Public Sector R&D

Overview

Today’s technologies have the potential to bend the carbon-emissions curve—but new, better, and cheaper innovations are a key component of any achievable plan for reaching a net-zero emissions economy by 2050. In other words, accelerated clean energy innovation is essential to halting climate change and limiting the rise of global temperatures.

Government investment in clean energy research, development, and demonstration (RD&D) can accelerate this necessary innovation and catalyze greater private sector investment. But current levels of public sector RD&D funding are not large enough to put the United States and the world on a path to net-zero emissions. As such, the federal government should both increase funding to its energy-RD&D agencies and reorganize them to address the climate crisis more effectively.

The federal government should be set up to make the best use of its resources, with a centralized office that is responsible for inventing, piloting, and commercializing clean energy technologies. To reduce duplication, focus the government’s efforts, and get the most innovation out of every dollar of funding, the federal government should establish a National Institutes of Energy Innovation (NIEI) modeled on the National Institutes of Health (NIH).

An NIEI would have a clear mission to support the world’s best scientists and entrepreneurs as they develop the critical technologies and solutions needed to address the climate crisis. The institutes would focus on advancements in cross-cutting technologies, end-use sectors, and clean electricity and fuel sources, reducing costs and spurring large-scale deployment. They would closely integrate breakthroughs in fundamental science with subsequent stages of product development, production, and deployment to achieve successful commercialization pathways for technologies.

In the near term, there are other important actions the federal government can take to improve the focus of its R&D efforts. The recommendations below focus on these actions.
Policy interventions include:

1. **Increasing federal funding for clean energy–innovation investments** at the Department of Energy (DOE) and other federal agencies by a factor of five over the next ten years.

2. **Updating DOE’s mission and goals** to meet the critical challenges facing the nation’s energy systems.

3. **Balancing the federal government’s innovation portfolio** so that it covers all sources of emissions and all sectors of the economy.

4. **Performing agency-wide, multi-year innovation-portfolio planning** that connects RD&D needs and funding to national energy and climate goals.

5. **Transforming DOE’s organizational structure** to better connect basic and applied energy research, rebalance the innovation portfolio, and depoliticize research programs.

6. **Stabilizing funding** for federal innovation programs.

### Legislative Principles and Policy Recommendations

#### 1. Increase federal funding for clean energy innovation.

Current levels of funding for clean energy innovation in the public and private sectors do not match the urgency and scale of investment needed to put the United States and the world on a path to net-zero emissions by mid-century. Congress should make clean energy innovation a national priority by providing funding stability for energy-innovation programs and ramping up funding for clean energy RD&D to $35 billion annually within 10 years.

Clean energy RD&D can lead to technological advances that reduce the cost of, and accelerate the transition to, a clean energy economy. In fact, federal support for clean energy innovation has already yielded tremendous public benefits. For instance, decades of federal investment in solar and wind power, lithium-ion batteries, and efficient LED lightbulbs have helped reduce their cost by 75 to 95 percent. At the same time, these investments have generated huge benefits for taxpayers. A review of federal renewable energy and energy-efficiency research programs between 1976 and 2015 found that an investment of $12 billion yielded $388 billion in net economic benefits from lower energy costs and avoided pollution. Similarly, federal investment in pollution-control technologies in the 1980s helped keep energy costs low while generating $50 billion in savings from public health benefits. These investments also helped make the U.S. a global leader in environmental technologies.

Nonetheless, the current pace of innovation is too slow to lead the nation and the world to net-zero emissions by 2050. Growth in energy demand is outpacing the clean energy transition: while global energy demand grew by 2.3 percent in 2018, carbon-free energy from renewables and nuclear power met just under a third of this new demand. In most cases, energy from unabated fossil fuels...

