



CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

December 20, 2018

S. 1457

Advanced Nuclear Energy Technologies Act

As reported by the Senate Committee on Energy and Natural Resources on May 21, 2018

SUMMARY

S. 1457 would specify objectives for the Department of Energy's (DOE's) programs related to the development of advanced nuclear energy technologies. The bill would direct the Secretary of Energy to enter into one or more agreements with nonfederal partners, by September 30, 2028, to implement at least four projects to demonstrate the potential for such technologies to be used in commercial nuclear reactors.

CBO expects that meeting that deadline would require a significant and sustained increase in federal spending relative to current funding for DOE's nuclear energy programs. Using information from DOE and the nuclear industry, CBO estimates that implementing S. 1457 would cost \$4 billion over the 2019-2023 period, and \$12.6 billion over the 2019-2028 period, assuming appropriation of the necessary amounts. That spending would support a broad range of research and engineering activities necessary to advance nuclear technology as well as activities related to designing, licensing, and implementing demonstration projects under the bill. In 2019, the Congress provided about \$1 billion for DOE's nuclear energy programs.

In addition, CBO expects that the government would support the financing of at least some of the costs to construct demonstration facilities required under S. 1457 through alternative contractual arrangements that are not contingent on further legislation. As a result, CBO estimates that enacting the legislation would increase direct spending by \$335 million over the 2019-2028 period. Because enacting S. 1457 would affect direct spending, pay-as-you-go procedures apply. S. 1457 would not affect revenues.

CBO estimates that enacting S. 1457 would not increase net direct spending or on-budget deficits by more than \$5 billion in any of the four consecutive 10-year periods beginning in 2029.

S. 1457 contains no intergovernmental or private-sector mandates as defined in the Unfunded Mandates Reform Act (UMRA).

ESTIMATED COST TO THE FEDERAL GOVERNMENT

The estimated budgetary effect of S. 1457 is shown in the following table. The costs of the legislation fall within budget function 270 (energy).

	By Fiscal Year, in Millions of Dollars											
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2019- 2023	2019- 2028
INCREASES IN SPENDING SUBJECT TO APPROPRIATION												
Estimated Authorization Level	0	1,090	1,110	1,300	1,330	1,440	1,470	1,590	1,620	1,660	4,830	12,610
Estimated Outlays	0	570	970	1,180	1,290	1,380	1,440	1,530	1,590	1,640	4,010	11,590
INCREASES IN DIRECT SPENDING												
Estimated Budget Authority	0	0	0	0	0	0	0	300	200	200	0	700
Estimated Outlays	0	0	0	0	0	0	0	45	105	185	0	335

BASIS OF ESTIMATE

For this estimate, CBO assumes that the bill will be enacted near the end of 2018 and that necessary amounts will be provided each year. Estimated outlays are based on historical spending patterns for similar activities.

Background

S. 1457 would direct the Secretary of Energy to enter into one or more agreements with nonfederal partners by 2028 to implement no fewer than four projects to demonstrate the potential use of advanced nuclear technologies. The requirement to pursue demonstration projects is broadly consistent with DOE's underlying statutory mission to carry out research and development (R&D) to advance the state of nuclear technology. However, because the bill specifies a minimum number of demonstration projects and a deadline for entering into agreements to carry them out, CBO expects that implementing the bill would require DOE to significantly expand and accelerate nuclear R&D activities over the next 10 years.

S. 1457 does not define the level of effort that would constitute a demonstration project. Historically, developing and deploying commercialized nuclear technologies has involved a range of projects, including early-stage test and engineering demonstrations, larger-scale demonstrations to support detailed designs of reactors and systems, and demonstrations of first-of-a-kind reactors to prove commercial viability. On the basis of information from DOE and nuclear experts about the state of advanced nuclear technologies that might be involved in the four projects that would be required under

S. 1457, CBO expects that DOE would enter into agreements to support a mix of early-stage test and engineering demonstrations and larger-scale projects that may involve commercial aspects.

Many nuclear experts agree that the cumulative federal and nonfederal costs to develop and demonstrate any particular nuclear concept for commercial deployment will total several billion dollars over a period of many years. For example, the Massachusetts Institute of Technology (MIT) reported that a range of experts generally agreed that the costs to develop, construct, and demonstrate a high-temperature gas-cooled reactor—widely considered a candidate for a near-term demonstration—would total about \$4 billion.¹ (That amount includes neither the funding that has already been spent to develop that technology—including early-stage R&D—nor the anticipated costs of postlicensing activities related to commercializing the technology. According to MIT, including those costs would bring total project costs to about \$6 billion.)

