Part: We need governments at all levels to set goals and standards, send market signals, and invest public resources; the private sector to mobilize capital and expertise and support enabling policies; investors to steer finance toward low- and zero-carbon solutions; and the public to support the policies and products that can deliver a decarbonized future.

Timing is Critical: For many years, experts and advocates encouraged “early action” to address climate change. While some important progress has been made, we are now far behind the curve, and must act urgently to make up for lost time.

The Benefits are Many: The strongest rationale for a decarbonization strategy may be the avoidance of escalating harms. Beyond avoiding such harms, decarbonization can yield enormous co-benefits, especially in driving economic growth and enhancing U.S. competitiveness.

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Strategic Objectives

An effective decarbonization strategy must be durable, so must rest on a broad political consensus. To establish and sustain this consensus, the strategy must address both climate and non-climate objectives. Overarching objectives should be:

- **Achieving net-zero emissions no later than 2050**
- **Reestablishing U.S. global leadership on climate change**
- **Developing and mobilizing a broad array of technological solutions**
- **Promoting cost-effective solutions**
- **Protecting and enhancing U.S. competitiveness and energy security**
- **Ensuring an equitable transition**
- **Strengthening climate resilience**
- **Responding to new information and circumstances**
- **Providing predictability to drive long-term investment**

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Core Elements



Establishing a Long-Term Framework

As the foundation for a successful decarbonization strategy, Congress should enact an overarching statutory framework guiding federal efforts to achieve net zero emissions.

KEY RECOMMENDATIONS:

Congress should set a national goal of making the United States carbon neutral no later than 2050 and establish an overarching statutory framework for achieving carbon neutrality, including a comprehensive review of progress every four years.

Congress should vest the President with the statutory responsibility to direct a phased effort across the federal government toward meeting the goal of carbon neutrality.

Congress should enact an economy-wide market-based policy that effectively puts an escalating price on carbon and other major greenhouse gas emissions.

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Driving Innovation

Rapidly accelerating low-carbon innovation will be essential to reaching carbon-neutrality by mid-century. Top priorities over the coming decade are to establish and implement a long-range low-carbon research and development agenda, significantly scale up federal resources for low-carbon innovation, and optimize the low-carbon innovation system.

KEY RECOMMENDATIONS:

Congress should establish decarbonization as a principal objective of the research mission of all relevant federal agencies and should direct the White House to lead an interagency innovation effort, including research, development, demonstration, and deployment strategies aimed at carbon neutrality in the transportation, power, buildings, and industry, land use, and oil and gas sectors.

Congress should ramp up funding for climate-related research and development to at least \$20 billion per year by 2030, including \$2 billion per year for the Advanced Research Projects Agency–Energy, and should provide \$50 billion to \$100 billion over the next decade for high-impact demonstration projects.

The federal government should strengthen administrative capacity and management practices to ensure the efficient and timely use of research funding and should consult closely with the private sector and other non-government stakeholders in developing and executing the low-carbon innovation agenda.

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Mobilizing Finance

Estimates of the financial resources that must be marshalled to decarbonize the U.S. economy vary widely, potentially running into the trillions of dollars. Only some of these costs, however, will be additional to what would otherwise already be spent to procure energy, goods, and services. Most of the financial resources needed for decarbonization will, rather, reflect a *shift* in investment flows.

KEY RECOMMENDATIONS:

Congress should direct the Securities and Exchange Commission to require public companies to disclose material climate-related financial risks under a range of climate scenarios and their strategies for managing those risks.

Congress should require the Federal Reserve to integrate consideration of climate-related risks into the periodic stress testing required of major financial institutions.

Congress should create a national green bank to leverage private investment in clean energy, energy efficiency, and other activities contributing to decarbonization. More states and localities should also create green banks for use in their own markets.

[Read the full report.](#)



Ensuring a Just Transition

Policies to decarbonize the U.S. economy must be bold, but they must also be equitable. They must bring everyone into a zero-carbon future, including frontline communities, such as low-income communities and communities of color, and those whose economic fortunes have been closely tied to high-emitting energy sources and industries.

