ITIF | INFORMATION TECHNOLOGY & INNOVATION FOUNDATION
CENTER FOR CLEAN ENERGY INNOVATION

# Energizing Innovation in Fiscal Year 2024

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The FY 2024 budget request, if met, could maintain bipartisan momentum for clean energy innovation. Congress should support that innovation to foster domestic clean energy industries that can compete globally, minimize foreign dependencies, and address climate change.

## KEY TAKEAWAYS

- President Biden's FY 2024 budget request (PBR) calls for $11 billion in clean energy RD&D investment for the Department of Energy (DOE), an 18 percent increase over FY 2023-enacted levels.
- Combined with funding increases from the Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA), clean energy RD&D investment for FY 2024 potentially could be $17 billion.
- The PBR pares back on clean energy manufacturing innovation and competitiveness, a direct contrast to its overall message of outcompeting China, as well as last year's PBR focus on manufacturing and competitiveness for DOE.
- Several programs, mostly applied energy programs, are still falling behind the levels ITIF recommended in its *Energizing America* report for buildings, bioenergy, geothermal, manufacturing, nuclear energy, and ARPA-E.
- The budget leans more toward basic energy than applied energy. While maintaining investments in cutting-edge research is important, the current budget proposal risks undercutting DOE's goal of advancing clean energy to reduce emissions.
- The CHIPS and Science Act authorized billions of funding in early-stage R&D and applied innovation investments for existing DOE energy RD&D offices plus more for new programs such as technology transfer and commercialization reforms.
- Congress should appropriate these funds to continue energizing innovation that will drive costs down and spur innovation.

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## EXECUTIVE SUMMARY

The Biden administration's FY 2024 budget request (PBR) for the Department of Energy (DOE) calls for an 18 percent increase in investment in clean energy research, development, and demonstration (RD&D) over FY 2023-enacted levels. The 117th Congress passed three landmark bills—the Investment in Infrastructure and Jobs Act (IIJA), the CHIPS and Science Act (CHIPS), and the Inflation Reduction Act (IRA)—that are reshaping energy innovation in the United States. But despite boosts from these bills, the requested levels for many energy RD&D programs trend below the levels that the Information Technology and Innovation Foundation (ITIF) and the Center on Global Energy Policy recommended in their 2020 report *Energizing America*.[1] Continuing along *Energizing America's* recommended trajectory is vital to develop the climate solutions the world needs while strengthening the competitiveness of U.S. technology developers and manufacturers.

The context for federal clean energy innovation investments is daunting. Unabated fossil fuels still dominate global consumption. New technologies that would drastically reduce greenhouse gas (GHG) emissions from many major sources cost substantially more than incumbent solutions, perform too poorly, or are simply unavailable. Although the global energy innovation system still has major gaps, many countries have advanced assertive programs targeting specific sectors that collectively threaten U.S. leadership, including in public funding for energy RD&D, where the United States has long been the top investor.

Yet, had it kept pace with growth in the U.S. economy since DOE's founding in 1978, the department's RD&D budget today would be $32 billion, more than three times its level in fiscal year 2023. The bipartisan consensus that led to recent legislation and funding increases must be sustained and further elevated to approach that level again, as numerous expert studies have

advocated. At a time when the nation really needs a big boost from innovation to address competitiveness, climate change, and supply chain resilience, DOE's budget is still a modest 0.04 percent of gross domestic product (GDP)—below several peer countries such as Norway, France, Finland, and even China. Congress should seize the opportunity to sustain the momentum, accelerate domestic clean energy industries, and shape the U.S. response to climate change.

This report describes DOE's RD&D programs, assesses significant updates to them, and discusses notable gaps that still remain. It is supported by an interactive data visualization site that will be updated throughout the FY 2024 budget cycle.

## INTRODUCTION

The FY 2024 budget is an important opportunity to keep up the momentum of U.S. investment in energy innovation. The passage of the three landmark bills—the IIJA, CHIPS, and IRA—have paved the way for a major expansion in federal RD&D funding to combat climate change and strengthen U.S. competitiveness. Many members of Congress have joined President Biden in calling for a reinvigoration of the national energy innovation system to reverse decades of declining investment and position the United States to thrive in the global clean energy transition. Congress and the Biden administration should address the innovation needs of the 2020s and ensure effective implementation of programs in these three bills.

Many U.S. competitors have been investing heavily in RD&D to develop low-carbon technologies and capture growing global clean energy markets. Most notably, China now invests more than the United States does in key technologies, including solar energy, lithium-ion batteries, advanced nuclear, carbon capture, and electric vehicles (EVs). Meanwhile, Europe is outstripping the United States in offshore wind (14.6 gigawatts vs. 0.42 gigawatts installed cumulatively in 2021) and has set aggressive targets in hydrogen and low-carbon steel.[2] While investment in energy RD&D continues to grow, the pace has slowed down since 2020, increasing by 1.4 percent between fiscal years 2020 and 2023 (the amounts are without the boosts from the landmark bills). As a share of the U.S. economy, federal investment has grown little, hovering around 0.04 percent of GDP.

This report builds on *Energizing America*, ITIF's 2020 book-length collaboration with Columbia University's Center on Global Energy Policy, as well as more recent ITIF annual reports on the energy RD&D budget and related analyses. It provides an overview of federal energy innovation programs, including the key role of DOE in advancing energy technologies, and highlights the department's impact on national energy systems. It assesses the significant updates to DOE's program authorizations made in the Energy Act and the prospects for greater investment in the FY 2024 budget and appropriations cycle.

Twenty-three infographics accompany this report in ITIF's online data visualization. Each includes a description of a DOE RD&D program and its technology goals, including renewable energy, transportation, energy efficiency, grid modernization, nuclear energy, fossil energy and carbon management, and basic sciences. The interactive data visualization also highlights recent initiatives in each program, along with its potential impacts, historic and authorized funding levels, and targeted recommendations for Congress and DOE to accelerate innovation. They form

the core of a living interactive data visualization that will be updated throughout the FY 2024 budget cycle.

## PRESIDENT BIDEN'S BUDGET REQUEST FOR FY 2024

In March 2023, the Office of Management and Budget released the outline of President Biden's budget request for FY 2024, which calls for a 18 percent increase in government-wide investment in clean energy innovation over FY 2023 enacted levels. Highlights include:

- $52 billion for DOE, a $6.2 billion (14 percent) increase over FY 2022;
- $11 billion for clean energy RD&D programs to DOE's applied energy offices, Office of Science, the Office of Clean Energy Demonstration (OCED), and the Advanced Research Projects Agency for Energy (ARPA-E);
- $8.8 billion for DOE's Office of Science, including $3.9 billion that would support climate-tech and clean energy research;
- $3.8 billion for DOE's Office of Energy Efficiency and Renewable Energy, including $636 million in total for the newly formed Advanced Materials and Manufacturing Technologies and Industrial Efficiency and Decarbonization offices; and
- $1.6 billion for DOE's Office of Nuclear Energy.

Table 1 provides a top-level summary of DOE's budget and table 2 provides a summary of DOE's RD&D programs.

