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Nuclear Energy: Overview of Congressional Issues

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Summary

The policy debate over the role of nuclear power in the nation's energy mix is rooted in the technology's fundamental characteristics. Nuclear reactors can produce potentially vast amounts of useful energy with relatively low consumption of natural resources and emissions of greenhouse gases and other pollutants. However, facilities that produce nuclear fuel for civilian power reactors can also produce materials for nuclear weapons. In addition, the process of nuclear fission (splitting of atomic nuclei) to generate power produces radioactive material that can remain hazardous for thousands of years and must be contained. How to manage the weapons proliferation and safety risks of nuclear power, or whether the benefits of nuclear power are worth those risks, are issues that have long been debated in Congress.

The 98 licensed nuclear power reactors at 59 sites in the United States generate about 20% of the nation's electricity. Two new reactors are currently under construction. About a dozen more are planned, but with no specific construction dates. Whether they will eventually move forward will depend largely on their economic competitiveness with natural gas and renewable energy sources. Throughout the world, 451 reactors are currently in service or operable, and 54 more are under construction, according to the World Nuclear Association.

The March 2011 disaster at the Fukushima Dai-ichi nuclear power plant in Japan increased attention to nuclear safety throughout the world. The U.S. Nuclear Regulatory Commission (NRC), which issues and enforces nuclear safety requirements, established a task force to identify lessons from Fukushima applicable to U.S. reactors. The task force's report led to NRC's first Fukushima-related regulatory requirements on March 12, 2012. Several other countries, such as Germany and Japan, eliminated or reduced their planned future reliance on nuclear power after the accident.

Highly radioactive spent nuclear fuel that is regularly removed from nuclear power plants is currently stored at plant sites in the United States. Development of a permanent underground repository at Yucca Mountain, NV, was suspended by the Obama Administration. The Trump Administration requested funding for FY2018 and FY2019 to revive the program, but it was not approved by Congress. The House voted to provide Yucca Mountain funding in both years, but the Senate provided no funding, and it was not included in the final bills.

The Obama Administration had appointed the Blue Ribbon Commission on America's Nuclear Future to recommend an alternative approach to the Nuclear Waste Policy Act's focus on Yucca Mountain. In response to the commission's recommendations, the Department of Energy issued a waste strategy in January 2013 that called for the selection of new candidate sites for nuclear waste storage and disposal facilities through a "consent-based" process and for a surface storage pilot facility to open by 2021. However, Congress has not enacted legislation for such a strategy, so Yucca Mountain remains the sole authorized candidate site.

The level of security that must be provided at nuclear power plants has been a high-profile issue since the 9/11 terrorist attacks on the United States in 2001. Since those attacks, NRC issued a series of orders and regulations that substantially increased nuclear plant security requirements, although industry critics contend that those measures are still insufficient.

Encouraging exports of U.S. civilian nuclear products, services, and technology while making sure they are not used for foreign nuclear weapons programs has long been a fundamental goal of U.S. nuclear energy policy. Recent proposals to build nuclear power plants in several countries in the less developed world, including the Middle East, have prompted concerns that international controls may prove inadequate.

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Synthesis of Key Issues

The long-running policy debate over the future of nuclear energy is rooted in the technology's inherent characteristics. Initially developed for its unprecedented destructive power during World War II, nuclear energy seemed to hold equal promise after the war as a way of providing limitless energy to all humanity. International diplomacy has focused ever since on finding institutional mechanisms for spreading the perceived benefits of nuclear energy throughout the world while preventing the technology from being used for the proliferation of nuclear weapons. Much of this international effort is focused on key nuclear fuel cycle facilities—plants for enriching uranium in the fissile isotope U-235 and for separating plutonium from irradiated nuclear fuel. Such plants can be used to produce civilian nuclear reactor fuel as well as fissile material for nuclear warheads.

Yet even the use of nuclear power solely for peaceful energy production has proven intrinsically controversial. The harnessing of nuclear fission in a reactor creates highly radioactive materials that must be kept from overheating and escaping from the reactor building, as occurred during the accidents at Fukushima, Chernobyl, and, to a lesser extent, Three Mile Island. Spent nuclear fuel that is regularly removed from reactors during refueling must be isolated from the environment for up to 1 million years. Potential technologies to reduce long-lived nuclear waste through recycling usually involve separating plutonium that could be used for nuclear weapons, although technologies designed to reduce proliferation risks are also the subject of worldwide research and development efforts. All nuclear energy technologies, even with recycling, would still leave substantial amounts of radioactive waste to be stored and disposed of. Central storage and disposal sites for nuclear waste have proven difficult to develop throughout the world, as illustrated by long-running controversy over the proposed U.S. waste repository at Yucca Mountain, NV.

