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## The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies

Pressing environmental, security, and economic challenges compel expanded U.S. efforts for more low- and non-polluting sources of electric power. This report offers recommendations to Congress and other federal and state policymakers for actions that could accelerate breakthrough innovation on “increasingly clean” electric power technologies – nuclear power, carbon capture and storage, and renewables such as solar and wind.

There is convincing evidence that wider-scale deployment of currently available technologies will not, on its own, address current challenges. Rather, there need to be significant innovative breakthroughs to improve technologies’ performance while lowering costs.

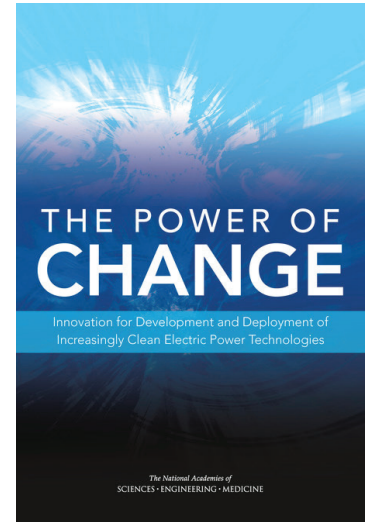
Congress, federal and state agencies, and regulatory institutions should significantly increase their support for innovation. It outlines specific actions for various actors, including steps that would aid in restructuring power markets and utility business models to incentivize the industry to accelerate its pursuit of technology innovation. Policymakers should also place a price on pollution so that the prices for various energy sources account for the health and environmental damages caused by them.

### INNOVATION NEEDED IN INCREASINGLY CLEAN POWER TECHNOLOGIES

Despite decades of gains in making electricity production cleaner, we continue to produce harmful amounts of air pollution. While the most severe and life-threatening pollution from electric power plants is largely a thing of the past in the U.S., power plant emissions of particulates as well as oxides of nitrogen and sulfur (NO<sub>x</sub> and SO<sub>x</sub>) still cause harm, contributing to premature deaths, increasing illnesses such as asthma, and increased hospitalizations. Electricity production also accounts for nearly 40 percent of all domestic greenhouse gas emissions, contributing to climate change.

These environmental damages create a significant, credible, and compelling case for expanding the use of low- or non-polluting technologies to generate electricity. This is especially true given the scale of the climate change challenge.

One reason that cleaner technologies are not more widely used is that prices for electricity currently do not reflect the costs of harms caused by it. Congress should place a price on pollution from electricity production, including greenhouse gases and pollutants such as nitrogen oxides and particulate matter, to reflect fossil fuels’ “hidden costs” to human health and the environment. Requiring electricity producers to take these hidden costs into account would help make clean energy sources cost competitive.



However, even if a price were placed on pollution in many parts of the United States most clean technologies would lack cost and performance profiles that would result in the high levels of adoption required. In most cases, their levelized costs are still higher than those of dirtier technologies, and there are significant challenges and costs in integrating them into the grid at high levels.

The best way to address these problems, and to encourage power markets to uptake clean power technologies, is to improve their performance and cost profiles - in other words, to accelerate innovation. Reducing the harmful effects of emissions due to electricity generation will require a broader range of low-cost, low- and zero-emission energy options than is currently available, as well as significant changes to the technologies and functionality of the electricity grid and the roles of utilities, regulators, and third parties.

Reducing the cost and improving the performance of increasingly clean energy technologies will in many cases require more than incremental changes to current technology. Entirely new technologies, sufficiently compelling in cost and performance to be globally deployable, likely are required.

## BARRIERS TO INNOVATION

There are several specific barriers to innovation for power technologies. An important set of barriers relates to the energy technology innovation system (ETIS). Overcoming these barriers and empowering private sector flows of capital and research and development activity are key.

The ETIS is a complex network of market and nonmarket institutions and incentives, and each stage of the innovation process presents a range of obstacles to the would-be innovator. The most important priorities for strengthening the system are identifying and creating new options, developing and demonstrating the efficacy of these options, and setting the stage for early adoption of technologies that are most promising.

There also are specific challenges for individual, promising technologies. For instance, avoiding the most costly climate change scenarios will almost certainly require an expansion of nuclear power. However, nuclear power faces major obstacles to expansion and innovation, including the high business and regulatory risks of designing innovative nuclear technologies, and the nation's lack of a long-term plan for managing spent fuel. Other technologies such as carbon capture for fossil fuels, energy efficiency technologies like solar, wind, and geothermal also face challenges specific to those technologies.