**Table 1: DOE budget by program area, FY 2021 enacted through FY 2024 request ($millions)**

| | FY21 Enacted | FY22 Enacted | FY23 Enacted | FY24 WH Request |
|---|---|---|---|---|
| **DOE Total Budget** | 41,927 | 44,856 | 46,243 | 52,000 |
| **Defense*** | 20,608 | 21,641 | 23,198 | 24,920 |
| **Environmental Management**** | 7,586 | 7,904 | 8,263 | 8,280 |
| **Office of Science, non-Energy RD&D** | 3,927 | 4,270 | 4,604 | 4,879 |
| **Office of Science, Energy RD&D** | 3,099 | 3,205 | 3,496 | 3,922 |
| **EERE, FECM, NE, OE, and CESER, non-Energy RD&D** | 864 | 1,253 | 1,157 | 742 |
| **EERE, FECM, NE, OE, and CESER, Energy RD&D** | 4,565 | 4,890 | 4,907 | 6,202 |
| **ARPA-E** | 427 | 450 | 470 | 650 |
| **OCED** | -- | 20 | 89 | 215 |
| **DOE Energy RD&D Programs** | 8,091 | 8,565 | 9,271 | 10,989 |

** NNSA and Other Defense Activities.*
*** Defense Environmental Cleanup, Non-Defense Environmental Cleanup, and Uranium Enrichment Decontamination and Decommissioning.*

**Table 2: DOE Energy RD&D programs summary, FY 2021 enacted through FY 2024 request ($millions)**

| | FY21 Enacted | FY22 Enacted | FY23 Enacted | FY24 WH Request |
|---|---|---|---|---|
| **DOE Energy RD&D Programs*** | 8,091 | 8,565 | 9,271 | 10,989 |
| **ARPA-E** | 427 | 450 | 470 | 650 |
| **Energy Efficiency & Renewable Energy** | 2,282 | 2,393 | 2,678 | 3,606 |
| *Sustainable Transportation* | | | | |
| Vehicle Technologies | 400 | 420 | 455 | 527 |
| Bioenergy Technologies | 255 | 262 | 280 | 323 |
| Hydrogen & Fuel Cell Tech | 150 | 158 | 170 | 163 |
| *Renewable Energy* | | | | |
| Solar Energy | 280 | 290 | 318 | 379 |
| Wind Energy | 110 | 114 | 132 | 385 |
| Water Power | 150 | 155 | 179 | 230 |
| Geothermal | 106 | 110 | 118 | 216 |
| Renewable Energy Grid Integration | -- | 40 | 45 | 59 |
| *Energy Efficiency* | | | | |
| Advanced Manufacturing** | 351 | 358 | 405 | -- |
| Advanced Materials and Manufacturing** | -- | -- | -- | 182 |
| Industrial Efficiency and Decarbonization** | -- | -- | -- | 336 |
| Building Technologies | 235 | 233 | 257 | 278 |
| *Program Support* | 245 | 254 | 319 | 528 |
| **Fossil Energy and Carbon Management R&D** | 684 | 697 | 805 | 815 |
| Carbon Management Technologies | 447 | 393 | 460 | 464 |
| Natural Gas Technologies | 57 | -- | -- | -- |
| Resource Sustainability | -- | 168 | 195 | 179 |
| Unconventional Oil Tech | 46 | -- | -- | -- |
| NETL Research | 83 | 83 | 87 | 89 |
| Program Support | 51 | 53 | 63 | 83 |
| **Nuclear Energy** | 1,350 | 1,389 | 1,314 | 1,361 |
| Reactor Concepts RD&D | 208 | 257 | 259 | 98 |
| Nuclear Energy Enabling Tech | 123 | 117 | 96 | 96 |

| | FY21 Enacted | FY22 Enacted | FY23 Enacted | FY24 WH Request |
|---|---|---|---|---|
| Fuel Cycle R&D*** | 309 | 320 | 322 | 423 |
| Advanced Reactor Demos*** | 250 | 250 | 85 | 203 |
| Versatile Test Reactor | 45 | -- | -- | -- |
| Other Programs | 348 | 378 | 476 | 467 |
| Program Support | 67 | 67 | 76 | 74 |
| **Electricity** | 202 | 267 | 282 | 276 |
| **Cybersecurity (CESER)** | 105 | 141 | 137 | 150 |
| **Science** | 3,099 | 3,205 | 3,496 | 3,922 |
| Basic Energy Sciences | 2,245 | 2,308 | 2,534 | 2,693 |
| Fusion Energy Sciences | 672 | 713 | 763 | 1,011 |
| BER Bioenergy Research Centers | 100 | 100 | 110 | 120 |
| Program Support | 82 | 84 | 89 | 98 |
| **Office of Clean Energy Demonstration** | -- | 20 | 89 | 215 |

** Energy programs include some non-RD&D functions, only those pertaining to RD&D functions are listed here.*
*** In late 2022, DOE split the Advanced Manufacturing Office (AMO) into two new offices: Advanced Manufacturing and Materials Office (AMMTO) and Industrial Efficiency and Decarbonization Office (IEDO).*
**** Does not include $300 million appropriated under the Ukraine Supplemental Act, 2023 (P.L. 117-180): Advanced Nuclear Fuel Availability ($100 million), National Reactor Innovation Center ($20 million), Risk Reduction for Future Demonstration ($120 million), and ARDP Demonstration Reactors ($60 million).*

## Gaps in the Proposed Budget and Longer-Term Challenges

Some gaps remain in the federal clean energy portfolio. While several programs are well beyond (e.g., Office of Clean Energy Demonstrations) or on par (e.g., Solar Energy Technologies Office) with the levels recommended in *Energizing America*, enacted and requested funding levels for several program offices lag behind (figure 1). The previous ITIF budget report and blog posts have repeatedly pointed out the relative lack of support for bioenergy, building, and geothermal technologies.[3] Moreover, support for ARPA-E and Nuclear Energy will also continue to fall behind *Energizing America's* recommended levels if the trend of significantly lower enacted amounts than PBR continues.[4]

**Figure 1: Selected program office funding vs. *Energizing America* recommendations ($millions)**

Whereas *Energizing America* recommends a gradual ramp-up and the National Academy of Sciences report recommends tripling clean energy RD&D, historical investments for some program offices have received only token increases.[5] As a result, funding for these program offices will continue to decline in subsequent years relative to *Energizing America's* recommendations unless regular appropriations for energy RD&D rise faster than their historic trend. The problem will become even more difficult when the IIJA sunsets after FY 2026.

