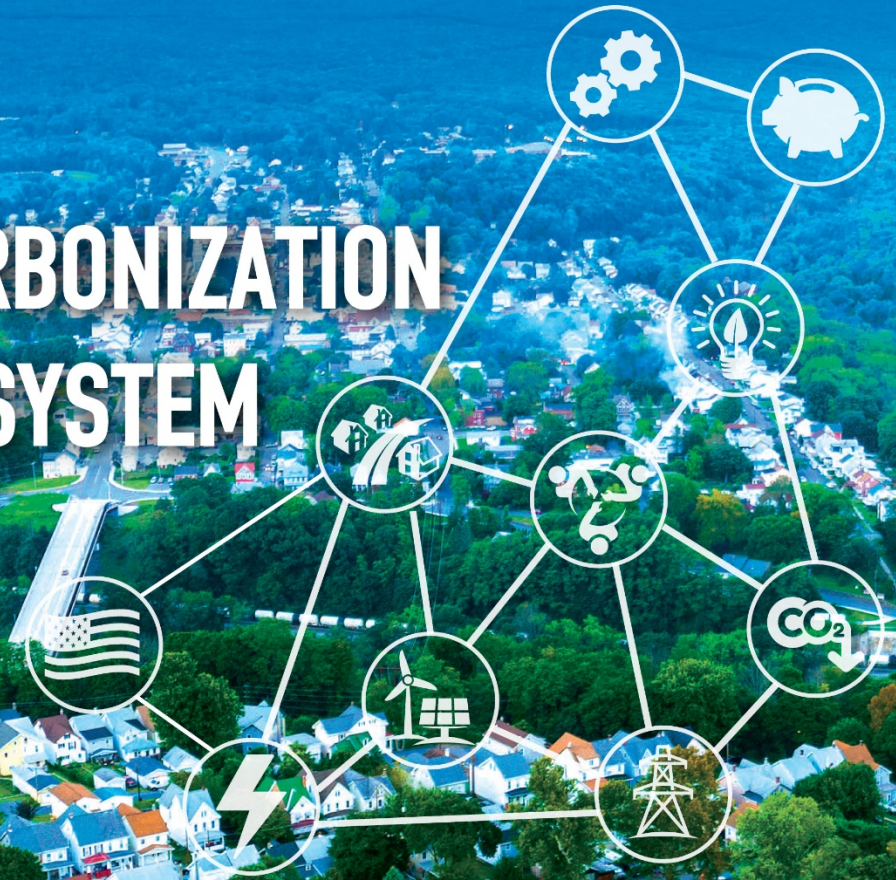
The National Academies of SCIENCES ENGINEERING MEDICINE

ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM

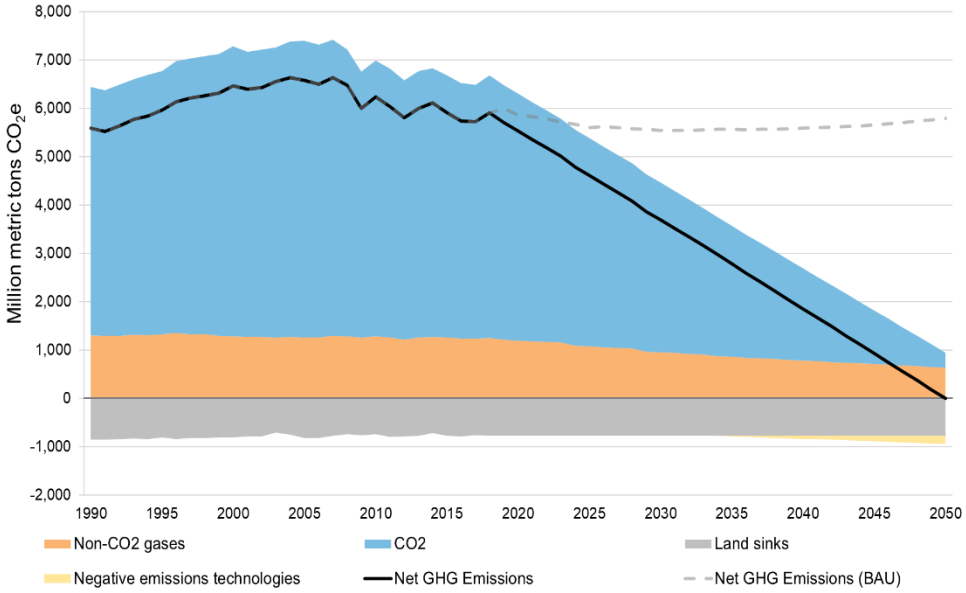


#USDecarb

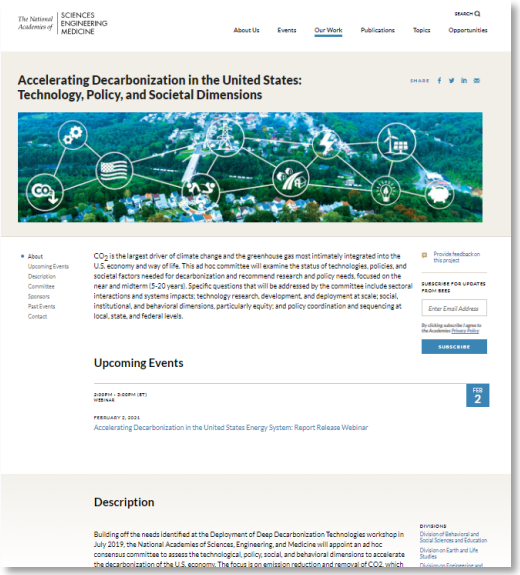
Climate Change and Decarbonization

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_2e/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



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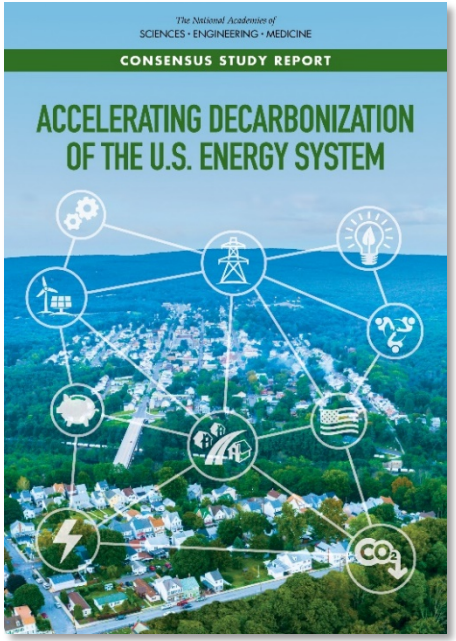
The committee was asked to evaluate the status of technologies, policies, and societal factors needed for decarbonization and recommend research and policy needs.

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



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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 **CO_2, 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

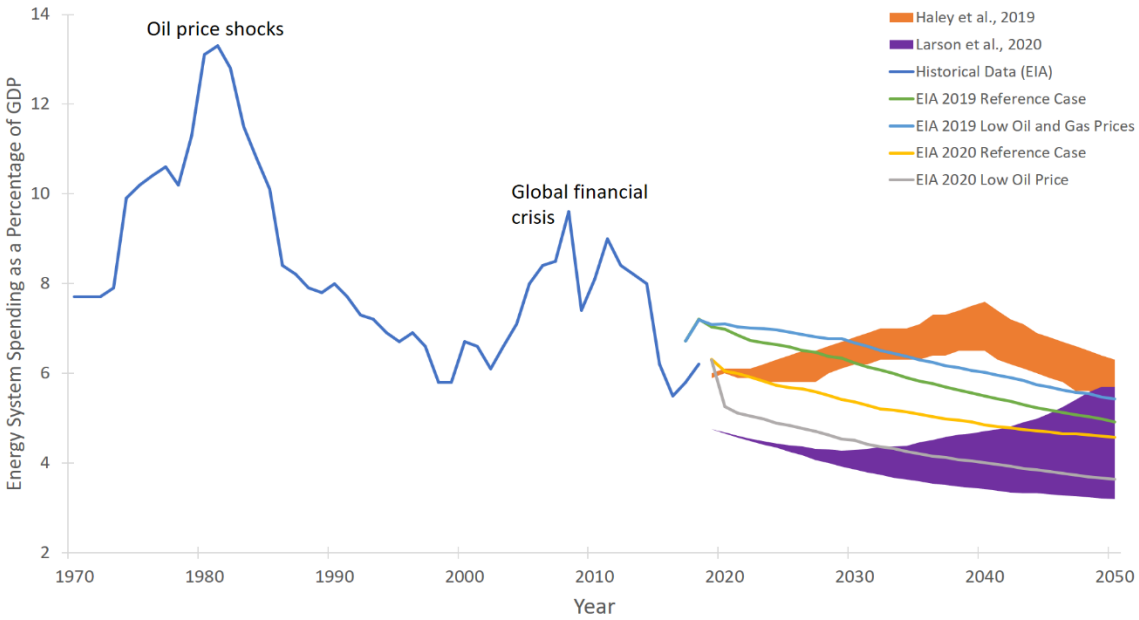
Jennifer Wilcox, University of Pennsylvania

Lessons Learned from Review of Previous Studies

Deep decarbonization is feasible and economic

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.



