Federal Energy R&D: Nuclear Energy

BY COLIN CUNLIFF AND BATT ODGEREL | MARCH 2020

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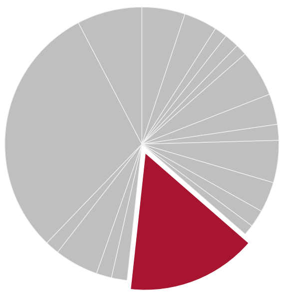
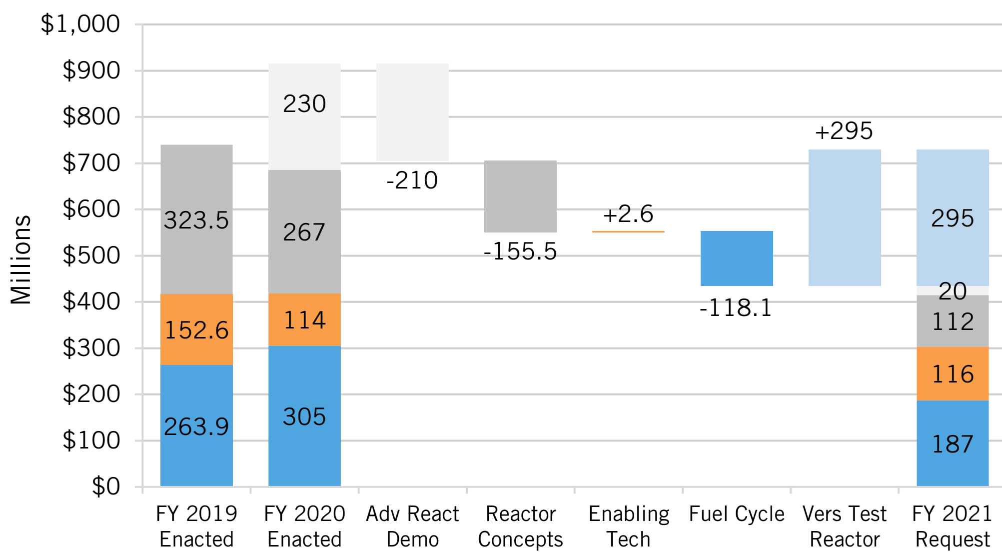


Nuclear Energy R&D (red)
Energy R&D (gray)

Nuclear power accounts for 19 percent of the electricity generated in the United States, and 53 percent of all carbon-free electricity, more than hydro and renewables combined.[1] Despite this success, the existing nuclear fleet is being challenged by low-cost natural gas and renewables, at the same time Russia and China are outpacing the United States in the development of advanced next-generation nuclear reactors.[2] To address these challenges, the Department of Energy's (DOE) nuclear energy (NE) program conducts research and development (R&D) on the technical challenges with maintaining the existing reactor fleet, and on the development of a robust pipeline of advanced reactor designs and supply-chain capabilities.[3]

Figure 1: The FY 2021 budget request would cut nuclear energy R&D by 21 percent



What's at Risk

Nuclear energy has unique regulatory challenges that limit the ability of the private sector to conduct full-scale R&D on its own. Plus, many of the facilities necessary for R&D are capital intensive and lie beyond the financial capacity of potential nuclear innovators. DOE has had success working with industry to develop small modular reactors (SMRs) based on current light-water-reactor technologies. The SMR Licensing Technical Support program, for example, addressed first-of-a-kind costs associated with design certification and licensing, resulting in the submission of the first SMR design certification application to the Nuclear Regulatory Commission in January 2017. Design certification review is expected to be completed by September 2020, with the first SMR module expected to begin operating in 2026.[4]

DOE is exploring advanced, non-light-water-reactor designs that could operate at higher temperatures (allowing for greater efficiency and provision of other energy services, such as process heat for the chemicals industry), produce lower volumes of waste, incorporate passive safety features, and reduce proliferation risks. However, DOE has conducted R&D in advanced reactors since the late 1990s, and so far, no advanced reactor concepts have progressed to full-scale demonstration, let alone commercialization.[5]

Recent action in Congress and by the administration aims to jump-start innovation in advanced nuclear technologies. In the FY 2019, the administration proposed a new R&D subprogram focused on advanced (non-light-water) SMRs, which Congress funded at $100 million. And in the FY 2020 budget cycle, Congress established a new Advanced Reactor Demonstration subprogram to build and demonstrate two advanced reactor designs by the mid-2020s. Congress also passed the Nuclear Energy Innovation Capabilities Act in September 2018 to facilitate private-sector innovation in advanced reactor technologies.[6] And in July 2019, the Senate Committee on Energy and Natural Resources approved the bipartisan Nuclear Energy Leadership Act to refocus DOE's nuclear energy research programs, establish a domestic supply of advanced reactor fuel, enable first-of-a-kind deployment of new nuclear technologies, and build a Versatile Test Reactor.[7] But these efforts are jeopardized without greater levels of sustained funding for nuclear energy R&D and pilot and demonstration projects to prove out designs at commercial scale.

Nuclear Energy R&D Subprograms

In FY 2020, NE conducted R&D in the following subprograms:[8]

- **Reactor Concepts RD&D** (research, development, and demonstration) focuses on new and advanced reactor designs and technologies, including advanced SMRs, fast reactors using liquid-metal coolants, high-temperature reactors, and micro-reactor technologies.