Globally, only $22 billion in public funds are spent on clean energy research and development (R&D) each year. In the United States, investment in energy RD&D as a portion of GDP has declined over the past four decades—from 0.14 percent of GDP in 1978 to 0.04 percent of GDP in 2019.\footnote{Energy Policy Act of 2005, 42 U.S.C § 16181 (2005): DOE shall conduct a balanced set of programs of energy research, development, demonstration, and commercial application with the general goals of (1) increasing the efficiency of all energy intensive sectors through conservation and improved technologies; (2) promoting diversity of energy supply; (3) decreasing the dependence of the United States on foreign energy supplies; (4) improving the energy security of the United States; and (5) decreasing the environmental impact of energy-related activities.} The United States currently spends about $7 billion per year on clean energy innovation, about 75 percent of which is funneled through the DOE.

This budget should be quintupled over ten years to at least $35 billion by 2030. This increase would bring climate- and energy-related research to 0.1 percent of GDP—in line with other national priorities. Rapid increases in federal RD&D investment have been enacted in the past: Congress doubled investment in biomedical research at the NIH over a five-year span from 1998-2003. As of fiscal year (FY) 2019, the budget of NIH is $37.9 billion per year.

### Historic and Recommended Investment in Clean Energy Research, Development, and Demonstration

![Historic and Recommended Investment in Clean Energy Research, Development, and Demonstration](chart)

2. **Update the Department of Energy’s mission and goals.**

Congress prescribes the goals of DOE’s energy research portfolio—in fact, all DOE grant announcements identify the specific goal the grant seeks to meet—yet it has not updated these goals since 2005.\footnote{Colin Cunliff, “FY 2020 Energy Innovation Funding: Congress Should Push the Pedal to the Metal,” April 2019, https://itif.org/energy-budget} In the fifteen years since, our energy system has undergone a rapid transformation—and over the next fifteen, this transformation will need to accelerate at a pace and scale never before seen in human history.
In order to encourage the development and deployment of innovative carbon-free energy technologies and help the nation meet its energy objectives, Congress needs to update DOE’s goals. These updates should fall into five main categories: climate change, manufacturing competitiveness, technology demonstrations, energy equity and environmental justice, and technology-specific program missions.

**Climate Change**

Current law only requires DOE perform energy research, development, demonstration, and deployment (RDD&D) to “decreas[e] the environmental impact of energy-related activities.” This broad mandate leaves much to interpretation and creates uncertainty that hinders the work of DOE scientists.10 Congress should update DOE’s goals to make clear that addressing climate change is a fundamental part of the Department’s mission. This will give its scientists a stronger mandate to pursue decarbonization solutions like low-carbon liquid fuels, dispatchable zero-carbon power, carbon capture, and carbon dioxide removal technologies. At the same time, making this focus explicit will eliminate the rationale for DOE’s few remaining research efforts aimed at extending the life of fossil-energy resources without carbon capture (like small modular coal plant designs, for example). Congress should clearly state that federal RDD&D funding should wholly prioritize development of low-carbon solutions.

**Manufacturing Competitiveness**

Addressing climate change is a huge global economic opportunity. For example, the International Energy Agency estimates that nearly $60 trillion will be invested in global energy markets over the next twenty years.11 Much of the opportunity in this space lies in manufacturing: building tomorrow’s energy technologies like solar, wind, batteries, efficient appliances, and carbon capture technologies, and reducing the energy demand and greenhouse gas (GHG) emissions associated with all manufacturing, particularly in energy-intensive industries like petroleum refining, chemicals, iron and steel, and cement.

The federal government can do much more to support clean energy manufacturing and catalyze this enormous economic opportunity. First, Congress should make increased U.S. manufacturing competitiveness a key goal for federal energy research. This shift will give DOE permission to develop new programs to support American workers.

At the same time, Congress should ask DOE to identify opportunities across the RDD&D pipeline to support U.S. industries. For example, in the growing offshore wind market, Congress could enact programs to support domestic wind turbine manufacturing, fund workforce training programs, improve permitting processes for offshore cables, and develop tax policies to speed offshore wind deployment.