## THE KEY ROLE OF THE FEDERAL GOVERNMENT IN THE GLOBAL ENERGY INNOVATION SYSTEM

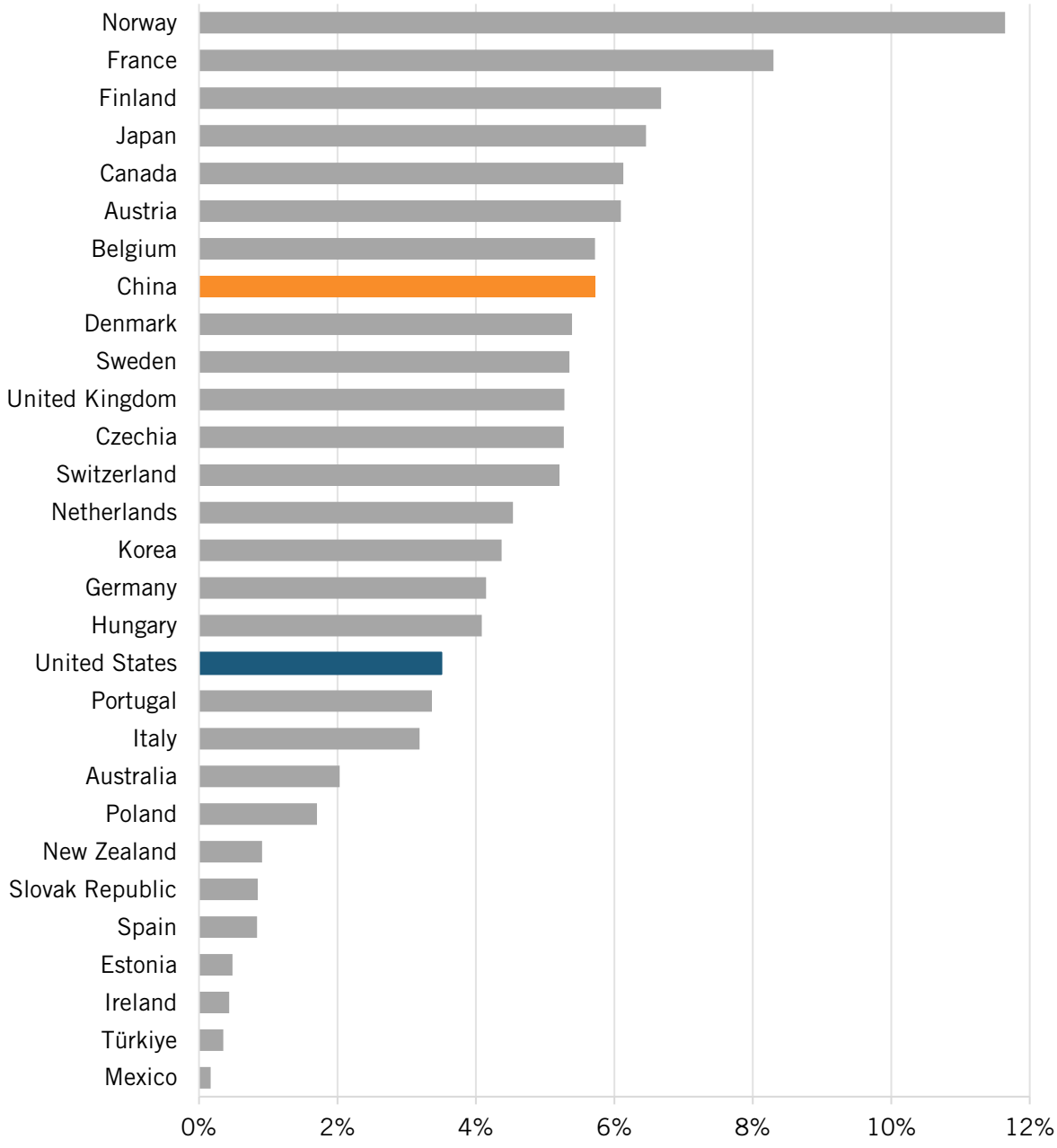
The transition from a global energy system dominated by unabated fossil fuels to one with net-zero emissions is vital to mitigate climate change, protect human health, and help revitalize the U.S. economy. However, clean energy alternatives have not yet been commercialized for some of the sectors that produce large amounts of GHG emissions, including aviation, shipping, steel, cement, and chemicals manufacturing. Meanwhile, many of the clean technologies that already have been commercialized—such as EVs—are still more expensive than the high-emitting technologies they would replace and face other barriers to scaling up. Costs and barriers must continue to fall for these clean technologies to be adopted at scale and to cut emissions dramatically.

Landmark climate laws such as the IIJA and IRA are welcoming news that reposition the United States as a leader in climate innovation.[6] (The IIJA provides $62 billion to DOE with over half of that in clean energy RD&D. The IRA provides $6.5 billion in advanced industrial facilities and high-assay low-enriched uranium for advanced nuclear reactors.) Still, emissions would decrease by just 30 percent to 43 percent by 2030 compared with 2005 levels, falling short of the 50 percent goal.[7] The passage of these laws should simply be the starting point; the U.S. government should continue to champion investments in innovation. But accelerating innovation requires an assertive federal policy that involves more than basic research funding. Innovation requires proactive public investment in both development and demonstration, along with the creation of markets to hasten early adoption and ignite private sector innovation and competition.[8]

### The Global Context for Federal Energy RD&D Investment

Global public and private investment in total energy investments was $2.4 trillion in 2022, an eight percent rise from 2021 levels, and above pre-pandemic levels.[9] But energy security concerns and higher energy prices in 2022 also drove some countries to increase fossil fuel investment at the expense of clean energy investments. Global public and private investment in 2022 reached $1.4 trillion in clean energy investments, but fell short of the amount needed ($4 trillion by 2030) to hit international climate goals.[10]

**Figure 2: Government energy RD&D investment as a percentage of GDP, 2021**[11]




In public funding for clean energy RD&D, an area wherein the United States has long been the top investor, U.S. leadership is now being challenged by China and Europe. China's investment in low-carbon energy RD&D between 2015 and 2020 grew from $2.6 billion to $4.0 billion, second only to the United States.[12] Sixteen other countries invested in 2021 more in energy RD&D as a share of their economies than did the United States (figure 2). As other countries have stepped up their investments in clean energy, the United States' share of cleantech patents filed in at least two jurisdictions (a proxy for high-quality patents) fell from 25 percent in 2013 to 20 percent in 2018, indicating that U.S. leadership in innovation is waning.[13]

Manufacturing competitiveness is notably absent in the PBR for DOE. For example, the FY 2024 PBR asks for $75 million for the Solar Energy Technologies Office' Manufacturing and Competitiveness subprogram, or one-third of the previous PBR's $225 million ask (ITIF has recently raised this issue).[14] Although outcompeting China is one of the major themes in the overall FY 2024 budget, it is in relation to the Indo-Pacific Strategy and bolstering agricultural research and development (R&D), not necessarily in clean energy investment.[15] This is in contrast to last year's President's Budget, which focused on clean energy manufacturing competitiveness.[16] The three landmark bills represent a big step forward, and the federal government should utilize these investments to advance innovation, secure intellectual property (patents), and drive top innovations all the way to commercialization. The United States must combine its bountiful natural assets with its culture of innovation to regain global leadership and competitiveness in clean energy technology, modernize and transform the U.S. manufacturing base, and create a new generation of clean energy jobs.[17]

## Innovation to Combat Climate Change

The global energy innovation agenda since the last decade has focused, with considerable success, on reducing the cost and expanding the use of wind and solar resources for electricity generation. Rapid cost declines in solar PV, wind turbines, and grid-scale batteries are enabling decarbonization of the power sector on a much faster timeframe than was imagined a decade ago.[18] As a result, the electric power sector made more progress on GHG emission reductions than did other major sectors. As ITIF has argued, continued innovation in renewable energy is not a given; public policy must continue to support technological improvements.[19] Indeed, the FY 2024 budget proposal aims to try again with expanding investment in offshore wind (box 1).