The March 2011 disaster at Japan's Fukushima Dai-ichi nuclear power plant, which forced the evacuation of areas as far as 30 miles away, has slowed nuclear power expansion plans around the world, particularly in Japan and Western Europe. However, dozens of new reactors are still being planned and built in China, India, Russia, and elsewhere.[1] In these areas, nuclear power's initial promise of generating large amounts of electricity without the need for often-imported fossil fuels, along with the more recent desire to reduce greenhouse gas emissions, remains a compelling motivation.

With 98 licensed reactors, the United States has the largest nuclear power industry in the world. But U.S. nuclear power growth has been largely stagnant for the past two decades, as natural gas and renewable energy have captured most of the market for new electric generating capacity.[2] Congress enacted incentives for new nuclear plants in the Energy Policy Act of 2005 (P.L. 109-58), including production tax credits, loan guarantees, and insurance against regulatory delays. Those incentives, combined with rising natural gas prices and concerns about federal restrictions on carbon dioxide emissions, prompted announcements by late 2009 of up to 30 new nuclear power reactors in the United States.[3] However, subsequent declines in natural gas prices and uncertainty about carbon dioxide controls have put most of those projects on hold. Currently, two

[1] World Nuclear Association, "World Nuclear Power Reactors and Uranium Requirements," November 2018, http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx.

[2] Energy Information Administration, "Natural Gas and Renewables Make Up Most of 2018 Electric Capacity Additions," May 7, 2018, https://www.eia.gov/todayinenergy/detail.php?id=36092.

[3] Nuclear Regulatory Commission, "Expected New Nuclear Power Plant Applications," updated March 28, 2008, https://www.nirs.org/wp-content/uploads/nukerelapse/industry/expectednewrxapplications32808.pdf.

new reactors in Georgia are under construction. Two identical reactors under construction in South Carolina were cancelled July 31, 2017. An older reactor, Watts Bar 2 in Tennessee, received an NRC operating license on October 22, 2015, after construction had been suspended for two decades. A variety of incentives to renew the growth of nuclear power have been proposed, including a plan by the Trump Administration to provide additional revenue to nuclear and coal power plants in wholesale electricity markets.

Existing U.S. nuclear power plants are facing difficult competition from natural gas and renewable energy. Seven U.S. reactors were permanently closed from 2013 through 2018. Three of those units closed because of the need for expensive repairs, and three were operating well but could not compete in their local wholesale electricity markets. The most recent retirement was New Jersey's Oyster Creek plant, which permanently shut down September 17, 2018, to avoid having to construct a cooling tower.[4] All seven units had substantial time remaining on their initial 40-year operating licenses or had received or planned to apply for 20-year license extensions from the Nuclear Regulatory Commission (NRC). The owners of 12 additional reactors have announced that they will permanently shut down by the mid-2020s (**Table 1**). The actual and planned shutdowns have prompted widespread discussion about the future of other aging U.S. reactors.

The extent to which the growth of nuclear power should be encouraged in the United States and around the world will continue to be a major component of the U.S. energy policy debate. Questions for Congress will include the implementation of policies to encourage or discourage nuclear power, post-Fukushima safety standards, development of new nuclear power and fuel cycle technologies, and nuclear waste management strategies.

Basic Facts and Statistics

The 98 licensed nuclear power reactors at 59 sites in the United States generate about 20% of the nation's electricity. The oldest of today's operating reactors were licensed in 1969, and the most recent was Watts Bar 2 in 2015. The most recently licensed reactor before that was its twin unit, Watts Bar 1, in 1996.[5] All U.S. reactors were initially licensed to operate for 40 years, but nearly all of them have received or applied for 20-year license renewals by NRC. Under the current mixture of 40- and 60-year licenses, 28 of today's operating reactors would have to shut down by 2030 and the rest by 2049, except for the newly licensed Watts Bar 2.[6] The owners of four reactors have applied to NRC for "subsequent license renewals," which would allow operation for up to 80 years. Another four subsequent license renewal applications have been announced.[7] As noted above, 12 reactors are currently scheduled to retire before their operating licenses or renewals expire.