Using that and other information from nuclear experts, CBO expects that completing the necessary R&D and related activities to facilitate the demonstrations under S. 1457 would require significant and sustained federal spending over the next two decades. CBO anticipates that most such spending—particularly for R&D to advance the maturity of candidate technologies and related design and licensing activities—would be subject to appropriation. CBO also expects that the government would provide at least some support—particularly for construction costs—through long-term commitments that would increase direct spending.²

Spending Subject to Appropriation

S. 1457 is generally consistent with DOE’s underlying statutory mission to advance the state of nuclear technology for commercial deployment, and demonstration projects have historically been important in that process. However, under current law, no such funds are specifically authorized to be appropriated for those activities, and no statutory requirement to pursue advanced nuclear demonstration projects within a particular timeframe exists. Therefore, this estimate reflects the full amount of funding CBO estimates would be needed to carry out the expanded nuclear R&D necessary to facilitate the four demonstration projects envisioned by S. 1457.

Using information from DOE, representatives of the nuclear industry, and academic experts, CBO estimates that implementing S. 1457 would require appropriations totaling

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1. Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World* (September 2018), <http://tinyurl.com/ycdxnugt>.
 2. For more examples of alternative financing arrangements for capital projects and CBO’s view of the principles that inform their budgetary treatment, see Congressional Budget Office, *Third-Party Financing of Government Projects* (June 2005), www.cbo.gov/publication/16554.

\$12.6 billion over the 2020-2028 period. (CBO does not expect that any additional funding would be required in 2019.)³ Funding provided under the bill would support many million person-hours of advanced R&D, engineering design, and licensing efforts related to demonstration projects, as well as activities related to developing fuels and supply chains, characterizing sites where demonstration facilities would be located, and overseeing those facilities' construction and operation.

Under S. 1457, CBO expects, funding in the initial years would be used to expand and accelerate DOE's ongoing R&D activities to advance the maturity of nuclear technologies in preparation for demonstrations. Funding would gradually rise in later years to support design and licensing efforts and preconstruction activities, and it would peak during the construction phase, which CBO expects could begin as early as 2026 for projects involving the most mature technologies. Because the construction phase (which CBO expects would last about five years) would continue beyond 2028, those higher levels of funding would need to continue into the next decade.

All told, assuming appropriation of the estimated amounts, CBO estimates that outlays would total \$11.6 billion over the 2020-2028 period, and \$1 billion after 2028. (CBO also expects that a significant amount of additional funding would be needed after 2028 to continue activities related to demonstration projects.) CBO's estimate reflects information from several studies and reports by government, academic, and industry experts on the anticipated costs and time required to develop sufficiently mature nuclear technologies to use in demonstrations.⁴ It does not include costs related to the operation and maintenance of facilities constructed under the bill, fuels used by those facilities, or the back-end costs related to managing the waste they produce; the bulk of such costs would occur after 2028 and continue for many years, CBO expects.

Direct Spending

Under S. 1457, CBO expects, DOE would use existing contractual authorities to enter into agreements with nonfederal entities to construct demonstration reactors with a combined capacity to generate roughly 500 megawatts of electricity (MW_e). CBO also

3. CBO estimates that the Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019, provides about \$1 billion in funding for nuclear R&D in 2019. If future appropriations were to remain at that level, adjusted for inflation, CBO projects that such funding would total about \$10.1 billion over the 2020-2028 period—or about 20 percent less than the amounts CBO estimates would be required to implement S. 1457.

4. See Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World* (September 2018), <http://tinyurl.com/ycdxnugt>; Energy Innovation Reform Project, *What Will Advanced Nuclear Power Plants Cost?* (July 2017), <http://tinyurl.com/y7m6rtvy>; Idaho National Laboratory, ART Program, *Advanced Demonstration and Test Reactor Options Study* (prepared by Argonne National Laboratory, Idaho National Laboratory, and Oak Ridge National Laboratory for the Department of Energy Office of Nuclear Energy, January 2017), <https://go.usa.gov/xP5S6>; and Department of Energy, Secretary of Energy Advisory Board, *Report of the Task Force on the Future of Nuclear Power* (September 2016), <https://go.usa.gov/xP5SS>.

expects that agreements would support four such projects of various sizes—from very small (less than 10 MWe) to much larger (up to 300 MWe). Using information from nuclear experts, CBO estimates that the capital costs of such facilities (including interest on funds borrowed to finance construction) would average about \$5,650 per kilowatt of electric generating capacity, for a total cost of roughly \$2.8 billion.⁵

CBO further expects that the government would support the financing of at least some of that estimated cost to construct demonstration facilities through alternative contractual arrangements—used under current law for existing projects—that would not be contingent on further legislation.⁶ As a result, CBO estimates that enacting the legislation would increase direct spending.