Significant needs for transformation signal substantial needs for RD&D investments in every GHG-emitting sector, including the power sector, which has had the most success in reducing emissions. In this sector, new, affordable, carbon-free firm generation that is available 24/7 and can be dispatched on-demand will be needed to achieve a carbon-free electricity system.[20] In the transportation sector, light-duty EVs are projected to reach cost parity with gas-powered cars in this decade, but significant hurdles related to charging times, driving range, availability of charging infrastructure, and impacts to the grid must be addressed.[21] In buildings, high-efficiency heat pumps and low global warming potential refrigerants can reduce emissions from heating and cooling, but costs must come down to enable wider deployment.

Innovation challenges are even more difficult for harder-to-abate sectors than for the power sector.[22] Aviation, marine shipping, and long-distance trucking are more challenging to electrify than are light-duty cars and trucks. They will likely require carbon-neutral fuels that are as energy dense as the petroleum-based fuels they would replace. Heavy industries such as steel, cement, and chemicals are especially challenging to decarbonize due to process emissions from chemical transformations and emissions from fossil fuel combustion that create high-temperature heat. Many promising solutions are being developed, but they must be validated and demonstrated at a commercial scale before they will make a dent in emissions.[23] Integration in complex systems for these relatively low-margin businesses signals the need for large uptakes in RD&D fundamentals and applied technology investments for an otherwise uphill battle.

Unlike software and biotechnology, clean energy faces substantial scale-up and commercialization challenges.[24] Technology development life cycles in this sector are long, and

projects are often capital-intensive and bear a significant amount of technical and financial risk.[25] Even venture capital funding, which tends to be less risk-averse than other sources of private capital, seeks quick payback times and generous returns on investments that make it a poor match for the cleantech industry.[26] (Although venture capital investments in cleantech have made a roaring comeback in recent years, the lion's share of these investments have gone to the transportation sector.[27]) For these reasons, the energy industry historically invests a very small share of its revenues in R&D.

In addition, because energy is valued as a commodity (there is no tangible difference in the electricity that comes from a coal plant versus a wind farm) and environmental externalities such as climate change are not valued in the market, emerging energy technologies frequently cannot distinguish themselves from incumbent technologies in terms of performance and must therefore compete on price from the moment they enter the market.[28] Electric utilities are often legally mandated to keep prices low while some (e.g., in California) are required to maintain a minimum return on equity, which may make it difficult or even impossible to invest in new technologies.[29]

In clean energy, therefore, the burden of financing high-risk, long-term investments falls more heavily on the public sector than in typical high-tech industries. Although they are occasionally overcome by bursts of irrational enthusiasm, the market failures in these industries are more profound than in most others.

### Box 1: Trying Again for Wind Energy Innovation

The FY 2024 PBR requests $385 million for the Wind Energy Technologies Office (WETO), or three times as much as the FY 2023-enacted level ($132 million). Previously, the FY 2023 PBR asked for $345 million for WETO, in which the elevated level of funding would support new and expanded RD&D projects on offshore wind, reduce environmental and siting barriers to land-based wind development, and expand its two new subprograms (Systems Integration and Data, Modeling, and Analysis).[30]

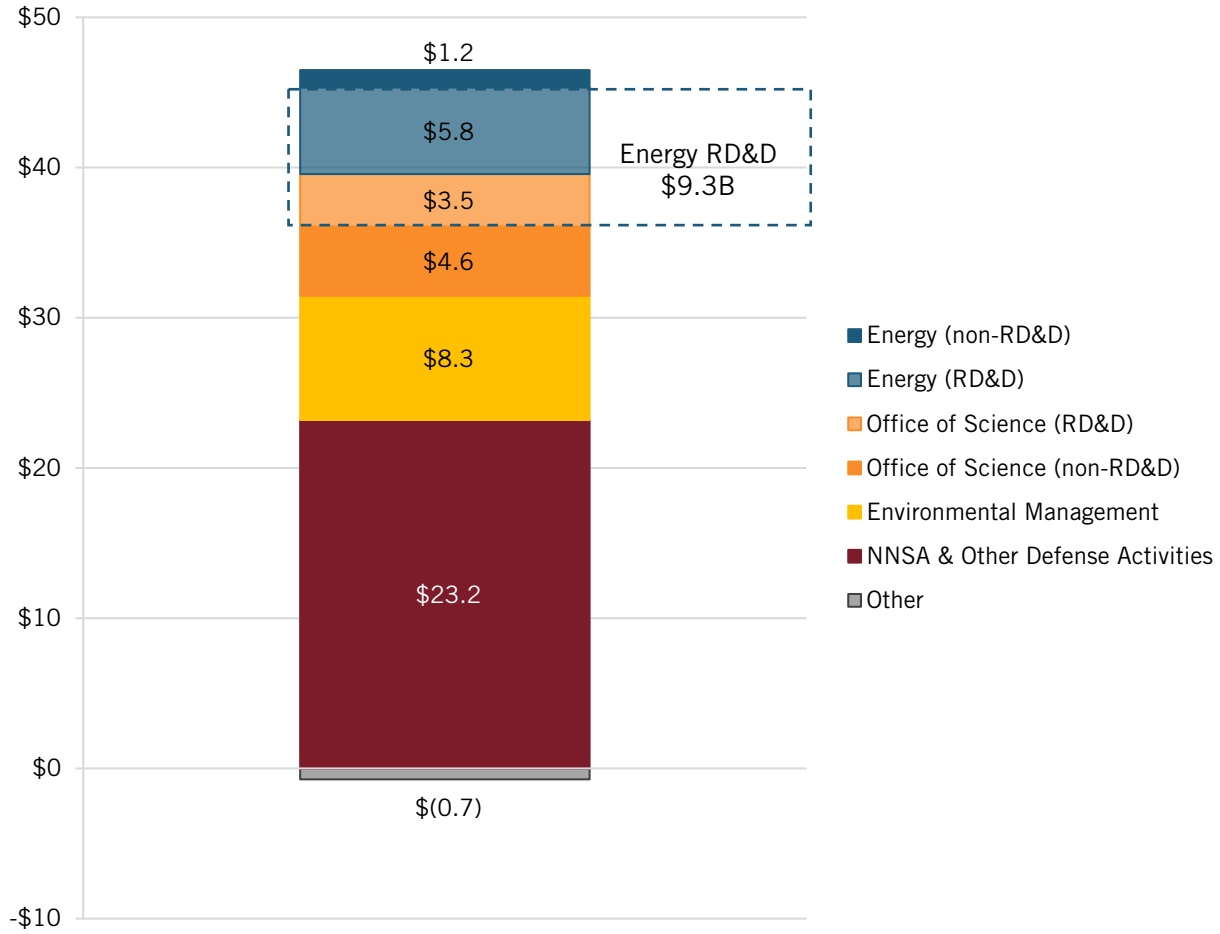
WETO's Offshore Wind subprogram would receive the largest share of the increase. The FY 2024 request would support WETO's Floating Offshore Wind EarthShot, atmospheric science to inform array optimization, transmission and delivery system protection, and other potential projects.[31] Meanwhile, WETO's Land-Based Wind subprogram would prioritize environmental and siting R&D and workforce development activities.

