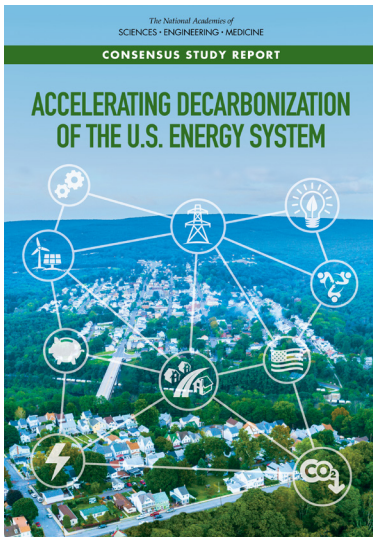




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## Accelerating Decarbonization of the U.S. Energy System



The world is transforming its energy system from one dominated by fossil fuel combustion to one with net-zero emissions of carbon dioxide (CO<sub>2</sub>), the primary anthropogenic greenhouse gas. This energy transition is critical to mitigating climate change, protecting human health, and revitalizing the U.S. economy. To help policymakers, businesses, communities, and the public better understand what a net-zero transition would mean for the United States, the National Academies of Sciences, Engineering, and Medicine convened a committee of experts to investigate how the U.S. could best decarbonize its transportation, electricity, buildings, and industrial sectors. This report, *Accelerating Decarbonization of the U.S. Energy System*, identifies 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 report presents a policy blueprint outlining critical near-term actions for the first decade (2021-2030) of this 30-year effort, including ways to support communities that will be most impacted by the transition.

### TECHNOLOGY GOALS

In order to reach net-zero carbon by 2050, the United States must begin taking action now to accomplish five main technology goals. Meeting these objectives over the current decade (2021-2030) will be essential to making the net-zero transition possible on a 30-year timeframe, so that long-lived energy infrastructure can be replaced with zero-carbon alternatives.



**Produce carbon-free electricity:** The nation needs to double the share of electricity generated by non-carbon-emitting sources to at least 75% by 2030. This will require record-setting deployment of solar and wind technologies, scaling back coal and some gas-fired power plants, and preserving operating nuclear plants and hydroelectric facilities where possible.



**Electrify energy services in transportation, buildings, and industry:** By 2030, the nation should aim for 50% of new vehicle sales across all classes to be zero-emission vehicles. The U.S. should replace 20% or more of fossil fuel furnaces with electric heat pumps in buildings and initiate policies so that new construction is all electric except in the coldest climate zones. Where industrial processes cannot be fully electrified, they should begin the transition to low-carbon heat sources.



**Invest in energy efficiency and productivity:** By 2030, total energy use by new buildings should be reduced by 50%. In existing buildings, energy used for space conditioning and plug-in devices should be lowered every year to achieve a 30% reduction by 2030. Goals for industrial energy productivity (dollars of economic output per energy consumed) should increase each year.



**Plan, permit, and build critical infrastructure:** By 2030, the nation should increase overall electrical transmission capacity by approximately 40% in order to better distribute high quality and low-cost wind and solar power from where it is generated to where it can be used across the country. The nation should also accelerate the build-out of the electric vehicle recharging network and initiate a national CO<sub>2</sub> capture, transport, and disposal network to ensure that CO<sub>2</sub> can be removed from point sources across the country.



**Expand the innovation toolkit:** The nation should triple federal investment in clean energy research, development, and demonstration (RD&D) in order to provide new technology options, reduce costs for existing options, and better understand how to manage a socially-just energy transition.

## SOCIO-ECONOMIC GOALS

A complete transformation of the energy system will affect most aspects of life in the United States, with impacts far beyond the deployment of new technologies. A net-zero emissions economy would combine the nation's impressive energy resources and culture of innovation to ameliorate ongoing social injustices in today's energy system and fairly distribute both opportunities and costs. Studies estimate that the transition could increase net employment by one to two million jobs over the next decade and revitalize multiple U.S. economic sectors. Policies to enable the transition to net-zero emissions should be designed to advance four critical socio-economic goals to ensure an equitable transition:



**Strengthen the U.S. economy:** Global demand for clean energy and climate mitigation solutions will reach trillions of dollars over the coming decades. The transition to a net-zero emissions economy provides an opportunity to revitalize U.S. manufacturing, construction, and commercial sectors, while providing a net increase in jobs paying higher wages than the national average.



**Promote equity and inclusion:** U.S. policies should promote equitable access to the benefits of clean energy systems, including reliable and affordable energy, new training and employment opportunities, and opportunities for wealth creation. Policies that facilitate the transition to a net-zero emissions economy should also work to eliminate inequities in the current energy system that disadvantage historically marginalized and low-income populations.



**Support communities, businesses, and workers:** Any fundamental technological and economic transition creates new opportunities as well as job losses and other associated impacts in legacy industries. There will be a need to identify and mitigate impacts on labor sectors and communities negatively impacted by the transition of the U.S. economy to net-zero emissions. U.S. policies should promote fair access to new long-term employment opportunities and provide financial and other support to communities that might otherwise be harmed by the transition.

