ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM

#USDecarb
Climate Change and Decarbonization

Limiting climate change to substantially less than 2 degrees Celsius requires global emissions to reach net-zero by mid-century (IPCC 2018)

U.S. emissions for 2019 were 6 Gt CO$_2$e/y of all greenhouse gases and 5 Gt CO$_2$/y, partially offset by a large CO$_2$ sink from its managed forests.
About the Study

The committee was asked to evaluate the status of technologies, policies, and societal factors needed for decarbonization and recommend research and policy needs.

This first report focuses on near and mid-term (5-20 years) high-value policy improvements, research investments, and approaches required to put the U.S. on a path to achieve long-term net-zero emissions.

The second report (expected 2022) will assess a wider spectrum of technological, policy, social, and behavioral dimensions of deep decarbonization and their interactions.

Sponsored by the Alfred P. Sloan Foundation, Heising-Simons Foundation, Quadrivium Foundation, Gates/Breakthrough Energy, ClearPath Foundation, and Incite Labs, with support from the National Academy of Sciences Presidents Fund.
Report Scope

Federal actions over the next ten years to put the US on a fair and equitable path to net-zero in 2050.

Sectors considered include CO₂, transportation, electricity, industry, buildings, and biofuels.

Not asked to determine whether the nation should move to net zero, only how to get there. Other GHGs, sinks created by forestry practices, and cropping practices that enhance soil carbon are not discussed in detail.

This report is broadly compatible with recent announcements from the Biden Administration. It was developed by an expert panel without prior consultation with the Administration.
Committee Roster

Stephen W. Pacala, Chair, Princeton University
Colin Cunliff, ITIF
Danielle Deane-Ryan, Libra Foundation
Kelly Sims Gallagher, Tufts University
Julia H. Haggerty, Montana State University
Chris T. Hendrickson, Carnegie Mellon University
Jesse Jenkins, Princeton University
Roxanne Johnson, BlueGreen Alliance
Timothy C. Lieuwen, Georgia Institute of Technology

Vivian E. Loftness, Carnegie Mellon University
Clark A. Miller, Arizona State University
Billy Pizer, Duke University
Varun Rai, University of Texas at Austin
Ed Rightor, American Council for an Energy-Efficient Economy
Esther S. Takeuchi, Stony Brook University
Susan F. Tierney, Analysis Group
Jennifer Wilcox, University of Pennsylvania
Lessons Learned from Review of Previous Studies
Projected energy costs are less during the 2020s than added health benefits. $2.1 trillion in incremental capital will be required. However, this is not a cost, and will be largely offset by operational savings.

Deep decarbonization is feasible and economic

Decarbonization Paths Compared to Historical Energy Spending
Deep decarbonization could revitalize U.S. manufacturing and increase employment

Technology deployment to achieve a net-zero emissions energy system could revitalize multiple U.S. economic sectors and provide up to 1-2 million net new jobs over the next decade.
Decarbonization policies must ensure a fair and equitable transition with public participation in decision making

“...clean energy transitions should help to create future U.S. energy systems that are more just, equitable, and inclusive. This requires careful attention to ensure that both the processes through which decisions about energy transitions are made and the outcomes of clean energy transitions are more inclusive of the full array of voices of workers and communities with stakes in the future of U.S. energy and that these diverse communities are treated fairly and equitably.”

“A more coordinated, national effort is needed to proactively engage diverse publics and stakeholders; to meaningfully integrate the social and economic dimensions of transitions into energy analysis and policy; and to work collaboratively with communities to create a strong clean energy economy that supports a robust U.S. workforce and distributes the costs, benefits, risks, opportunities, and burdens of decarbonization as fairly and equitably as possible.”
Deep decarbonization requires immediate action

Actions required during the first ten years are robust to uncertainty about the final make-up of the energy system.

Long-lived assets must be replaced by net-zero alternatives when they reach the end of their life cycle.
Expansion of RD&D is essential

Net-zero alternatives for some sectors are still pre-commercial, including aviation, shipping, steel, cement, and chemicals manufacturing.
Key Findings and Recommendations from the Report
Technology Goals

Electrify energy services in transportation, buildings, and industry

Examples include moving half of vehicle sales (all classes combined) to EV’s by 2030, and deploying heat pumps in one quarter of residences.

Improve energy efficiency and productivity

Examples include accelerating the rate of increase of industrial energy productivity (dollars of economic output per energy consumed) from the historic 1% per year to 3% per year.

Produce carbon-free electricity

Roughly double the share of electricity generated by carbon-free sources from 37% to 75%.

Expand the innovation toolkit

Triple federal support for net-zero RD&D.

Plan, permit, and build critical infrastructure

Examples include new transmission lines, an EV charging network, and a CO₂ pipeline network.
Socio-Economic Goals

Strengthen the U.S. economy

Use the energy transition to accelerate US innovation, reestablish US manufacturing, increase the nation’s global economic competitiveness, and increase the availability of high-quality jobs.