In March 2021, DOE announced with the Department of Interior (DOI) and the Department of Commerce announced a national goal of deploying 30 gigawatts of offshore wind capacity by 2030.[32] Currently, less than 0.5 megawatts of offshore wind power is installed and online.[33] Offshore wind is a fledgling industry and is not cost competitive with incumbent energy-generation sources. Since cost reduction is essential to adoption, funds committed to RD&D should pointedly address this need. Additional barriers to deployment include siting, permitting, supply chain, and mooring technologies issues. To enable development in deeper waters, the United States needs innovation on platforms, moorings, turbines, controls, installation, operation, maintenance, and cost reductions in high-voltage direct current technology.[34]

## THE DEPARTMENT OF ENERGY OVERVIEW

As the nation's largest funder of energy RD&D, DOE fills a foundational role in the U.S. energy innovation ecosystem. However, it oversees much more than the nation's energy system. Indeed, when the other activities of DOE—defense, environmental cleanup, and non-energy-focused basic science—are considered, only a small portion of its budget (one-fifth) remains to support clean energy innovation. Figure 3 shows DOE's budget by organization. The department's $9.3 billion energy RD&D portfolio includes just a minority of the department's Office of Science, along with most of the funding assigned to its varied applied energy offices.

**Figure 3: FY 2023-enacted DOE budget by major function ($billions)**




*Note: "Other" is negative due to rescission of the SPR Petroleum Account ($2 billion).*

DOE was assembled in 1977 from previously scattered federal agencies, the largest of which was the Atomic Energy Commission, which had managed the military's nuclear weapons program since just after World War II. Today, DOE's National Nuclear Security Administration (NNSA) and other defense programs housed within DOE comprise slightly more than half of the agency's nearly $46 billion budget. The next biggest function, DOE's Office of Environmental Management is tasked with cleaning up the massive pollution left behind by the weapons program. It absorbs 18 percent of the budget. Together, these two slices make up over two-thirds of the department's budget and contain no energy RD&D programs. For every $2 of DOE's

budget to energy RD&D programs, $7 goes to nuclear security, defense, and environmental management.

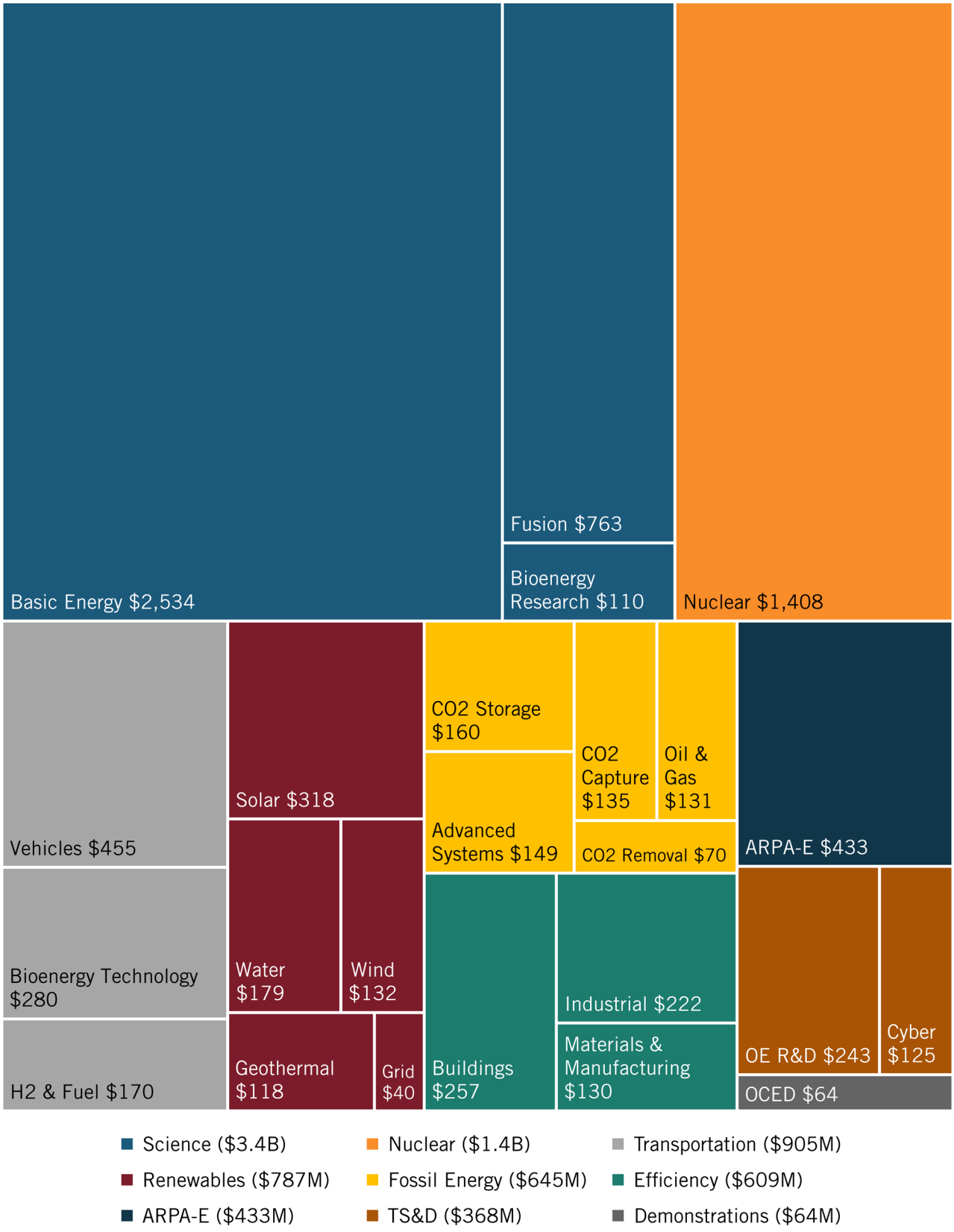
DOE's $8.1 billion Office of Science (SC) is one of the government's largest funders of basic science research, providing critical research infrastructure for its national laboratories. SC's research investment is spread across eight program areas: Advanced Scientific Computing Research, Basic Energy Sciences (BES), Biological and Environmental Research (BER), Fusion Energy Sciences (FES), High Energy Physics, Nuclear Physics, Isotope R&D and Production, and Accelerator R&D and Production. While SC is an important component of the nation's discovery science ecosystem, less than half of its budget is specifically devoted to advancing energy research. (ITIF includes only BES, FES, and the portion of BER that supports bioenergy research centers in its definition of "energy-related research.")