KEY RECOMMENDATIONS:

Policies that could increase the cost of energy should include mechanisms to minimize any cost burden on low-income populations and small businesses.

A share of climate investment should be dedicated to deploying solutions and infrastructure in historically marginalized communities, including urban tree planting, energy efficiency retrofits, community solar, electric vehicle charging, and low- and zero-carbon public transit.

Congress should increase support to communities in transition to train workers and foster new industries that can contribute to a stable economy and tax base.

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GETTING TO ZERO: A U.S. CLIMATE AGENDA

Sectoral Elements



Power

The power sector is expected to be the lynchpin in efforts to decarbonize the economy, as other sectors rely more heavily on electricity to reduce their own emissions. This means the power sector must meet much higher levels of demand even as it dramatically reduces its own carbon intensity. Economy-wide carbon pricing can drive significant emissions reductions, but a range of complementary policies will also be needed to decarbonize power and to ensure coordinated efforts across sectors. Priorities over the coming decade include accelerating the development and deployment of low- and zero-carbon generation technologies, building low-carbon infrastructure, and modernizing wholesale power markets.

KEY RECOMMENDATIONS:

Congress should provide a range of tax credits for zero-carbon generation and should mandate the use of carbon capture or corresponding sequestration-based offsets for all fossil fuel-fired power generation by a date certain.

In the absence of meaningful economy-wide carbon pricing or a national clean energy standard, all states should adopt ambitious clean energy standards that can be met by the full range of zero-carbon technologies, including renewables, nuclear, large hydro, and fossil fuel generation with carbon capture.

Congress should direct FERC to develop a comprehensive, long-range infrastructure strategy and should prioritize the siting of “climate-critical” infrastructure. FERC should reform wholesale power markets to more explicitly value the low-carbon, capacity and reliability attributes of competing power sources.

State public utility commissions should work with the power sector to help facilitate the electrification of other sectors.

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Transportation

While economy-wide carbon pricing will encourage lower-carbon transportation, its impact on the sector will be limited, as fuel represents only a small portion of the cost of owning and operating a vehicle. Strong complementary policies are thus especially critical here. Priorities over the coming decade include accelerating the deployment of zero-emission vehicles (ZEVs), building out the charging and fueling infrastructure they require, supporting a wider range of personal mobility options, and taking steps to decarbonize other modes of transportation, including aviation, rail, and shipping.

KEY RECOMMENDATIONS:

Congress should direct the Environmental Protection Agency to establish a greenhouse gas performance standard ensuring that half of new light-duty vehicle sales are zero-emission vehicles by 2035, and a similarly ambitious standard for medium- and heavy-duty trucks.

Congress should extend the current EV tax credit, make it available as a point-of-sale rebate, and expand it to include all new ZEVs, including fuel cell EVs, and medium- and heavy-duty trucks.

States should develop comprehensive long-range plans to accelerate the deployment of zero-emission vehicle charging and refueling infrastructure. Congress should fund the development of these state plans and should provide funding to states that have plans to construct charging and refueling infrastructure.

Local governments should - with dedicated federal planning support - develop integrated transportation and land use plans that expand non-automotive transportation options to strengthen mobility while reducing congestion, air pollution, and carbon emissions.

Congress should establish a performance standard that freezes aviation emissions at 2020 levels, allowing for the use of biofuels and offsets, modeled on the Carbon Offsetting and Reduction Scheme for International Aviation.

[Read the full report.](#)



Industry

Given its tremendous diversity, its heavy reliance on large quantities of heat, and the fundamental nature of many core manufacturing processes, the industrial sector is especially challenging to decarbonize. Economy-wide carbon pricing can drive some emission reductions, but a wide range of complementary policies are also needed. Priorities over the next decade include developing innovative lower-carbon manufacturing processes, setting standards to drive energy efficiency, electrification and other forms of fuel switching, and safeguarding the competitiveness of energy-intensive, trade-exposed sectors.