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10. Ibid.
Technology Demonstrations
DOE's current authorization calls for it to build a “balanced” portfolio of RDD&D, yet the agency’s attention to critical later-stage research that reduces the time to market for clean energy technologies has fluctuated according to each administration’s ideological leanings. Meanwhile, the private sector is often reluctant to take expensive risks in this area, which is why it is essential that the government support technology demonstration and commercial application. Congress can boost DOE efforts in this space by establishing, for instance, an office dedicated to managing DOE demonstration projects.

Energy Equity and Environmental Justice
The negative effects of climate change and pollution fall most heavily on low-income and historically marginalized communities that the clean energy transition has been slow to reach. Congress should specify that equity, energy access, and environmental justice are critical objectives of DOE research, and it should authorize and fund specific programs to address the energy needs and pollution burden of low-income and historically disadvantaged communities.

Technology-Specific Missions
Along with agency-wide goals, Congress mandates technology-specific research-area missions for each program office—missions that have, until Congress recently passed the Energy Act of 2020, not been updated since the Energy Policy Act of 2005. The lack of updated, specific authorizing language has often led to limited and inconsistent interpretation of research funding areas by DOE program managers. Moving forward, more regular comprehensive updates will be needed to reflect contemporary research challenges and opportunities in energy technology.

3. Balance the federal government’s innovation portfolio.
Right now, DOE’s innovation portfolio is heavily weighted towards the electric power sector. More than half of the agency’s total applied-energy RD&D budget goes toward research on electricity generation and grid modernization, even though the power sector currently produces only about 30 percent of the nation’s GHG emissions. As Congress increases DOE’s budget, it should expand existing RD&D programs in the transportation, manufacturing, and buildings sectors and create new research programs that fill gaps in the federal innovation portfolio. Congress should also expand funding for RD&D at agencies focused on other carbon-intensive portions of the economy like agriculture.

Existing Clean Energy RD&D Programs at DOE
Today, transportation accounts for 32 percent of all GHG emissions in the U.S. It recently overtook the electric power sector as the nation’s largest source of GHG emissions, and it also accounts for approximately one-quarter of DOE’s applied energy-research investments. Emissions in the transportation sector have held steady since 2005 as increases in vehicle miles traveled and greater emissions from aviation and shipping have offset improved fuel economy for light-duty cars and trucks. Without increased innovation, this trend is likely to continue.
To reach net-zero emissions by 2050, DOE should set ambitious targets and direct additional funding and research to the development and commercialization of carbon-neutral transportation fuels, vehicle efficiency, and vehicle electrification. The Departments of Transportation and Defense should also play an important role in programs advancing key transportation technologies.

The industrial sector, the third-largest source of direct GHG emissions in the U.S., produces 26 percent of total emissions. (This number does not include indirect emissions from electricity consumption.) Industrial emissions have also held steady since 2005 at about 1.5–1.6 billion metric tons per year. Despite this lack of improvement, the industrial sector accounts for a relatively small share of the total clean-innovation portfolio. DOE’s Advanced Manufacturing Office (AMO) houses the agency’s only RD&D program that focuses on the manufacturing sector; its actions are focused primarily on reducing manufacturing’s energy intensity. In addition, the office accounts for just 6 percent of DOE’s total applied-energy RD&D investments, and is not authorized or funded to advance other technologies to reduce industrial emissions like green hydrogen and carbon capture.

Residential and commercial buildings consume more energy than any other sector of the U.S. economy: they use roughly 75 percent of the nation’s electricity and account for 40 percent of its total energy demand. Direct (non-electricity) emissions in this sector comprise about 11 percent of total U.S. GHG emissions. But in FY 2019, Congress invested only $176 million—about 4 percent of DOE’s total applied-energy budget—in RD&D to reduce energy consumption and carbon emissions from the buildings sector through DOE’s Building Technologies Office (BTO). To achieve net-zero emissions by 2050, Congress should increase funding for federal clean-manufacturing and building-technologies programs.