DOE's energy programs include both RD&D and non-RD&D functions. Most of the energy RD&D budget is distributed across the applied energy offices: Energy Efficiency and Renewable Energy (EERE), which houses programs in renewable energy, sustainable transportation, and energy efficiency; Electricity, which supports grid modernization; Cybersecurity, Energy Security, and Emergency Response (CESER); Fossil Energy and Carbon Management (FECM); and Nuclear Energy (NE). In addition, ARPA-E is a stand-alone, semiautonomous agency that advances cross-cutting research in high-potential, high-impact energy technologies that are too early for private sector investment. OCED supports clean energy technology demonstration projects (box 2).

**DOE's energy programs include both RD&D and non-RD&D functions. Most of the energy RD&D budget is distributed across the applied energy offices.**

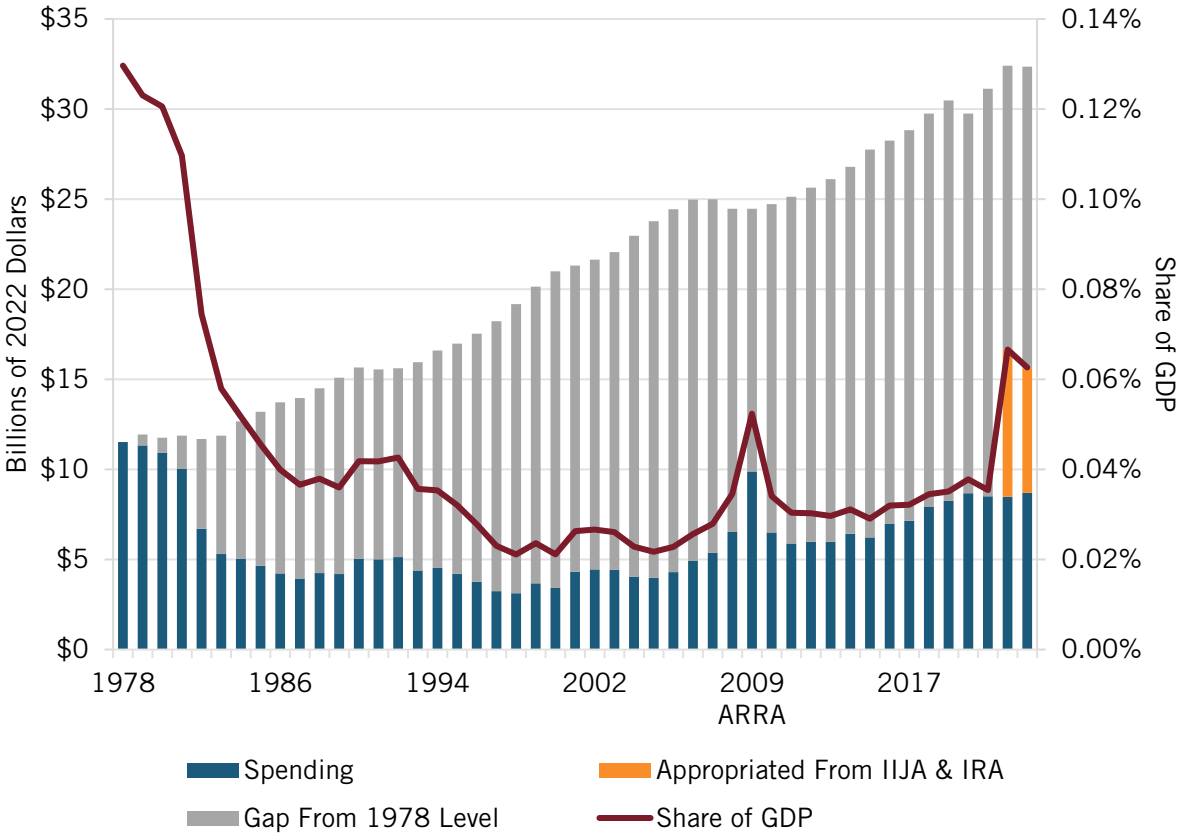
DOE's entire energy RD&D portfolio totaled $9.3 billion in FY 2023—$3.4 billion from SC and $5.8 billion from energy programs—or 20 percent of DOE's budget (figure 3). The portfolio spans 24 science and technology program areas across 7 technology categories: renewable energy; transportation; energy efficiency; energy transmission, storage, and distribution (TS&D); nuclear energy; fossil energy and carbon management; and basic energy-related research (figure 4).

**Figure 4: DOE RD&D funding per office, FY 2023 (programs in $millions, totaling $9.3 billion)[35]**



The federal government has invested a higher proportion of funds in energy RD&D in periods of need. The oil crisis of the 1970s spurred a greater investment in energy RD&D. In 1978, Congress invested $12 billion (in 2022 dollars) in energy RD&D, or 0.14 percent of GDP. Had federal investment kept pace with growth in the economy, DOE's RD&D budget today would be $32 billion, on par with other national priorities such as health research.[36] The IIJA and IRA added $7 billion on top of the regular FY 2023 budget, bringing the total to $17 billion, or half of the 1978 benchmark (see figure 5). The crises, challenges, and opportunities of today related to climate change, energy security, and supply chains call for a renewed and sustained investment in energy RD&D.

**Figure 5: U.S. Energy Department RD&D spending, FY 1978 through FY 2023[37]**



### Box 2: Effective OCED Oversight and Implementation for Max Impact

DOE's OCED, established by the IIJA in December 2021, partners with the private sector to deliver clean energy demonstration projects at scale. It has received $21.5 billion in appropriations from the IIJA and $5.8 billion from the IRA. This funding will set up several important demonstration programs such as Carbon Capture, Advanced Reactor, Energy Storage, Regional Clean Hydrogen Hubs, and the Advanced Industrial Facilities Deployment Program (AIFDP). The OCED program is a landmark opportunity for DOE and partners to foster innovation all the way to deployment at scale, where learnings can rapidly lead to improved integration with major systems, cost reductions, and proof that low-carbon technologies and the markets they serve are viable

OCED has already announced funding opportunities for some of these programs, including the clean hydrogen hubs ($8 billion). To achieve maximum impact, the selection process should be effective, fair, transparent, and timely. Specifically, ITIF has recommended that DOE should (1) clearly differentiate actual selection criteria mandates, boundary conditions, and post-selection elements; (2) prioritize a narrowed set of selection criteria; (3) establish an independent merit review panel consisting primarily of private sector reviewers and additional reviewers from DOE's applied programs, labs, and community groups; and (4) publish a consultative document that lays out the review panel and its plans for utilizing outside expertise.[38]

Meanwhile, OCED should support a transformative approach to industrial emissions reduction in its AIFDP portfolio. For example, a transformative approach such as electrified ethane crackers could achieve 30 times greater carbon dioxide ($CO_2$) reduction than a piecemeal approach such as implementing a number of industrial heat pumps in ethanol dry mills.[39] A transformative approach could also have a large upside for the reduction of other pollutants.[40] For AIFDP to be a success, DOE should reflect the comparative advantage of the program in its award selections, focus on industrial processes and technologies that do not receive sufficient and targeted funding via other federal programs, and prioritize investments that support the construction or installation of first-of-a-kind through third-of-a-kind commercial-scale demonstration projects.[41]

