# Accelerating Decarbonization of the Energy Sector

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*Building a more resilient, sustainable economy as we transition from fossil fuels to a clean-energy system is one of the grand challenges of the twenty-first century. Curbing climate change to two degrees or lower—a level that most nations in the world have set as their long-term goal—requires that net carbon dioxide emissions decline to zero within several decades.*

*Energy is critical to every aspect of life and every sector of the U.S. economy. It is also the major contributor to U.S. carbon dioxide emissions. The mission of the U.S. Department of Energy (DOE), along with its science and technology programs and capabilities, is key to accelerating clean energy innovation in the U.S. We propose the following five recommendations to accelerate the impact of DOE science, technology, and demonstration programs on decarbonization of the energy sector.*

**Recommendation #1: Use the convening power of DOE to build strong regional public–private partnerships to accelerate decarbonization of the energy system.**

The U.S. Secretary of Energy should convene regional public and private industry leaders to develop strategies to decarbonize regional energy systems. These regional workshops will bring together climate experts, research institutions, government leaders, regulators, regional energy planners, and energy system owners to develop a common understanding of the impacts of climate change on the energy system.

Based on the feedback provided at these workshops, near- and long-term regional decarbonization strategies and roadmaps will be developed. The strategies will address technology and system integration, affordability, equity, and the policies and financing needed to decarbonize regional energy systems. DOE and the national labs' roles are to provide objective scientific data, technology research and development, and technology evaluation and system analysis to regional stakeholders.

**Recommendation #2: Advance DOE's efforts to electrify the energy system.**

Create a DOE-wide cross-cutting initiative to develop a science and technology roadmap to accelerate electrification of the energy system, aiming towards decarbonization. In 2019, energy-related carbon dioxide emissions in the U.S. were approximately 5,142 million metric tons (37% transportation, 28% industrial, 19% residential, and 16% commercial).[1] Electric power accounted for 31% of all carbon dioxide emissions.[1] Transitioning from fossil fuels to carbon-free electricity across all sectors will require technology innovation and policy that incentivizes extensive electrification of the energy system.

Because a flexible, resilient, secure electric grid is foundational to electrifying the energy system, DOE should continue the cross-cutting Grid Modernization Initiative. The grid of the future must: (a) accommodate and optimize all types of energy generation, storage, and smart loads along the entire delivery chain from generation to end use; (b) prepare for the integration of large amounts of renewable electricity and the electrification of vehicles and industrial processes; (c) thoughtfully embrace energy digitization (i.e., interactive devices at the edge, real-time sensors, artificial intelligence and machine learning, and new control theories) to optimize the energy system without compromising cybersecurity.

The energy system electrification roadmap should be developed in partnership with U.S. industry, academia, and other government agencies, and deployment priorities should be informed by input received at workshops in Recommendation #1. The DOE national labs will play key roles in supporting DOE road-mapping efforts, science and technology research and development, regional planning tool development, and high-fidelity, highly spatially and temporally resolved data for resource planning and demand forecasting.

[1] U.S. Energy Information Administration, "What Are U.S. Energy-related Carbon Dioxide Emissions by Source and Sector?" (accessed November 1), https://www.eia.gov/tools/faqs/faq.php?id=75&t=11.

**Recommendation #3: Expand DOE research, development, and demonstrations of energy storage technologies.**

Continue to expand the coordinated efforts across DOE initiated under the Energy Storage Grand Challenge. Energy storage is a key enabler for the electrification and decarbonization of the energy system. Energy storage, especially batteries, is critical to grid flexibility and resilience as more variable renewable generation capacity is deployed. Energy storage is in the very early stages of deployment to the U.S. market. As of 2018, there were 869 MW (1,236 MWh) of installed battery storage systems in operation in the U.S.[2] relative to 1,200,000 MW of installed generation capacity.[3]

There is an intense, ongoing global competition to own the supply chain and manufacturing of energy storage technologies. The U.S. must lead the world in the development of all forms of next-generation energy storage technologies, for short-, medium, and long-duration applications. A secure and robust U.S. energy storage supply chain (i.e., materials, software, hardware, communications, and workforce development) is key to U.S. competitiveness and security. DOE programs and national laboratory capabilities should be coordinated with industry and acadamia to accelerate the development and deployment of next-generation technologies.

**Recommendation #4: Expand DOE research and development on hard-to-decarbonize sectors.**

Initiate a "moonshot" program across DOE on the development of low-carbon-intensity fuels and chemicals with carbon capture and storage. A moonshot program would set aggressive targets to demonstrate feasible approaches to produce low-carbon-intensity fuels and chemicals for transportation (heavy-duty trucks, aviation, marine, military, rail, and off-road) and other products. In 2019, diesel, jet, and other fuels (not gasoline) accounted for roughly 814 million metric ones of carbon dioxide emissions in the U.S.[4] This quantity represents approximately 43% of transportation's carbon dioxide emissions. These applications will not easily be electrified. This effort would integrate the scientific capabilities of the DOE national laboratories with the best ideas and concepts from academia and industry to reduce the carbon-intensity of fuels, chemicals, and materials. This effort would require coordination of science and applied development, exploiting national scientific user facilities, leadership class computational capabilities, and new computational paradigms (e.g., heterogeneous, neuromorphic, and quantum computing).

**Recommendation #5: Expand DOE research, including bridging fundamental and applied research, in energy–Earth system interactions.**

Continue to expand research that integrates changes in climate at a regional level and the impact to a future energy system. Changes in climate affect the amount of energy we need and our ability to produce that energy. Research is needed to improve projections of future climate shifts, including extreme events, and to identify energy decarbonization strategies that are robust to these changes. In addition to greenhouse gas emissions, energy systems affect water, land, and climate. For example, many energy production technologies require large amounts of water for cooling, which can affect river and lake ecosystems. Research is needed to better understand the future impacts on and requirements of energy systems – in terms of changes in climate, water, and land – to identify energy transitions and the sequencing of the transitions that simultaneously maintain affordable energy, improve equity, reduce emissions, promote sustainability, and enhance national security.

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[2] U.S. Energy Information Administration, *Battery Storage in the United States: An Update on Market and Trends* (2020), https://www.eia.gov/analysis/studies/electricity/batterystorage/

[3] U.S. Energy Information Administration, "What is U.S. Energy Generation by Energy Source?" (accessed November 1, 2020), https://www.eia.gov/tools/faqs/faq.php?id=427&t=3.

[4] U.S. Energy Information Administration, *U.S. Energy-Related Carbon Dioxide Emissions, 2019* (2020), https://www.eia.gov/environment/emissions/carbon/.