New Clean Energy RD&D Programs at DOE

Harder-to-decarbonize sectors include aviation, shipping, long-distance road transportation, and heavy industry such as cement, steel, and chemicals. While these sectors account for a large and growing share of U.S. and global carbon emissions, they are not well represented in the federal energy-research portfolio. A study published in Science found that in 2014, these harder-to-abate sectors accounted for 9.2 billion metric tons of CO₂, or 27 percent of global carbon emissions. Congress should authorize and fund DOE to perform additional research in these areas.

Congress should also establish a comprehensive RD&D initiative for atmospheric-carbon removal. Carbon removal offsets residual emissions—especially non-CO₂ gases—that are impossible or prohibitively expensive to eliminate completely at the source. They also provide a hedge against the possibility that other climate-mitigation technologies fail to advance as quickly as they are needed. Between 1993 and 2019, the federal government invested only $10.9 million on direct air capture (DAC) technologies and $24.7 million on carbon mineralization. In FY 2020, for the first time, Congressional appropriators directed DOE to increase investments in a few particular carbon-removal approaches within existing research programs (in the office of Fossil Energy (FE) and the Bioenergy Technologies Office (BETO), for instance). This is a step in the right direction, but

it is not enough. Congress will likely need to authorize a new federal interagency program—like the U.S. Global Change Research Program, which manages climate change research across thirteen federal agencies—to explore all carbon-removal pathways and make the best use of federal capabilities across multiple agencies.13

**Expanded Clean Agriculture RD&D Programs**

Agricultural production comprises an important share of U.S. GHG emissions—about 9 percent of direct GHG emissions in 2018, and 12 percent when including indirect emissions from agricultural land use change, fuel combustion, and fertilizer manufacturing.14 However, support for clean agricultural RD&D has been limited. U.S. Department of Agriculture (USDA) RD&D funding peaked in 2003 and has not historically emphasized climate-beneficial agricultural innovation.

Agricultural productivity growth—increasing the amount produced per unit of land, labor, water, fertilizer, and other inputs—substantially reduces agricultural GHG emissions, often at very low cost. Increasing crop and livestock yields enables farmers to meet growing food demand while reducing their cost of production and food prices, at the same time limiting land use change and related emissions.15 Soil carbon sequestration is another emerging mitigation opportunity. Soils have tremendous capacity to hold carbon within the top few meters of soil—in fact, they currently hold three times more carbon than the atmosphere.16 But they have recently become a net source of CO₂ emissions rather than a sink, because heavily-cultivated agricultural soils can lose 50 to 70 percent of their original organic carbon.17 Better agricultural practices can reverse soil-carbon losses and improve nitrogen fixing, providing climate benefits while also improving soil structure, increasing crop yields, reducing fertilizer inputs, and reducing erosion.

Congress should increase investment in clean agricultural RD&D across the USDA, particularly at the Agriculture and Food Research Initiative (AFRI) and the Agricultural Research Service (ARS). Priority research opportunities include crops that can sequester more carbon and fix more nitrogen, soil carbon and fertilizer management practices, biochar and compost, fertilizer technologies, manure use, animal feed efficiency, plant-based and cultured meat, grazing management science, and plant genomics. Additionally, Congress should fully fund the Agriculture Advanced Research and Development Authority (AGARDA), which was modeled after other advanced R&D agencies such as DARPA and ARPA-E and is intended to support high-risk, high-reward innovative research that is too risky for the private sector. AGARDA was authorized in the 2018 Farm Bill but has not been funded in FY 2019 or FY 2020. Finally, Congress should increase technical and financial assistance to farmers to transition to best carbon, manure, and fertilizer management practices (through the Natural Resources Conservation Service (NRCS) Conservation Technical Assistance program, for example).
U.S. Greenhouse Gas Emissions and Department of Energy Research, Development, and Demonstration Spending According to Sector