The extent and nature of federal support for the costs to construct demonstration reactors under S. 1457 is uncertain, but several reports suggest that constructing advanced nuclear reactor technologies will require risk-sharing agreements between the government and nonfederal partners.⁷ For example, alternative forms of financial or contractual support could be provided by DOE, the Department of Defense, or another agency that uses nuclear materials or energy.⁸ For this estimate, CBO expects federal agencies would use such alternative means of financing to support about 25 percent of the estimated costs to construct demonstration reactors. That estimate of the proportion of federal support is in line with a recent MIT analysis that suggests that a significant amount of federal support at key milestones—such as during a project’s construction—would be needed to facilitate sufficient private-sector investment.⁹

On the basis of this information, CBO estimates that the government would make commitments to support about \$700 million in capital spending to construct facilities—equivalent to about 125 MWe of capacity. CBO’s estimate of budget authority related to

5. See Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World* (September 2018), Appendix K, pp. 235-242, <http://tinyurl.com/ycdxnugt>.

6. For example, in 2016 DOE entered into agreements with private entities to build and operate a small modular reactor at the Idaho National Laboratory. The electricity generated by that project will be marketed by an entity that is authorized to sell electricity to federal agencies through long-term contracts.

7. See Idaho National Laboratory, ART Program, *Advanced Demonstration and Test Reactor Options Study* (prepared by Argonne National Laboratory, Idaho National Laboratory, and Oak Ridge National Laboratory for the Department of Energy Office of Nuclear Energy, January 2017), <https://go.usa.gov/xP5S6>; and Department of Energy, Secretary of Energy Advisory Board, *Report of the Task Force on the Future of Nuclear Power* (September 2016), <https://go.usa.gov/xP5SS>.

8. For examples of alternative financing, see SMR Start, *Policy Statement on U.S. Public-Private Partnerships for Small Modular Nuclear Reactors* (February 2017), <http://tinyurl.com/y9yoxwkt> (PDF, 429 KB); Kutak Rock and Scully Capital, *Purchasing Power Produced by Small Modular Reactors: Federal Agency Options* (submitted to the Department of Energy, January 2017), <https://go.usa.gov/xUBUc>.

9. See Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World* (September 2018), Chapter 4, pp. 109-115, <http://tinyurl.com/ycdxnugt>.

those commitments reflects their full anticipated costs, up front, in the years when they are made. For this estimate, CBO expects such commitments would occur in each of fiscal years 2026 through 2028. Estimated outlays stemming from those commitments are spread across the period during which project sponsors are expected to construct facilities, which CBO expects would average about five years per project. As a result, CBO estimates that increases in mandatory outlays under S. 1457 would total \$335 million over the 2026-2028 period, and \$365 million after 2028.

UNCERTAINTY

The timing and magnitude of federal costs to implement demonstration projects of nuclear technologies under S. 1457 would vary considerably, depending on the maturity of technology involved, the projects’ scope and purpose, and the extent to which costs are shared with nonfederal partners.

Some aspects of those costs are particularly uncertain. For example, the magnitude of costs related to R&D, design, and licensing might be relatively similar across different technologies, but technology-specific activities, such as developing fuels and supply chains, might be more variable. Finally, although CBO expects that the underlying cost per megawatt to construct advanced nuclear facilities might be similar across a relatively broad range of technologies, overall estimates of capital spending to construct facilities could differ considerably depending on the size of projects.

PAY-AS-YOU-GO CONSIDERATIONS

The Statutory Pay-As-You-Go Act of 2010 establishes budget-reporting and enforcement procedures for legislation affecting direct spending or revenues. The net changes in outlays that are subject to those pay-as-you-go procedures are shown in the following table.

CBO Estimate of Pay-As-You-Go Effects for S. 1457, the Advanced Nuclear Energy Technologies Act, as reported by the Senate Committee on Energy and Natural Resources on May 21, 2018												
	By Fiscal Year, in Millions of Dollars										2019-	2019-
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2023	2028
NET INCREASE IN THE DEFICIT												
Statutory Pay-As-You-Go Effect	0	0	0	0	0	0	0	45	105	185	0	385

INCREASE IN LONG-TERM DIRECT SPENDING AND DEFICITS

CBO estimates that enacting S. 1457 would not increase net direct spending by more than \$2.5 billion or on-budget deficits by more than \$5 billion in any of the four consecutive 10-year periods beginning in 2029.

MANDATES

S. 1457 contains no intergovernmental or private-sector mandates as defined in UMRA.

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