A near universal challenge is the range of local and regional resources, regional electricity markets, state-specific policies, regulatory and market structures, and several thousand utility jurisdictions. Still, these also offer an opportunity. Leveraging opportunities through ongoing government support for innovation and encouraging private sector investment can create opportunities for the United States to be a technology leader in rapidly growing global markets for renewable technologies.

## EVOLUTION IN THE ELECTRIC POWER SYSTEM

A key ingredient for expanding innovation is a market that encourages and sustains innovative activities. Developing and deploying cost-effective increasingly clean energy technologies will require an electric power sector with systems, regulation, and infrastructure that encourages and accommodates those technologies. Developing such a power sector will, in turn, require technological changes to the power system so that it is capable of integrating these new technologies and in greater quantities. To this end, utility regulators will need to incentivize utilities to become fully engaged in innovation and the demonstration of new technologies – with rules that permit reasonable and nondiscriminatory access to the transmission and delivery systems.

## KEY FINDINGS AND RECOMMENDATIONS

The committee developed a suite of findings and recommendations to address existing challenges and utilize opportunities. The most important address market failures and build incentives for markets to encourage innovation for increasingly clean electric power technologies.

Among the committee's key findings:

- Evidence suggests that policies focused disproportionately on subsidizing increasingly clean technologies will not produce the large, timely, cost-effective improvements required to address pollution. Rather, what is required to achieve these improvements is a major investment in innovation.
- Market failures and nonmarket barriers for increasingly clean power technologies exist at all stages of the innovation process.

- Efforts that leverage regional energy markets and initiatives by states, universities, entrepreneurs, industry, and others can complement federal actions to help bridge funding and commercialization gaps.
- The risks involved in transporting and storing CO<sub>2</sub> and the lack of a regulatory regime are key barriers to developing and deploying technically viable and commercially competitive carbon capture and storage technologies for the power sector at scale.
- Consistent siting, streamlined permitting, clear and responsive interconnection processes and costs, training in installation best practices, and reductions in other soft costs can have a significant impact on lowering the cost of solar and other distributed generation renewable technologies.
- To expedite innovative solutions, it will be necessary to redesign business models and regulatory incentives currently designed for a centrally controlled system so they are built on a customer-driven model with multiple solutions.

On the basis of its findings, the committee formulated 24 recommendations that, if enacted, will accelerate the development of breakthrough technologies for increasingly clean electric power production. The eight most important are presented here:

- The federal and state governments should significantly increase their emphasis on supporting innovation in increasingly clean electric power generation technologies.
- Congress should consider an appropriate price on pollution from power production to level the playing field; create consistent market pull; and expand research, development, and commercialization of increasingly clean energy resources and technologies.
- The Department of Energy (DOE) should direct funds to a broader portfolio of projects than will ultimately prove viable and should tolerate the inevitable failure of some experiments, while at the same time winnowing at each stage of the innovation process.
- The federal, state and local governments, as well as the private sector should take steps to remove barriers to, provide targeted support for, and place a high priority on the development and deployment of all cost-effective energy-efficiency measures.
- The Nuclear Regulatory Commission, on an accelerated basis, should prepare for a rulemaking on the licensing of advanced nuclear reactors that would establish (1) a risk-informed regulatory pathway for considering advanced non-light water reactor technologies, and (2) a staged licensing process with clear milestones and increasing levels of review at each stage, from conceptual design to full-scale commercial deployment.
- Congress should direct the Environmental Protection Agency to develop a set of long-term performance standards for the transport and storage of captured CO<sub>2</sub>. This effort should include establishing management plans for long-term stewardship and liability for storage sites once they have been closed, as well as greenhouse gas accounting programs.
- DOE and national laboratory programs should provide technical support to states, cities, regulators, and utilities for identifying and adopting best practices—such as common procurement methods, soft cost reduction approaches, power purchase agreements, structures for subsidies and renewable energy certificates, and common renewables definitions (taking into account regional resources)—that could align regional policies to enable more consistent and efficient markets in support of renewables.
- State regulators and policy makers should implement policies designed to support innovation. For example, they could evaluate approaches in which utility or energy customer funds are set aside to support state and regional innovation programs.

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[For More Information...](#) This Report Highlights was prepared by the Board on Science, Technology, and Economic Policy, based on the Consensus Study *The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies* (2016). The study was sponsored by the U.S. Department of Energy, the National Academy of Sciences, Engineering, and Medicine's Presidents' Circle Fund, and the National Academy of Sciences Thomas Lincoln Casey Fund. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; <http://www.nap.edu>.

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