### Greenhouse Gas Emissions (2017)

- Agriculture: 9%
- Buildings: 12%
- Manufacturing: 22%
- Transportation: 29%
- Electricity: 28%
- Buildings: 12%
- Manufacturing: 22%
- Transportation: 29%
- Electricity: 28%

### Department of Energy Research and Development Spending (FY2016)

- Buildings: 3%
- Manufacturing: 7%
- Transportation: 25%
- Electricity: 56%
- Other: 9%

4. **Perform agency-wide multi-year innovation-portfolio planning.**

At its core, DOE is a grant-making agency: it funds energy RDD&D in academia, at the National Labs, and in the private sector. Decisions on how to allocate the funds Congress appropriates are guided in part by multi-year research plans, but mostly through the agency’s annual budget-formulation process.

Increasing agency funding to the level this playbook recommends, while making sure those funds can support as many potential net-zero technology breakthroughs as possible, will require a much more robust and comprehensive planning process.

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Current Practice

DOE’s current budget process works in two directions at once: from the bottom up and from the top down. From the bottom up, many (but not all) individual technology offices such as the Solar Energy Technology Office develop five-year Multiyear Program Plans in consultation with researchers in academia, the National Labs, and the private sector. These plans identify research needs in the near- and mid-term, as well as strategies to achieve cost-reduction and performance-improvement targets. These research needs, in turn, are incorporated in an annual budget proposal.

From the top down, the White House provides the agency its budget request to Congress. Budget proposals from each individual office are compiled into the President’s Budget Request for DOE. Congress receives this request, and using their own process, generally increases or decreases individual technology program offices from prior year funding levels at the same rate across DOE’s energy programs. In other words, funding levels are mostly a function of the previous year’s Congressional appropriation. This means they are slow to accommodate changing priorities.

Planning for Changing Priorities

In addition to funding more energy research in general, the government needs a funding-allocation process that can account for the rapid transformations that must take place in the energy system to reach net-zero emissions by 2050.

First, every DOE office should conduct multi-year portfolio planning that identifies cost, performance, and deployment targets as well as the research needed to achieve these targets. Experts in government, academia, and the private sector should validate these targets and research needs. In addition, these targets should be comparable across technologies so the agency can assess the relative progress and promise of each technology.

This portfolio should inform a unified, agency-wide strategic plan for energy research that maps national goals (like emissions reductions) and RDD&D needs onto future budgetary requirements. This long-term plan should prioritize the development of energy technologies that can address the climate crisis. While this will not be an easy task, others have proposed quantitative methodologies for designing an optimal DOE research portfolio to maximize benefits given a constrained budget.19

This process might also identify research pathways that are currently being underfunded (such as carbon dioxide removal technologies and industrial GHG sources) along with others that have been thoroughly investigated and need a transition strategy. A 2019 report coauthored by former Secretary of Energy Ernest Moniz identified a need for “clearer performance measures [that] will enable more effective entrance and exit strategies.”20
These plans should be comprehensive enough to identify policies across the federal government—not just within DOE—that have the potential to boost new technologies and improve their deployment outcomes. In fact, DOE has attempted this type of comprehensive-planning effort before. In 2011, and again in 2015, the agency’s Quadrennial Technology Review assessed the current state of energy technologies and research needs for the future but did not connect these needs to agency priorities and budgeting. In 2018, Congress passed H.R. 589, the Department of Energy Research and Innovation Act, which requires this type of portfolio analysis and strategic planning. DOE has not yet identified the steps it is taking to do this work.

This requirement indicates that Congress is starting to seek more transparency around DOE’s budgeting process and more information to help it set final budget levels. This, in turn, can help Congress and other stakeholders increase their risk tolerance and comfort with emerging technologies.