Support communities, businesses, and workers

Proactively support those directly and adversely affected by the transition

Promote equity and inclusion

Ensure equitable distribution of benefits, risks and costs of the transition to net-zero.

Integrate historically marginalized groups into decision-making by ensuring adherence to best practice public participation laws.

Ensure entities receiving public funds report on leadership diversity to ensure non-discrimination.

Maximize cost-effectiveness

The National Academies of Sciences • Engineering • Medicine
Policy Recommendations Table

Report contains 30 near-term policy recommendations across 4 main categories.

This presentation covers 12 of these recommendations.

View full policy table at nap.edu/decarbonization-policies
# Key System-Wide Actions for the Next 10 Years

<table>
<thead>
<tr>
<th>Policy</th>
<th>Technology Goals</th>
<th>Socio-Economic Goals</th>
<th>Gov Entities</th>
<th>Appropriation, if Any</th>
<th>Notes</th>
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<tbody>
<tr>
<td>U.S. CO₂ and other GHG emissions budget reaching net zero by 2050.</td>
<td><img src="lightning_bolt.png" alt="Lightning bolt" /> <img src="wind_turbine.png" alt="Wind turbine" /> <img src="solar_panel.png" alt="Solar panel" /></td>
<td><img src="flag.png" alt="Flag" /> <img src="gear.png" alt="Gear" /> <img src="gear.png" alt="Gear" /></td>
<td>Executive and Congress</td>
<td>$5 million per year.</td>
<td>Budget is central for imposing emissions discipline, although any consequences for missing the target must be implemented through other policies. Funds are primarily for administration of the budget and data collection and management.</td>
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<td>Economy-wide price on carbon.</td>
<td><img src="lightning_bolt.png" alt="Lightning bolt" /> <img src="wind_turbine.png" alt="Wind turbine" /> <img src="solar_panel.png" alt="Solar panel" /></td>
<td><img src="flag.png" alt="Flag" /> <img src="gear.png" alt="Gear" /> <img src="piggy_bank.png" alt="Piggy bank" /></td>
<td>Congress</td>
<td>None. Revenue of $40/tCO₂ rising 5% per year, which totals approximately $2 trillion from 2020 to 2030.</td>
<td>Carbon price level not designed to directly achieve net-zero emissions. Additional programs will be necessary to protect the competitiveness of import/export exposed businesses.</td>
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<td>Establish 2-year federal National Transition Task Force to assess vulnerability of labor sectors and communities to the transition of the U.S. economy to carbon neutrality.</td>
<td><img src="lightning_bolt.png" alt="Lightning bolt" /> <img src="wind_turbine.png" alt="Wind turbine" /> <img src="solar_panel.png" alt="Solar panel" /></td>
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<td>Congress</td>
<td>$5 million per year.</td>
<td>Task force responsible for design of an ongoing triennial national assessment on transition impacts and opportunities to be conducted by the Office of Equitable Energy Transitions.</td>
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<td>Establish White House Office of Equitable Energy Transitions.</td>
<td>![solar_pane]</td>
<td>![green_leaf]</td>
<td>Congressional appropriation</td>
<td>$25 million per year, rising to $100 million per year starting in 2025.</td>
<td>Federal office establishes targets and monitors and advances progress of federal programs aimed at a just transition.</td>
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<td>• Establish criteria to ensure equitable and effective energy transition funding.</td>
<td>![wind_turbine]</td>
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<td>• Sponsor external research to support development and evaluation of equity indicators and public engagement.</td>
<td>![gear]</td>
<td>![eco]</td>
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<tr>
<td>• Report annually on energy equity indicators and triennially on transition impacts and opportunities.</td>
<td>![gear]</td>
<td>![eco]</td>
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<td>Establish an independent National Transition Corporation to ensure coordination and funding in the areas of job losses, critical location infrastructure, and equitable access to economic opportunities and wealth, and to create public energy equity indicators.</td>
<td>![solar_pane]</td>
<td>![green_leaf]</td>
<td>Congressional appropriation</td>
<td>$20 billion in funding over 10 years.</td>
<td>Primary means to mediate harms that occur during transition, including support for communities that lose a critical employer, support for displaced workers, abandoned site remediation, and opportunities for communities to invest in a wide range of clean energy projects.</td>
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<td>Establish a federal Green Bank to finance low- or zero-carbon technology, business creation, and infrastructure.</td>
<td><img src="image" alt="Light Bulb" /> <img src="image" alt="Sustainability" /> <img src="image" alt="Energy" /></td>
<td><img src="image" alt="National Flag" /> <img src="image" alt="Innovation" /> <img src="image" alt="Economy" /></td>
<td>Congressional authorization and appropriation</td>