As for OCED itself, DOE's Office of Inspector General has identified five major risk areas concerning insufficient federal staffing, oversight of projects, internal controls, recipient-level controls, and circumvention of project controls.[42] DOE should set aside sufficient resources for program staffing and build robust internal controls and independent oversight systems. And Congress should engage in smart oversight by ensuring that funding balances both risks and payoffs and that technologies funded, supported, and built in America are not stolen or sold off to foreign competitors.[43]

## DOE RD&D: GENERATING ENVIRONMENTAL AND ECONOMIC BENEFITS

With a relatively small investment, federal energy RD&D has delivered big returns for the American public. DOE's investments have led to commercialization of new products, lower costs and speedier deployment of clean technologies, energy savings for consumers and businesses, less pollution from dirty energy, and GHG emissions reductions. DOE research has won a third of the top 100 R&D awards given out annually by *R&D World* magazine for each of the last five years.[44]

## Energy and Climate Benefits of DOE Programs

For its applied energy programs, DOE sets technology cost/performance targets based on the RD&D activities possible at a given budget level (table 3). As part of its goal-setting process, DOE and national laboratory experts assess the ability of its program activities both to improve a technology's characteristics (e.g., capital cost) and move it closer to commercialization. Since 2020, DOE has launched several initiatives to make clean energy more cost and performance competitive.

**Table 3: DOE technology cost and performance targets[45]**

| Technology or Initiative | Description | Year Initiated |
|---|---|---|
| **SunShot** | In March 2021, DOE announced it was moving up its SunShot goal by five years, targeting $0.03/kWh by 2025 and a new target of $0.02/kWh by 2030 for utility-scale solar | 2011 (updated in 2021) |
| **Electric Vehicle Batteries** | Reduce by 2030 the cost of battery cells for EVs to $60/kWh, increasing their range to 300 miles, and decreasing charging time to 15 minutes | 2021 |
| **Hydrogen Shot** | Reduce the cost of clean hydrogen by 80 percent to $1 per kilogram in one decade | 2021 |
| **Long Duration Storage Shot** | Reduce within the decade the cost of grid-scale energy storage by 90 percent for systems that deliver 10+ hours of duration | 2021 |
| **Carbon Negative Shot** | Reduce the cost of CO2 removal from the atmosphere to $100/ton of net CO2-equivalent | 2021 |
| **Enhanced Geothermal Shot** | Reduce the cost of enhanced geothermal systems (EGS) to $45/MWh by 2035 | 2022 |
| **Floating Offshore Wind Shot** | Reduce the cost of floating offshore wind to $45/MWh by 2035 | 2022 |
| **Industrial Heat Shot** | Develop cost-competitive industrial heat decarbonization technologies with at least 85 percent lower GHG emissions by 2035 | 2022 |

If DOE meets its targets, the nation will gain significant benefits, including lower consumer energy bills and better health and environmental outcomes. Clearly, RD&D is an important part of the decarbonization tool kit.

# 2023: MAINTAINING THE MOMENTUM FOR ENERGY INNOVATION

In a polarized political system, energy innovation has long enjoyed bipartisan support for various reasons. Large majorities of voters across the political spectrum support more funding for research into clean energy. A December 2022 poll finds that 79 percent of registered voters support funding more research into renewable energy sources.[46] Lawmakers from diverse backgrounds have embraced energy innovation as a strategy to combat climate change and promote U.S. competitiveness. Since 2011, Congress has increased federal funding for energy RD&D (inflation-adjusted) in every single year except 2015 and 2021. Furthermore, Democrats

and Republicans have joined forces to advance legislation to accelerate innovation in technologies as diverse as energy storage, advanced renewables, carbon capture, and nuclear power.

Undoubtedly, one of the most notable achievements from the previous Congress is the establishment of OCED, filling in the demonstration gap to get major innovations across the second "valley of death."[47] In addition to ensuring that OCED will be a success, DOE also needs additional investment and resources toward the next stage of energy innovation: the development and early commercialization of clean energy technologies. CHIPS paved the way to do just that: Congress authorized DOE to establish and collaborate closely with a new nonprofit Foundation for Energy Security and Innovation (FESI)—another notable achievement coming out of the previous Congress (box 3). Furthermore, CHIPS is continuing the innovation momentum by authorizing $100 million over four years for its Lab-Embedded Entrepreneurship Program to support the transfer of early-stage technologies through the commercialization pipeline; up to $800 million in applied laboratory infrastructure to fund deferred maintenance, critical infrastructure needs, and modernization efforts; and $100 million over four years to support funding for a small business voucher program within DOE.

### Box 3: FESI, a Flexible New Tool to Accelerate Energy Innovation

In July 2022, Congress authorized DOE to establish and collaborate closely with the new nonprofit FESI, an idea ITIF had championed for nearly a decade.[48] FESI, like similar foundations affiliated with other federal agencies, will partner with DOE to advance its missions—and especially to help it bring new technology to the market more quickly.[49] FY 2024 is the first year FESI is expected to receive funding. The FY 2024 PBR requests $31 million ($29.5 million of initial capital and $1.5 million for administrative expenses).[50]

Housed in DOE's Office of Technology Transitions (OTT), FESI serves to increase private and philanthropic sector investments to accelerate the commercialization of energy technologies. CHIPS includes a seed fund to help get the FESI up and running and attract the talent and donors it needs to fill gaps that remain within the energy innovation ecosystem.[51] (Although ITIF does not include OTT's programs as energy RD&D related, FESI has the resources to foster energy innovation.)

Additionally, FESI has the potential for place-based energy innovation. Clean manufacturing industries are in different regions globally (e.g., locations that make car engines are not necessarily good for making car batteries). Places that win production and jobs in the low-carbon economy will move nimbly to integrate innovation, skills, supply chains, natural resources, and entrepreneurial acumen.[52] Such competition is global and dynamic, and FESI can help U.S. regions compete by, for example, providing bridge funding when state and local programs are in flux or partnering with regionally oriented community foundations.[53] Moreover, DOE officials and philanthropic, community, and business leaders will sit on FESI's board; and the cross-sectoral partnership will complement and supplement DOE's programs.