5. Transform the Department of Energy’s organizational structure.

For the past 20 years, DOE and its scientists have been directly responsible for many of the advances in clean energy technology that are helping to reduce the world’s GHG emissions. However, given the scale and the urgency of the problem, DOE will need more funding as well as an internal structure that enables the agency to effectively use its resources. At present, the agency lacks dedicated and empowered assistant secretary level-leadership for several critical decarbonization areas—such as transportation, industry, and buildings—as well as for cross-cutting areas like large-scale carbon management. A reimagined DOE that overcomes these challenges can accelerate innovation in new solutions and ensure technology penetration in low-income and historically disadvantaged communities.

Restructure DOE for Better Translation of Fundamental Science into New Energy Technologies

Congress can solidify the link between basic and applied-energy research by requiring a single Office of the Under Secretary for Science and Energy. Over the years, the office has been combined or separated based on the administration in power, which has limited its efficacy. Maintaining the structure of a single office would better enable it to drive collaboration between DOE’s energy research programs, align budgets to keep up with the changing demands of the energy sector, provide streamlined management of the laboratories associated with DOE programs, encourage cross-cutting research, and perform portfolio analysis and planning in support of climate-change goals.

Reorganize DOE’s Renewables, Transportation, and Efficiency Portfolio

DOE’s largest technology program, the Office of Energy Efficiency and Renewable Energy (EERE), receives over $2 billion annually from Congress and conducts a wider variety of missions than any other DOE applied-energy research office: research into renewables (wind, solar, geothermal, and water power), transportation (vehicle efficiency, vehicle electrification, biofuels, hydrogen
and fuel cells), and energy efficiency (building efficiency and clean energy manufacturing). In contrast, other DOE programs address a more condensed set of challenges. (For example, the Nuclear Energy office focuses on three core, related challenges—extending the life of current nuclear power plants, designing new nuclear fuels and reactors, and addressing nuclear waste issues.)

The EERE office has outgrown its structure. For instance, one result of crowding these three substantial EERE programs into one office is under-investment in energy research in the transportation and buildings/industrial sectors relative to the GHG emissions from those sectors. To elevate the importance of these critical sectors, Congress should separate this one office into three—renewables, transportation, and buildings/industry—and increase their funding.

Specifically, Congress should elevate the offices of deputy assistant secretaries for Sustainable Transportation and for Buildings and Manufacturing to the role of assistant secretary. This would in effect split EERE into three assistant secretary offices (including an Assistant Secretary for Renewable Power), which is appropriate given the size of the office and range of technology challenges covered by these programs.

**Depoliticize DOE Research Programs**

Science, not politics, should guide the DOE—but as of the last official count in 2020, DOE had over 170 political appointees, including each of the leaders of its energy-research offices.21 (Compare to other federal scientific agencies: in 2020, NASA had 21 political appointees, NSF had 2, and NIH had 1.)

Many of these senior DOE appointees require confirmation by the Senate—and while they wait to be confirmed, temporary leaders with varying management experience and priorities rotate in and out of these positions. For example, EERE’s Assistant Secretary position was vacant from May 2016 until January 2019. This disruption slows the development of climate-technology solutions.

Congress should require that DOE hire senior energy-research leaders from across the government’s highly qualified career Senior Executive Service. These leaders are selected for their management expertise and/or scientific knowledge, and they can bring steady leadership to DOE programs that is consistent with the vision of the department’s Secretary and Under Secretary.

6. **Stabilize funding for federal innovation programs.**

Congress has supported an innovation-based climate agenda on a bipartisan basis, providing modest budget increases in each of the past five years. Funding for clean energy RD&D at DOE grew by about 41 percent between 2015 and 2020, or about 8 percent annually.22

But the annual budget and appropriations process results in large year-over-year fluctuations in program funding levels and injects large uncertainties into the portfolio-planning process. For example, annual changes in funding for the nuclear energy, fossil energy, and energy-efficiency programs at DOE over the last twenty years range from 75 percent to +200 percent.23 Such extreme volatility limits the effectiveness of federal innovation programs and hampers the ability of their managers to implement long-term research agendas.

