Federal Energy R&D: Nuclear Energy

BY COLIN CUNLIFF | APRIL 2019

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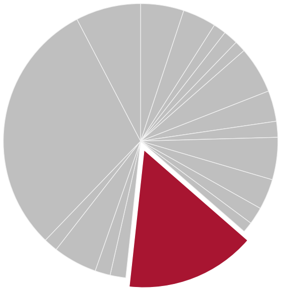
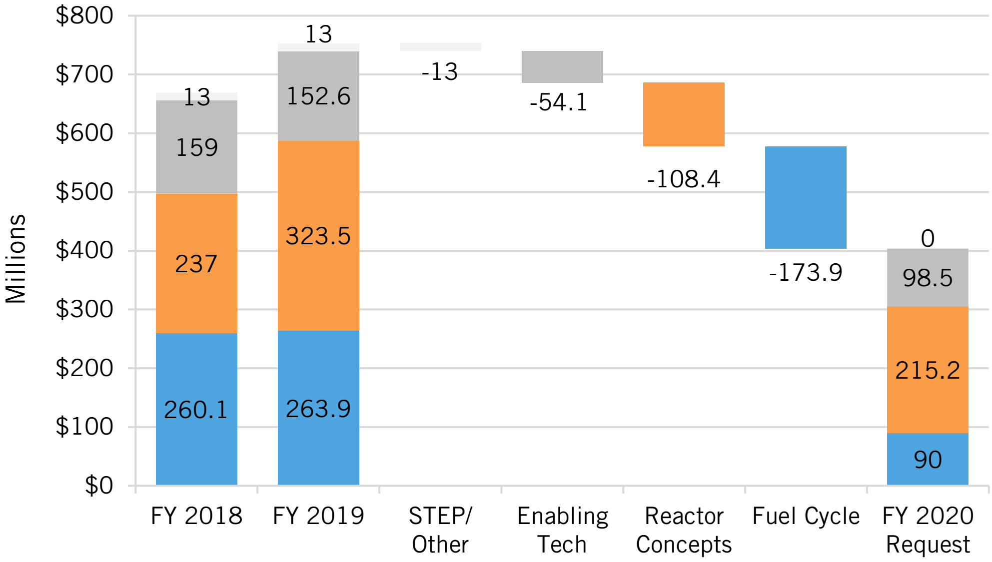


Nuclear Energy R&D (red)
Energy R&D (gray)

Nuclear power accounts for 19 percent of the electricity generated in the United States, and 54 percent of all carbon-free electricity.[1] Despite this success, the existing nuclear fleet is being challenged by low-cost natural gas and renewables, at the same time that 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 R&D on 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 2020 Budget Request Would Cut Nuclear Energy R&D by 46 Percent.[4]



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 January 2021, with the first SMR module expected to begin operating in 2026.[5]

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 heating), 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.[6]

Recent action in Congress and by the administration aims to jumpstart innovation in advanced nuclear technologies. In the last budget cycle, the administration proposed a new R&D subprogram focused on advanced (non-light-water) SMRs, to which Congress appropriated $100 million in its FY 2019 budget. In September 2018, Congress passed the Nuclear Energy Innovation Capabilities Act to facilitate private-sector innovation in advanced reactor technologies.[7] And in March 2019, a bipartisan group of 15 senators introduced the Nuclear Energy Leadership Act to spur the development and demonstration of new nuclear technologies.[8] But these efforts are jeopardized without greater levels of sustained funding for nuclear energy R&D.

Nuclear Energy R&D Subprograms

Nuclear energy R&D is conducted in the following subprograms:[9]

- **Reactor Concepts RD&D** develops new and advanced reactor designs and technologies, including advanced SMRs, fast reactors using liquid-metal coolants, high-temperature reactors, and micro-reactor technologies. The subprogram also houses a new effort, launched in FY 2018, to build and operate a Versatile Advanced Test Reactor user facility to enable testing of materials and fuel designs in a fast-neutron environment.

- **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.

- **Supercritical Transformation Electric Power (STEP) and other NE R&D** includes contributions to the cross-cutting STEP program, which develops supercritical carbon dioxide Brayton cycle technologies (which are potentially applicable to nuclear, concentrated-solar, bio-, geothermal, and fossil-fuel power), as well as nuclear-workforce training and education programs.

Key Elements of the FY 2020 Budget Proposal

- **A 66-percent reduction in Fuel Cycle R&D**, including reduced funding for advanced nuclear fuels, material recovery and waste-form development, used nuclear fuel disposition R&D, as well as elimination of systems analysis and integrated waste management activities. Funding to demonstrate the capability to produce high-assay low-enriched uranium (HA-LEU) domestically would receive a boost.
- **A 33-percent reduction in Reactor Concepts R&D**, including reduced funding for light-water-reactor sustainability and advanced-reactor technologies; a 90-percent reduction in the Advanced Small Modular Reactor program; and an increase in funding for the Versatile Advanced Test Reactor.
- **A 35-percent reduction in Nuclear Energy Enabling Technologies**, including elimination of the Energy Innovation Hub for Modeling and Simulation; large reductions in crosscutting technology development and nuclear science user facilities; and creation of a new Transformational Challenge Reactor activity to develop advanced manufacturing methods for small- and micro-reactors.
- **Elimination of the STEP and nuclear-workforce development programs.**

ENDNOTES

1. EIA, "Monthly Energy Review," Table 7.2a, (Washington, D.C.: EIA, Release Date March 26, 2019), http://www.eia.gov/mer. Accessed April 10, 2018.
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. DOE, "FY 2020 Congressional Budget Justification" Volume 3 Part 2, 265, (DOE Chief Financial Officer, DOE/CF-0153, April 2019), https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-part-2_0.pdf.
4. Ibid, 267.
5. NuScale expects to file a combined construction and operation license application (COLA) in 2019, allowing the design certification and COLA review processes to proceed concurrently. Karen Thomas, "NuScale files US' first SMR License Application as Suppliers Await Tender," *Nuclear Energy Insider*, January 10, 2017, https://analysis.nuclearenergyinsider.com/nuscale-files-us-first-smr-license-application-suppliers-await-tender; NuScale, "Licensing" https://www.nuscalepower.com/technology/licensing, accessed April 10, 2019.
6. 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.

7. 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.

8. U.S. Senate Committee on Energy and Natural Resources, “Murkowski, Booker, and 13 Colleagues Reintroduce the Nuclear Energy Leadership Act” (SENR, March 27, 2019) https://www.energy.senate.gov/public/index.cfm/2019/3/murkowski-booker-and-13-colleaguesreintroduce, accessed April 2, 2019.

9. DOE, “FY 2020 Congressional Budget Justification” Volume 3 Part 2, 261-328.

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