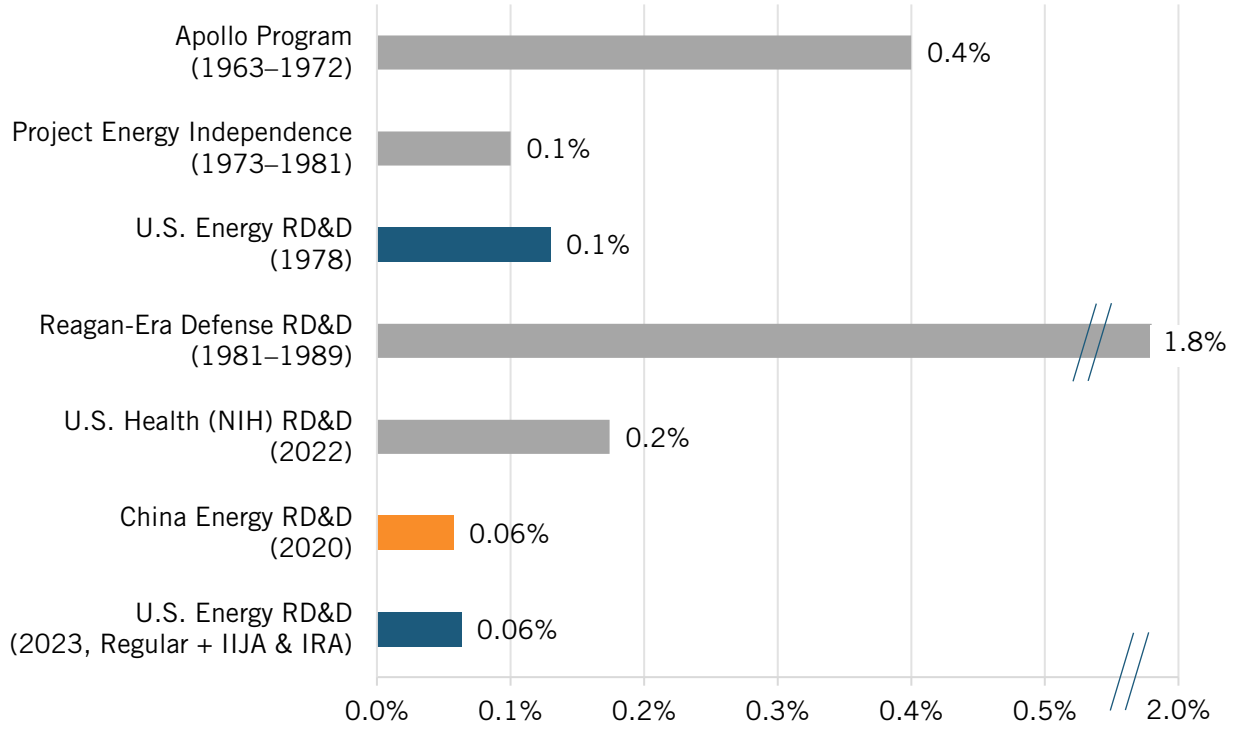
FESI, paralleling other agency-affiliated foundations, will be an independent nonprofit (501(c)(3)) organization that has a unique relationship with DOE. It will most likely resemble the Foundation for the National Institute of Health (FNIH).[54]

## 2024: TAKING THE NEXT STEP

These actions and achievements have established a renewed momentum in clean energy innovation in the United States amid potential pushbacks in a split Congress. A growing chorus of science and technology policy experts, in addition to the authors of *Energizing America*, are backing this call. For instance, a pair of recent studies from the National Academies of Sciences, Engineering, and Medicine (NASEM)—*Accelerating Decarbonization of the U.S. Energy System* and *The Future of Electric Power in the U.S.*—call on policymakers to triple energy RD&D investments.[55] The American Energy Innovation Council (AEIC), the Center for Climate and Energy Solutions (C2ES), and the President's Council of Advisors in Science and Technology have endorsed this target as well.[56] Other organizations have called for even more ambitious increases. The Environmental Defense Fund set a goal of $32 billion by FY 2025.[57] Breakthrough Energy suggests $35 billion by 2030.

These targets for federal energy RD&D spending are all roughly 0.1 percent of GDP.[58] Other national innovation missions in space, health, and defense show that the United States can marshal its innovative capacity on a much larger scale than it currently does for energy (figure 6). Federal investment in RD&D has accelerated the development of life-saving drugs, modernized the military's arsenal, and put astronauts on the moon. Steep and transformative changes in clean energy to preserve a climate that's fit for humans deserves equal consideration.

**Figure 6: Federal RD&D funding as a percentage of GDP for selected national innovation missions[59]**



## OTHER LEGISLATIVE OPPORTUNITIES

The administration's FY 2024 budget proposal is not the only pending legislation with the potential to impact the federal energy RD&D portfolio. CHIPS authorized over $35 billion in early stage R&D and applied innovation investments for existing DOE energy RD&D offices (cf. Sec. 10102, 10103(f), 10105, 10771, and 10781(f)), $2.8 billion for science laboratories infrastructure program (cf. Sec. 10108), as well as $345 million for new programs such as Regional Clean Energy Innovation Program to expand and support the current federal energy RD&D portfolio (cf. Sec. 10622, 10713, 10714, and 10715). But Congress still needs to approve funding in budget negotiations.

## WHAT HAPPENS NEXT

The next step in the budget process after the president's proposal is offered is for congressional leaders to agree on the top line of the defense and nondefense discretionary budgets. The appropriations committees must then apportion this total to their subcommittees, setting what are referred to as the "302(b) allocations" for each of the 12 bills that fund the government.[60] DOE, along with the Army Corps of Engineers, DOI, and other related agencies, is funded through the Energy and Water Development (E&W) appropriations bill. Appropriators' ability to increase DOE RD&D funding will be limited by the E&W 302(b) suballocations. While 302(b) levels are not self-enforcing (members can enforce them by raising points of order during the consideration of budgetary legislation), the Budget Act of 1974 provides that the Appropriations Committees may revise their suballocations.[61]

All appropriations are to pass both chambers of Congress and be signed by the president before the next fiscal year begins on October 1. However, continuing resolutions that extend current fiscal-year spending levels into the next fiscal year have frequently been used in recent years, and multiple observers expect that pattern to continue this year.

Concurrent with the appropriations process, Congress's authorizing committees are picking up where the 117th Congress left off. The House Subcommittee on Energy, for instance, held hearings on the importance of innovation on the development of clean hydrogen, energy security, and power grid for the next generation of energy infrastructure and DOE's role in the U.S. research ecosystem and interagency collaboration opportunities with the National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, and U.S. Department of Agriculture.[62] The Senate Committee on Energy and Natural Resources also held hearings on nuclear energy expansion.[63] The Senate Committee on Energy and Natural Resources also conducted a wide-ranging hearing with DOE Secretary Granholm on the FY 2024 budget request for DOE.[64] While these hearings may not impact the FY 2024 budget directly, they could lead to new legislation that would update existing DOE programs or create new ones.

## CONCLUSION

The United States has a proud history of rising to global challenges by unleashing its potential to innovate. If policymakers decisively invest in the clean energy technologies of the future and sustain that investment, history can repeat itself. Congress should seize the opportunity offered by the FY 2024 budget to build on the foundations laid by the three landmark bills and continue to elevate energy innovation as a national priority.

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## About ITIF

The Information Technology and Innovation Foundation (ITIF) is an independent 501(c)(3) nonprofit, nonpartisan research and educational institute that has been recognized repeatedly as the world's leading think tank for science and technology policy. Its mission is to formulate, evaluate, and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress. For more information, visit itif.org/about.

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