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22. https://itif.org/publications/2020/03/30/energy-innovation-fy-2021-budget-congress-should-lead

As such, Congress should supplement the annual appropriations process with alternative funding models that provide long-term stability and insulate the innovation portfolio from political uncertainty. Former Secretary of Energy Ernest Moniz has identified several options based on other successful federal RD&D programs:24

**Earmark specific revenue streams** to clean energy RD&D programs so that annual funding is predictable and stable and is not scored against appropriations caps. This approach has been used successfully for other federal programs. For example, the Ultra Deepwater and Unconventional Natural Gas and Other Petroleum Fund, authorized by Congress in 2005, was funded from a portion of federal oil and natural gas royalties and not subject to annual appropriations, though Congress exercised oversight of the program. And in 2013, Alaska Republican Senator Lisa Murkowski called for the creation of an “Advanced Energy Trust Fund” backed by revenue from oil and gas drilling on federal lands to support clean energy innovation.25

**Establish a new public-benefits user charge**, like the gas tax which funds the Highway Trust Fund, to support clean energy innovation. For example, a small fee of 2.5 cents per gallon of gasoline would raise $15 billion annually—more than twice what the federal government currently invests in clean energy RD&D. Similarly, a small “wires charge” on electricity could be used to fund grid modernization and clean-electricity programs. Several states currently use public-benefits charges to accelerate deployment of clean technologies. Alternatively, a small portion of a carbon price could be used to fund energy innovation programs. The two carbon-pricing policies that already exist in the United States—California’s cap-and-trade program and the Regional Greenhouse Gas Initiative—do this to some extent.

**Provide automatic advance appropriations** to provide funding certainty for large, multi-year research projects. The DOE Clean Coal Technologies program in the 1980s and 1990s was funded through advance appropriations, which led to greater stability for public-private cost-sharing agreements.

**Enable research programs to submit a “bypass budget,”** also known as a professional-judgment budget, that is based on scientific opportunity rather than the regular budget and appropriations process. Under the regular budgeting process, agencies first submit budget requests to the President through the Office of Management and Budget (OMB). OMB then works to reconcile competing budget priorities into a single consolidated proposal, the President’s Budget Request, which is submitted to Congress. This process can pit unrelated federal programs against each other and subjects annual budgeting to the policy priorities of the administration. But in some cases, Congress has asked federal agencies to prepare their own budget—submitted directly to Congress and “bypassing” OMB—based on scientific and research opportunities. For example, the Consolidated and Further Continuing Appropriations Act of 2015 (P.L. 113-235) directs the NIH to submit an independent Alzheimer’s research budget each year, and the Commodity Futures Trading Commission (CFTC) likewise submits its own budget based on an assessment of what it needs to execute its mission.26 Congress could thus direct DOE and other agencies to develop and submit a separate budget directly to Congress based on scientific and research opportunities.


In addition, Congress’ annual appropriation for DOE’s applied-energy offices comes with earmarks, specific direction on research topics, and limits on funding by topic. For example, for the 2020 Appropriation, Congress told DOE’s Vehicle Technology Offices that it was required to spend $5 million on “two-stroke opposed piston engines.” Even when these topics have merit, this level of Congressional specificity interferes with DOE program managers’ efforts to fund research that has the most promise for transforming the nation’s energy systems.

In sum: Congress should reform the way it appropriates funding to DOE for R&D. Providing general policy direction without prescribing or limiting areas of research would allow DOE scientists to optimize their research portfolios to maximize clean energy outcomes. Congress has already implemented this model for ARPA-E, one of DOE’s most popular programs. It should transition DOE’s other applied-energy programs to it as well.

Volatility in Funding for Select DOE Programs (Annual Percent Change)
The Impact of Public Sector R&D

Federal investment in clean energy innovation lowers energy costs for consumers and businesses, increases the global competitiveness of clean-tech businesses in the U.S., improves energy equity and environmental justice for low-income communities, and reduces pollution—including the GHG emissions that cause climate change.