<td>Capitalized with $30 billion, plus $3 billion per year until 2030. Additional requirements include public reporting of both energy equity analyses of investment and leadership diversity of firms receiving funds.</td>
<td>Fields covered include science, engineering, policy, and social sciences, for students researching and innovating in low-carbon technologies, sustainable design, and the energy transition.</td>
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<td>Establish educational and training programs to train the net-zero workforce, with reporting on diversity of participants and job placement success.</td>
<td><img src="image" alt="Light Bulb" /> <img src="image" alt="Sustainability" /> <img src="image" alt="Energy" /></td>
<td><img src="image" alt="National Flag" /> <img src="image" alt="Innovation" /> <img src="image" alt="Economy" /></td>
<td>Congressional appropriations to Department of Education, DOE, and NSF</td>
<td>$5 billion per year for GI Bill-like program. $100 million per year for new undergraduate programs. $50 million per year for use-inspired and $375 million per year for other doctoral and postdoctoral fellowships. Eliminate visa restrictions for net-zero students. $7 million over 2020–2025 for the Energy Jobs Strategy Council.</td>
<td>Fields covered include science, engineering, policy, and social sciences, for students researching and innovating in low-carbon technologies, sustainable design, and the energy transition.</td>
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<td>Increase clean energy and net-zero transition RD&amp;D that integrates equity indicators.</td>
<td><img src="image" alt="Light Bulb" /> <img src="image" alt="Sustainability" /> <img src="image" alt="Energy" /></td>
<td><img src="image" alt="National Flag" /> <img src="image" alt="Innovation" /> <img src="image" alt="Economy" /></td>
<td>Congressional appropriation for and directions to DOE and NSF</td>
<td>DOE clean energy RD&amp;D triples from $6.8 billion per year to $20 billion per year over 10 years. DOE funds studies of policy evaluation at $25 million per year and regional innovation hubs at $10 million per year; DOE- and NSF-funded studies of social dimensions of the transition should be supported by an appropriation of $25 million per year.</td>
<td>Establish criteria for receiving funds on equity analysis, appropriate community input, and leadership diversity of companies applying for public investments. DOE to report on equity impacts and diversity of entities receiving public funds.</td>
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<td>Set rules/standards to accelerate the formation of markets for clean energy that work for all.</td>
<td><img src="image1.png" alt="Electricity" /> <img src="image2.png" alt="Gear" /> <img src="image3.png" alt="Wind" /></td>
<td><img src="image4.png" alt="Green" /></td>
<td>Congress</td>
<td>None.</td>
<td>Two of these congressional actions involve FERC, and three involve the DOE.</td>
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<td>Enact five congressional actions to advance clean electricity markets, and to improve their regulation, design, and functioning.</td>
<td><img src="image1.png" alt="Electricity" /> <img src="image5.png" alt="Lightning" /></td>
<td><img src="image6.png" alt="Flag" /></td>
<td>Congress</td>
<td>$8 million per year for Federal Energy Regulatory Commission (FERC) Office of Public Participation and Consumer Advocacy.</td>
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<td>Set national standards for light-, medium-, and heavy-duty zero-emissions vehicles, and extend and strengthen stringency of CAFE standards. Light-duty ZEV standard ramps to 50% of sales in 2030; medium- and heavy-duty to 30% of sales in 2030.</td>
<td><img src="image7.png" alt="Headlight" /> <img src="image1.png" alt="Electricity" /> <img src="image2.png" alt="Gear" /> <img src="image3.png" alt="Wind" /></td>
<td><img src="image6.png" alt="American Flag" /></td>
<td>Congress</td>
<td>None.</td>
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<td>Set manufacturing standards for zero-emissions appliances including hot water, cooking, and space heating. Department of Energy (DOE) continues to establish appliance minimum efficiency standards. Standard ramps down to achieve close to 100% all-electric in 2050.</td>
<td><img src="image8.png" alt="Lightbulb" /> <img src="image1.png" alt="Electricity" /> <img src="image5.png" alt="Lightning" /></td>
<td><img src="image6.png" alt="Flag" /></td>
<td>Congress</td>
<td>None.</td>
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Plans for Second Report

Decisions on topics and structure of second report guided by task statement and informed by committee’s discussions.

Topics might include:

- agriculture and forestry carbon sinks
- greater sector-specific detail
- expanded treatment of technologies that will be important in the 2030-2050 time range
- broader range of policy actors (state, local, private sector, non-governmental organizations)
- national security implications
- wider consideration of benefits
Thank you!

Download the report and report resources at nap.edu/decarbonization

Subscribe for updates on the study website at nationalacademies.org/decarbonization

Join the conversation on twitter with #USDecarb

Other public events and briefings are in the works.

– We welcome suggestions for additional briefings, please email decarbonization@nas.edu