KEY RECOMMENDATIONS:

Congress should increase funding to develop and commercialize alternative thermal heat technologies and to develop innovative industrial processes with much smaller greenhouse gas footprints.

The federal government should undertake a benchmarking process to establish intensity-based greenhouse gas objectives for major sub-industries.

Congress should extend and increase the existing 45Q tax credit for carbon capture to support the capture of process and on-site energy-related emissions, and should provide tax credits for energy efficiency improvements.

Federal, state, and local governments should support the deployment of combined heat and power systems.

An economy-wide carbon pricing program should include provisions aimed at safeguarding competitiveness and minimizing carbon leakage risks.

The United States should ratify the Kigali Amendment phasing down the use of hydrofluorocarbons and Congress should provide the Environmental Protection Agency with clear authority to take the steps necessary to implement it.

[Read the full report.](#)



Buildings

Decarbonizing the buildings sector (both residential and commercial) requires improving energy efficiency and switching to lower-carbon energy sources—in particular, to electricity. Key challenges include the tremendous diversity of buildings, the slow turnover of the building stock, and the competing financial interests of owners, occupants, and lenders. Priorities over the coming decade include establishing overarching goals for decarbonizing the building sector, implementing targeted measures to electrify buildings and to improve the energy efficiency of buildings and appliances, and helping building owners and occupants finance building upgrades.

KEY RECOMMENDATIONS:

State and local governments should set overarching goals for the decarbonization of commercial and residential buildings, and should regularly update their building codes to require the use of available and affordable energy efficiency measures and other carbon-reducing practices.

Federal, state, and local governments should provide incentives for building owners and homeowners to switch from fossil fuel-powered to electric appliances such as electric space and water heating systems.

All states should authorize Property Assessed Clean Energy (PACE) programs to help finance energy-related improvements in both residential and commercial buildings.

States and localities should encourage the use of energy savings performance contracts in public buildings to improve energy efficiency, reduce emissions, and save taxpayer money.

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Land Use

U.S. agricultural activities produce a variety of greenhouse gas emissions, but the land sector as a whole is a net greenhouse gas sink, with soils and vegetation absorbing significant quantities of CO₂ from the atmosphere. Increasing this land-based sequestration to help offset remaining emissions from other sectors will be essential to achieving carbon neutrality. Priorities over the coming decade include strengthening incentives and capacity for carbon sequestration on farms and forests, reducing on-farm emissions from fertilizers and livestock, bringing lower-carbon food products to market, and reducing food waste throughout the system, from farmer to consumer.

KEY RECOMMENDATIONS:

Congress should provide the U.S. Forest Service stronger funding to restore forests, increase forests' resilience to wildfires, and provide support for private forest owners in areas at risk.

State policy-makers should implement renewable natural gas programs including tax and other financial incentives, such as capital investment or project rebate programs. Drawing on the success of Renewable Portfolio Standards in electricity markets, states should expand or create renewable portfolio standards for renewable thermal energy, including renewable natural gas.

Congress should fund the U.S. Department of Agriculture to develop improved soil carbon measurement methods and equipment, and to develop food, fiber, and biomass crops that require fewer inputs and can better sequester carbon.

Local governments should implement and support composting programs that use post-consumer food waste to produce fertilizer or use biodigesters to generate biogas.

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Oil and Gas

Emissions associated with the combustion of oil and natural gas currently account for more than half of U.S. greenhouse emissions. Many of the policies recommended elsewhere in this report will dramatically reduce these emissions by transitioning other sectors away from fossil fuels. These include economy-wide carbon pricing, federal standards driving the deployment of net-zero emissions vehicles and policies to decarbonize buildings through efficiency and electrification. Other recommended policies would enable the oil and gas sector to continue serving U.S. energy needs as the economy decarbonizes, including measures to advance direct air capture, land-based sequestration, and carbon capture, utilization, and storage, which can be used to further reduce, or offset, fossil fuel emissions. Here we discuss additional policies to reduce the overall greenhouse gas intensity of U.S. oil and gas supply.