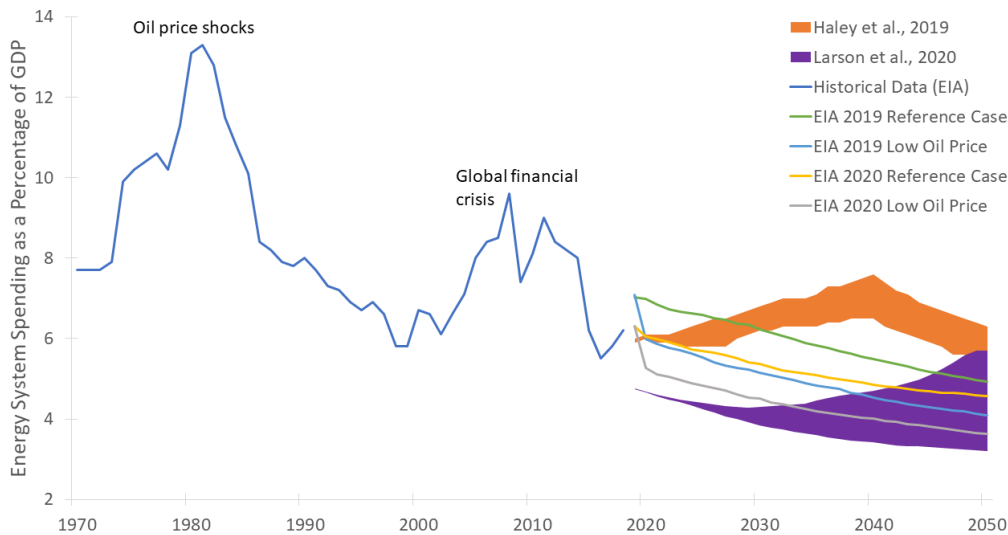


**Maximize cost-effectiveness:** A cost-effective strategy (balanced by equity considerations) will reduce carbon emissions, strengthen the U.S. economy, and avoid undue burdens on American households and businesses during the transition to a net-zero emissions economy. If the country can avoid spending more than necessary to achieve net-zero emissions, additional resources will be available to meet other societal needs.

## LESSONS LEARNED

The study committee came to its conclusions after extensively reviewing previous studies on various possible decarbonization pathways between now and 2050. In these studies, several key messages consistently emerge:

- *Deep decarbonization is technologically feasible*, but will require fundamental shifts in our energy systems.
- *Energy spending during a net-zero transition will be manageable* and less than historical expenditures.
- The *socio-economic dimensions of the transition must be considered* alongside technological change.



Projected expenditures for decarbonization efforts through 2050 (orange and purple shaded areas) vary depending on future levels of electrification, technology adoption, energy prices, and carbon capture. However, these projections as a proportion of GDP are similar to historical spending and business-as-usual cases (colored lines) as estimated by the Energy Information Administration (EIA). Therefore, achieving net-zero emissions by 2050 is not only possible, but on par with previously anticipated spending.

- **Creating a net-zero emissions energy system could revitalize the U.S. economy.** These changes provide the opportunity to promote equity and inclusion and support communities, businesses, and workers.
- **Long lifetimes for energy infrastructure will limit the pace of the transition.** As existing assets reach the end of their life cycles, they must be replaced by equipment consistent with the net-zero transition plan.
- **Repurposing existing fossil fuel infrastructure can reduce the overall costs** of the transition while reducing the potential for stranded assets and workers.
- **A net-zero emissions economy is very different from an economy with more modest carbon reductions.** Policies that produce only incremental reductions in emissions without facilitating the transformation can lead to technology lock-in and make deep decarbonization by mid-century unattainable.

## KEY SYSTEM-WIDE POLICIES TO SUPPORT DECARBONIZATION IN THE UNITED STATES

The report recommends a series of policy changes (see attached table for details) to support the net-zero transition in the United States. In particular, it calls for implementing a set of key system-wide policies, including:

- Setting an official **emissions budget** for the United States for carbon dioxide and other greenhouse gases to support the goal of reaching net-zero emissions by 2050
- An **economy-wide price on carbon**, in addition to other policies focusing on particular sectors
- A new **National Transition Task Force** to evaluate how best to support labor sectors and communities that will be affected by the energy transition
- A new **Office of Equitable Energy Transitions** within the White House to establish criteria, measure, and report back on net-zero transition impacts and equity considerations
- A new independent **National Transition Corporation** to provide support and opportunities for displaced workers and affected communities
- A new **Green Bank**, initially capitalized at \$30 billion, to ensure the required capital is available for the net-zero transition and to mobilize greater private investment
- A **comprehensive education and training initiative** to develop the workforce required for the net-zero transition, to fuel future innovation, and to provide new high-quality jobs
- **Triple federal investment in clean energy RD&D** at the Department of Energy over the next ten years as well as the support for social science research on the socio-economic aspects of advancing the transition

## KEY SECTOR-SPECIFIC POLICIES TO SUPPORT DECARBONIZATION IN THE UNITED STATES

In addition, this report calls for implementing a set of key sector-specific policies, including:

- Setting a **clean energy standard** for electricity generation designed to reach 75% clean electricity by 2030 and net-zero emissions by 2050
- Congressional and Federal Energy Regulatory Commission (FERC) actions to **advance clean electricity markets** and improve their regulation, design, and operation
- National **zero-emissions vehicle standards** for light, medium, and heavy-duty vehicles, including stronger Corporate Average Fuel Economy (CAFE) standards
- **Manufacturing standards for zero-emissions appliances** by 2050 while continuing to establish appliance minimum efficiency standards
- Requiring recipients of federal funds and their contractors to meet **labor standards**, and enforcing **Buy America/Buy American provisions** for federally-funded activities
- Invest in **efficiency improvements for low-income households**, expanded **rural broadband** access, and the **electrification of tribal lands**

For more information about the report, including a complete list of the report's policy recommendations and discussion of sector-specific considerations, please check out our digital report overview at [nap.edu/decarbonization](https://nap.edu/decarbonization).

Learn more about the study and sign up for updates at [nationalacademies.org/decarbonization](https://nationalacademies.org/decarbonization).

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