- **Fuel Cycle R&D** studies advanced fuel-cycle technologies that have the potential to enhance safety, improve resource utilization, reduce waste generation, and limit risk of proliferation.

- **Nuclear Energy Enabling Technologies** works to develop cross-cutting technologies in reactor materials, advanced sensors and instrumentation, innovative manufacturing and construction technologies, advanced cooling concepts, and modeling and simulation—and provides support for nuclear-science user facilities.

- **Advanced Reactor Demonstration** is a new subprogram established by Congress in FY 2020 to build and demonstrate two advanced reactor designs within the next 5 to 7 years.

- **Supercritical Transformation Electric Power (STEP) and other NE R&D** (not shown in figure 1) include R&D on supercritical carbon dioxide Brayton-cycle technologies (which are potentially applicable to all steam electric generation), as well as nuclear-workforce training and education programs.

Key Elements of the FY 2021 Budget Proposal

- **New funding to begin construction of the Versatile Test Reactor (VTR),** a user facility that will enable testing of materials and fuel designs common to many advanced, non-light-water-reactor designs.[9]

- **A 91 percent cut to the Advanced Reactor Demonstration Program,** including the elimination of funding for two advanced reactor demonstration projects; no new funding for risk reduction for future demonstrations; a $10 million cut to the National Reactor Innovation Center; and a $10 million cut to regulatory development and advanced reactor safeguards research.

- **A 58 percent reduction in Reactor Concepts R&D**, including a $90 million cut to advanced small modular reactor R&D; a $16.5 million cut to light-water-reactor sustainability R&D; and a $16 million boost to advanced reactor technologies development. The VTR would be moved out of Reactor Concepts and into its own subprogram.

- **A 39 percent reduction in Fuel Cycle R&D**, including reduced funding for accident-tolerant fuels, advanced nuclear fuels, material recovery and waste-form development, and used nuclear fuel disposition R&D, as well as the elimination of integrated waste management activities. Funding to support the development and testing of Tri-structural isotropic (TRISO) fuel—which is more resistant to irradiation, corrosion, and high temperatures than traditional nuclear fuels—would receive a slight boost.

- **A 2 percent increase in Nuclear Energy Enabling Technologies**, including reductions in advanced modeling and simulation and nuclear science user facilities; and small increases in cross-cutting technology development and the Transformational Challenge Reactor program.

- **Elimination of the STEP and nuclear workforce development programs.**

ENDNOTES

1. U.S. Energy Information Administration (EIA), "Monthly Energy Review," Table 7.2a, (Washington, D.C.: EIA, Release Date February 25, 2020), http://www.eia.gov/mer.
2. Russia currently operates two sodium-cooled fast reactors: the 600-megawatt BN600, which began operation in 1980, and the 800-megawatt BN800, which entered commercial operation in 2016. China is operating an experimental 20-megawatt fast reactor—which began operations in 2011—and is designing a 1,000-megawatt prototype fast reactor. For more on advanced nuclear technologies, see International Energy Agency, "Nuclear Energy Technology Roadmap" (IEA and the Nuclear Energy Agency, 2015), https://webstore.iea.org/technology-roadmap-nuclear-energy-2015.
3. U.S. Department of Energy (DOE), "FY 2021 Congressional Budget Justification," Volume 3 Part 2, 9 (DOE Chief Financial Officer, DOE/CF-0164, February 2020), https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-2_2.pdf.
4. NuScale, "Licensing," accessed February 5, 2020, https://www.nuscalepower.com/technology/licensing;"NuScale's SMR Design Clears Phase 4 of Nuclear Regulatory Commission's Review Process," *BusinessWire* (December 12, 2019), https://www.businesswire.com/news/home/20191212005796/en/.
5. A Abdulla et al., "A Retrospective Analysis of Funding and Focus in US Advanced Fission Innovation," Environmental Research Letters, 084016, 2017, 12, https://doi.org/10.1088/1748-9326/aa7f10.
6. For a brief review of recent activity, see Colin Cunliff, "An Innovation Agenda for Deep Decarbonization: Bridging Gaps in the Federal Energy RD&D Portfolio" (Information Technology and Innovation Foundation, November 2018), 21–25, http://www2.itif.org/2018-innovation-agenda-decarbonization.pdf.
7. Nuclear Energy Leadership Act, S. 903, 116th Cong. (2019), https://www.congress.gov/bill/116th-congress/senate-bill/903.
8. DOE, "FY 2021 Congressional Budget Justification" Volume 3 Part 2, 9–166.
9. Jeremy Harrell and Spencer Nelson, "A Versatile Way to Grow Advanced Nuclear Power" (ClearPath, 2018), https://clearpath.org/our-take/a-versatile-way-to-grow-advanced-nuclear-power/. Early work on VTR design was funded through the Reactor Concepts RD&D subprogram.

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ABOUT THE AUTHORS

Colin Cunliff is a senior policy analyst for clean energy innovation with the Information Technology and Innovation Foundation. He previously worked at the U.S. Department of Energy (DOE) on energy sector resilience and emissions mitigation. He holds a Ph.D. in physics from the University of California, Davis.

Batt Odgerel is a policy fellow for clean energy innovation at the Information Technology and Innovation Foundation. He previously worked for the Energy Policy Research Foundation and Smart Electric Power Alliance. Batt holds a master's degree in energy policy from Johns Hopkins University.

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