KEY RECOMMENDATIONS:

EPA should establish standards under the Clean Air Act regulating methane emissions across the oil and gas value chain, including emissions from natural gas flaring, venting, and unintentional leaks during production, processing, transmission, and distribution.

State policy-makers should implement renewable natural gas programs including tax and other financial incentives, such as capital investment or project rebate programs. Drawing on the success of Renewable Portfolio Standards in electricity markets, states should expand or create renewable portfolio standards for renewable thermal energy, including renewable natural gas.

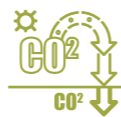
Congress should amend the tax code and other provisions to phase federal subsidies away from higher-carbon energy sources and toward lower-carbon energy sources, including fossil fuels with carbon capture.

Federal agencies should assess the climate-related impacts of new oil and natural gas infrastructure projects, and conduct similar assessments on proposals at the programmatic level that expand oil and natural gas leasing on federal lands.

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Cross - Sectoral Elements



Carbon Capture, Utilization, and Storage

Technologies to capture carbon from industrial facilities, power plants, and, ultimately, the atmosphere must be a critical element of a U.S. decarbonization strategy. Captured carbon can either be stored underground or incorporated into commercial products such as building materials and fuels. In the long run, technologies to directly capture of CO₂ from the atmosphere can produce the “negative emissions” likely needed to achieve carbon neutrality (alongside natural sequestration approaches such as afforestation and reforestation).

KEY RECOMMENDATIONS:

Congress should reauthorize and increase funding for DOE’s carbon capture program and should extend both the “begin construction” and claiming deadlines for the 45Q tax credit for CCUS.

Congress should strongly ramp up research and development to cut the cost of direct air capture, and should establish a DAC tax credit, possibly by amending 45Q.

Creating a “CO₂ superhighway”—a network of pipelines connecting sources of CO₂ to locations where it will be utilized or stored—should be a national priority in any major infrastructure legislation, with the aim of substantially completing such a network by 2030.

[Read the full report.](#)



Digitalization

Digital technologies are transforming how we use and consume energy. The digitalization of energy—through the use of sensors, networked devices, data, and analytics—has enabled a systems-based approach that can significantly reduce energy use and carbon emissions across the economy.

Priorities over the coming decade to realize the full potential of digital solutions include prioritizing systems-based research and development, addressing information gaps, leveraging government procurement of digital solutions, and expanding access to broadband networks.

KEY RECOMMENDATIONS:

Congress and DOE should prioritize RDD&D efforts that enable systems-based efficiency through digital technologies, and should support the development of real-time measurement and verification protocols for systems-level efficiencies in buildings, industry, and transportation.

All levels of government—federal, state, and local—should lead by example by requiring agencies to procure digital solutions, documenting the related energy efficiencies and cost-savings, and publicizing the lessons learned.

Congress should fund and oversee the scaling and accelerated deployment of broadband infrastructure nationwide, especially in rural areas.

[Read the full report.](#)



Bioenergy

Bioenergy has significant potential to contribute to decarbonization across multiple sectors. Different forms of bioenergy can be produced from a wide range of organic materials including crops, agricultural and food wastes, and forest products. The CO₂ released by the burning of biofuels can be balanced out by the CO₂ absorbed from the atmosphere in the growth process, including through the long-term management of forests to increase carbon stocks. Pairing bioenergy with carbon capture and storage – for instance, running a power plant on biofuels and capturing and sequestering the resulting emissions – can produce “negative emissions” that offset emissions from other activities.

KEY RECOMMENDATIONS:

DOE should partner with businesses on pilot demonstrations of bioenergy with carbon capture and storage to study its emission-reducing or negative-emissions potential and to encourage commercial development.

Federal agencies should work collaboratively to develop consistent methodologies to more accurately assess the net emissions benefits of biofuels.

States should provide incentives to the power and industrial sectors to use low-carbon bioenergy and bioenergy with carbon capture and storage in place of carbon-intensive fuels.