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

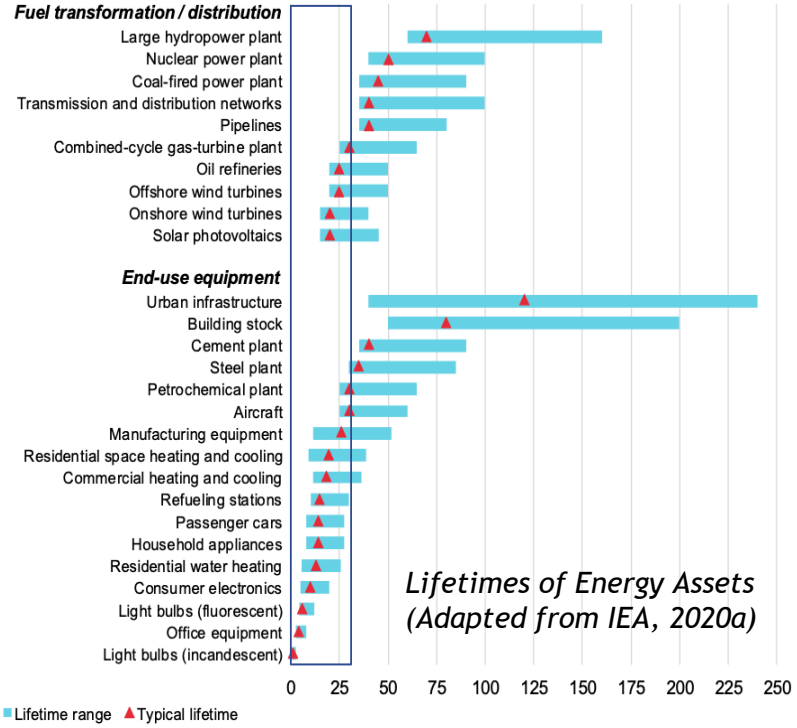
"…clean energy transitions should help to create future U.S. energy systems that are more just, equitable, and inclusive. This requires careful attention to ensure that both the ***processes*** through which decisions about energy transitions are made and the ***outcomes*** of clean energy transitions 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.



Lifetimes of Energy Assets (Adapted from IEA, 2020a)

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 CO_2 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

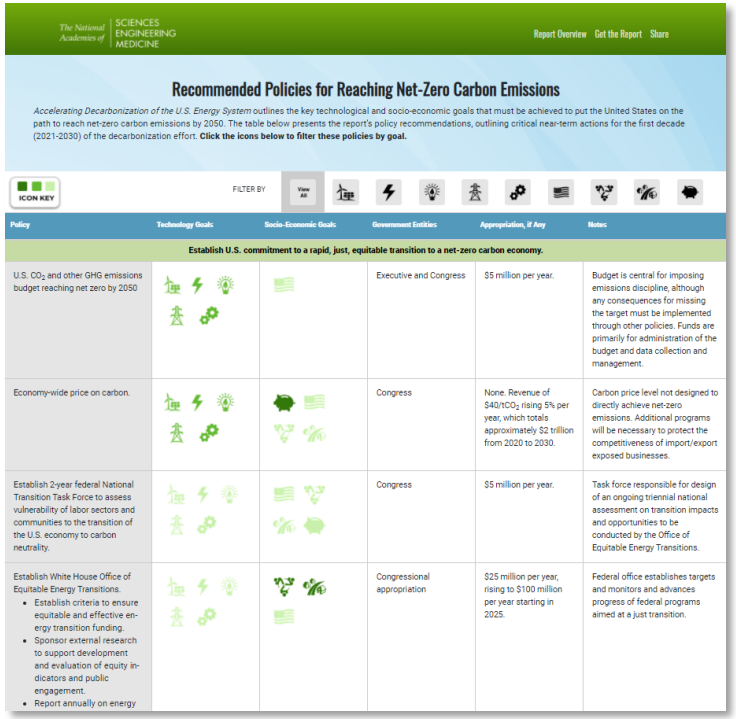
Promote equity and inclusion

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



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Report Overview Get the Report Share

Recommended Policies for Reaching Net-Zero Carbon Emissions

Accelerating Decarbonization of the U.S. Energy System outlines the key technological and socio-economic goals that must be achieved to put the United States on the path to reach net-zero carbon emissions by 2050. The table below presents the report's policy recommendations, outlining critical near-term actions for the first decade (2021-2030) of the decarbonization effort. **Click the icons below to filter these policies by goal.**

ICON KEY FILTER BY View All

Policy	Technology Goals	Socio-Economic Goals	Government Entities	Appropriation, if Any	Notes
Establish U.S. commitment to a rapid, just, equitable transition to a net-zero carbon economy.					
U.S. CO_2 and other GHG emissions budget reaching net zero by 2050			Executive and Congress	$5 million per year.	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.
Economy-wide price on carbon.			Congress	None. Revenue of $40/tCO$_2$ rising 5% per year, which totals approximately $2 trillion from 2020 to 2030.	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.
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.			Congress	$5 million per year.	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.
Establish White House Office of Equitable Energy Transitions. • Establish criteria to ensure equitable and effective energy transition funding. • Sponsor external research to support development and evaluation of equity indicators and public engagement. • Report annually on energy			Congressional appropriation	$25 million per year, rising to $100 million per year starting in 2025.	Federal office establishes targets and monitors and advances progress of federal programs aimed at a just transition.