The United States has historically been a global leader in clean energy innovation: federal investments and public-private cooperation produced many technologies that now make major contributions to energy systems in the U.S. and around the world. Federally funded nuclear power RD&D, for instance, led to large-scale private investment in commercial power plants that now account for nearly 20 percent of U.S. electricity generation and 56 percent of zero-carbon power generation. Government research has helped slash the costs of four key clean technologies—solar, wind, LED lighting, and electric vehicles—between 55 and 94 percent since 2008, leading to impressive growth in adoption.28

Cost Reductions And Capacity Building For Four Key Clean Energy Technologies

Numerous studies have documented the impacts of federal energy RD&D on U.S. and global energy systems.

- Federal support for shale-gas resource characterization and directional drilling, in tandem with industry-matched applied research and a federal production tax credit, led to the dramatic rise of shale gas from less than 1 percent of domestic gas production in 2000 to nearly 60 percent in 2016.29
- DOE-funded RD&D in flue-gas desulfurization (FGD) scrubbers resulted in over $50 billion in savings from public-health benefits and lower FGD costs. In turn, this helped make America a global leader in environmental technologies.30
- DOE research partnerships with major engine manufacturers to develop more efficient diesel engines saved the U.S. trucking industry 17.6 billion gallons of diesel fuel, which translated into $34.5 billion in reduced fuel expenditures and $35.7 billion in health and environmental benefits from lower pollution.31

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Investments in DOE’s BTO between 2010 and 2015 culminated in the successful commercialization of 27 cleaner products, including energy-efficient water heaters, solid-state lighting, and energy-saving windows. A retrospective assessment of BTO investments between 1976 and 2015 across three technology areas—heating, ventilation, and air conditioning (HVAC); water heating; and appliances—found that BTO investments have yielded a benefit-to-cost ratio of more than 20 to 1.\(^\text{32}\)

Going forward, federal RD&D programs will continue to drive down costs and accelerate deployment of clean energy technologies. But current funding levels are not enough to drive the pace of innovation needed to achieve decarbonization by mid-century. In 2017, DOE published the first integrated economy-wide assessment of the potential combined benefits of its entire technology RD&D portfolio, the Quadrennial Energy Review (QER).\(^\text{33}\) The QER examined two different RD&D funding scenarios: one in which funding remained constant through 2040, and another in which funding was doubled. DOE found that maintaining constant funding would reduce emissions by 12 percent and residential energy bills by 25 percent; by contrast, doubling funding for energy RD&D, which would allow for more accelerated energy innovation, would reduce emissions by 30 percent and energy bills by 34 percent.

The QER study also assessed the impact of a carbon price—starting at $20/tCO\(_2\) and increasing by 5 percent every year—both alone and in combination with the two RD&D scenarios. On its own, the carbon price lowered emissions but raised energy bills. But combined with energy RD&D, a carbon price drives more emissions reductions than either approach does on its own. In other words: by making clean energy cheaper, energy RD&D moderates the consumer impact of a carbon price, enabling deep emissions reductions while also reducing energy bills.

Still, even the most aggressive scenario the QER considered is not enough to put the U.S. on a path to net-zero emissions by 2050. This underscores the need for greater ambition and greater investment in innovation.
Projected U.S. energy CO₂ emissions under various technology and policy (CP20: carbon price of $20 per tonne of CO₂, starting in 2017 and increasing at a rate of 5% per year in real dollars) assumptions. Also included is a dotted straight line indicating energy-sector reductions that are consistent with an economy-wide 80% reduction from 2005 levels by 2050. Historical energy CO₂ emissions are shown for 2005–2014 based on data from the U.S. Energy Information Administration (EIA).

Source: Energy CO₂ Emissions Impacts of Clean Energy Technology Innovation and Policy, DOE