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H¹ Hydrogen

Hydrogen has significant potential to contribute to decarbonization as a valuable zero-emission energy carrier across multiple sectors of the economy. Hydrogen can be stored for long periods and used on demand. Converting it into heat and electricity produces no emissions—only heat and water. The production of hydrogen itself can generate significant greenhouse gas emissions, depending on the method used. However, surplus electricity from zero-emitting renewables and nuclear can be used during periods of overgeneration to produce large quantities of “green” zero-carbon hydrogen. In addition, carbon capture can be used with processes that create hydrogen from natural gas to produce “blue” hydrogen, currently the lowest-cost form of low-carbon hydrogen.

KEY RECOMMENDATIONS:

DOE should partner with industry to accelerate the development of low-carbon pathways to produce hydrogen and to develop alternative industrial processes that rely on hydrogen instead of fossil fuels.

Congress should fund the development of state and regional plans to kickstart the buildout of storage, pipeline networks, and other infrastructure to support higher levels of hydrogen use across sectors.

Congress and states should provide incentives for the adoption of technologies employing hydrogen, such as hydrogen fuel cells.

[Read the full report.](#)

GETTING TO ZERO: A U.S. CLIMATE AGENDA
Business Leadership



Business Leadership

Climate change is an all-in effort, and the private sector in particular must play a leading role in positioning the United States for carbon neutrality. Every major company should have a strategy for contributing to and succeeding in this transition. These strategies can complement, supplement, and play an important role in informing government policies. Key elements of these strategies should include managing emissions, investing for long-term decarbonization, disclosing climate-related risks, strengthening resilience to climate impacts, and partnering with policymakers, the public, and private-sector peers.

KEY RECOMMENDATIONS:

Companies should adopt carbon-neutrality goals and use only sequestration-based emission offsets after 2050. They should employ internal practices such as carbon pricing to systematically incorporate climate-related costs into investment and operational decisions.

Companies should invest now in the technologies and workforce needed to decarbonize the economy.

Companies should thoroughly assess and voluntarily disclose to stakeholders and investors their climate-related risks and opportunities, as well as their strategies to lower emissions, invest in long-term needs, and boost resilience.

Companies should actively engage policymakers at all levels to voice support for the policies needed to decarbonize the economy, partner with their private-sector peers and collaborate across and between sectors to spread action throughout their industries, and help consumers understand their options for reducing their carbon footprints.

[Read the full report.](#)



Conclusions

Climate change is perhaps the most profound challenge of our time. An effective global response is to some degree contingent on an effective U.S. response. While the United States has made important strides in reducing its global greenhouse gas emissions, far greater efforts are needed across society to decarbonize the U.S. economy and avoid the worst potential impacts of climate change.

Getting to Zero offers one vision for aligning the U.S. economy with the urgent need to address climate change. It builds on a very extensive body of research and analysis on decarbonization challenges and solutions, and is informed by close consultations with leading companies in key economic sectors. This is by no means a definitive blueprint, however. Rather, it is our best approximation at this stage of the efforts needed to achieve carbon neutrality. The most effective strategies for achieving that goal can only be fully ascertained over time, as we learn by doing and take account of new information and advances.

Ultimately, the prospects for, the shape of, and the success of a comprehensive U.S. decarbonization strategy rest heavily on political considerations. Analysis and dialogue can help point the way, but our destination can be reached only if we are able to summon the necessary political will.

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Who We Are

[The Center for Climate and Energy Solutions](#) is an independent, nonpartisan, nonprofit organization working to forge practical solutions to climate change.

As one of the world's top environmental think tanks, C2ES brings together policymakers business leaders, and others to develop ideas that will deliver lasting climate progress. Our mission is to advance policies and actions that reduce greenhouse gas emissions, promote clean energy, and strengthen resilience to climate impacts.

We believe a sound climate strategy is essential to ensure a strong, sustainable economy, and that environmental and economic progress go hand in hand.

Indeed, many leading companies agree. The C2ES Business Environmental Leadership Council is the largest U.S.-based group of Fortune 500 companies dedicated solely to addressing our climate challenges.



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