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

Essential and Highest Priority | Important | Supporting Role

Policy	Technology Goals	Socio-Economic Goals	Gov Entities	Appropriation, if Any	Notes
Establish U.S. commitment to a rapid, just, equitable transition to a net-zero carbon economy.					
U.S. CO_2 and other GHG emissions budget reaching net zero by 2050.			Executive and Congress	$5 million per year.	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.
Economy-wide price on carbon.			Congress	None. Revenue of $40/t$CO_2$ rising 5% per year, which totals approximately $2 trillion from 2020 to 2030.	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.
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.			Congress	$5 million per year.	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.

Key System-Wide Actions for the Next 10 Years

Policy	Technology Goals	Socio-Economic Goals	Gov Entities	Appropriation, if Any	Notes
Establish U.S. commitment to a rapid, just, equitable transition to a net-zero carbon economy.					
Establish White House Office of Equitable Energy Transitions. • Establish criteria to ensure equitable and effective energy transition funding. • Sponsor external research to support development and evaluation of equity indicators and public engagement. • Report annually on energy equity indicators and triennially on transition impacts and opportunities.			Congressional appropriation	$25 million per year, rising to $100 million per year starting in 2025.	Federal office establishes targets and monitors and advances progress of federal programs aimed at a just transition.
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.			Congressional appropriation	$20 billion in funding over 10 years.	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.

Policy	Technology Goals	Socio-Economic Goals	Gov Entities	Appropriation, if Any	Notes
Invest (research, technology, people, and infrastructure) in a U.S. net-zero carbon future.					
Establish a federal Green Bank to finance low- or zero-carbon technology, business creation, and infrastructure.			Congressional authorization and appropriation	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.
Establish educational and training programs to train the net-zero workforce, with reporting on diversity of participants and job placement success.[g]			Congressional appropriations to Department of Education, DOE, and NSF	$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.	Fields covered include science, engineering, policy, and social sciences, for students researching and innovating in low-carbon technologies, sustainable design, and the energy transition.
Increase clean energy and net-zero transition RD&D that integrates equity indicators.[i]			Congressional appropriation for and directions to DOE and NSF	DOE clean energy RD&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.	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.

Key Sector- and Community-Specific Strategies

Policy	Technology Goals	Socio-Economic Goals	Gov Entities	Appropriation, if Any	Notes
Set rules/standards to accelerate the formation of markets for clean energy that work for all.					
Set energy standard for electricity generation, designed to reach 75% zero-emissions electricity by 2030 and decline in emissions intensity to net-zero emissions by 2050.			Congress	None.	
Enact five congressional actions to advance clean electricity markets, and to improve their regulation, design, and functioning.[b]			Congress	$8 million per year for Federal Energy Regulatory Commission (FERC) Office of Public Participation and Consumer Advocacy.	Two of these congressional actions involve FERC, and three involve the DOE.
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.			Congress	None.	
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.			Congress	None.	

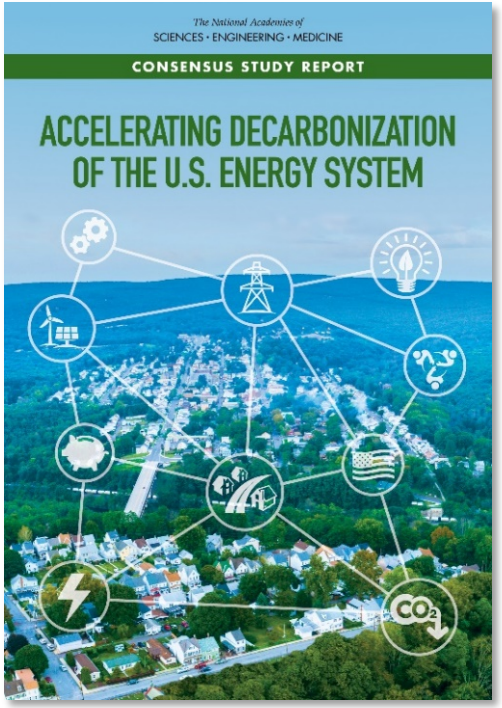
Plans for Second Report

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.

- Climate Conversation: Thurs, Feb 18 at 3pm ET
  Register at **climate-convo-decarb.eventbrite.com**
- We welcome suggestions for additional briefings, please email **decarbonization@nas.edu**