[4] The New Jersey Department of Environmental Protection issued an administrative consent order on December 9, 2010, allowing Oyster Creek to continue running without a cooling tower in return for an agreement by the plant's owner, Exelon, to retire the plant by the end of 2019, 10 years before the expiration of its NRC operating license. See https://www.sec.gov/Archives/edgar/data/1109357/000119312510277630/dex991.htm.

[5] Nuclear Regulatory Commission, *Information Digest, 2018–2019*, NUREG-1350, Volume 30, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/.

[6] Nuclear Regulatory Commission, "Status of Initial License Renewal Applications and Industry Initiatives," September 25, 2018, https://www.nrc.gov/reactors/operating/licensing/renewal/applications.html.

[7] Nuclear Regulatory Commission, "Status of Subsequent License Renewal Applications," July 13, 2018, https://www.nrc.gov/reactors/operating/licensing/renewal/subsequent-license-renewal.html.

Whether new reactors will be constructed to replace the existing fleet or even to expand nuclear power's market share will depend largely on costs. The cost of building and operating a new nuclear power plant in the United States is generally estimated to be significantly higher than natural gas combined-cycle plants (which use both combustion and steam turbines to generate electricity) and above wind and solar as well. For example, the Energy Information Administration (EIA) estimates that, for plants coming on line in 2022, the average cost of electricity generation from a nuclear power plant would be 9.3 cents per kilowatt-hour (kwh), while advanced combined-cycle gas-fired generation would cost 4.9 cents/kwh and a coal plant with 90% carbon capture and storage would cost 11.9 cents/kwh. EIA estimates that, including tax credits, electricity from onshore wind would cost 4.8 cents/kwh, solar photovoltaics 5.0 cents/kwh, and geothermal 4.2 cents/kwh.[8] Such estimates depend on a wide range of variables, such as future fuel costs, regional solar and wind availability, current and future tax incentives, and environmental regulations.

The two new U.S. reactors under construction at the Vogtle nuclear plant site in Georgia, after considerable construction delays and cost overruns, are now scheduled to begin operating in November 2021 and November 2022.[9] As noted above, construction of two new units in South Carolina has been terminated. Licenses to build and operate 10 additional reactors have been issued by NRC. However, applications for 14 other new reactors have been withdrawn or suspended.[10] Aside from the 2 new Vogtle units, the 10 other planned reactors with issued licenses do not have specific schedules for moving toward construction.

Throughout the world, 451 reactors are currently in service or operable, and 54 more are under construction. France is the most heavily nuclear-reliant country in the world, with 58 reactors generating 72% of the country's electricity in 2017. Thirty-one countries in 2017 (plus Taiwan) generated at least some of their electricity from nuclear power.[11]

After the Fukushima accident, Germany, which had previously generated about 30% of its electricity with nuclear power, closed 8 of the country's 17 power reactors and decided to shut the remainder by 2022. Japan, which had also generated about 30% of its electricity with nuclear power and had planned to raise that level to 50%, now is planning for about 20% by 2030. All Japanese reactors were closed within a year after the tsunami, and only 9 of Japan's 42 operable reactors are currently in commercial service. An additional 17 Japanese reactors have applied for restart, which involves safety upgrades to meet new regulatory requirements. It is not clear how many of Japan's operable reactors will ultimately seek restart approval.[12] France had planned to reduce nuclear power to 50% of the country's total generation by 2025, although that goal has been delayed.[13]

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[8] Energy Information Administration, "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018," Table 1b, March 2018, https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf. Levelized costs include capital costs averaged over the life of the plant, plus fuel and maintenance costs and tax credits.

[9] Georgia Power Company, "New Construction Milestones at Vogtle," May 16, 2018, https://www.georgiapower.com/company/plant-vogtle/vogtle-news/2018-articles/new-construction-milestones-at-vogtle.html.

[10] Nuclear Regulatory Commission, "Combined License Applications for New Reactors," April 25, 2018, https://www.nrc.gov/reactors/new-reactors/col.html.

[11] World Nuclear Association, "Nuclear Share Figures, 2007-2017," http://www.world-nuclear.org/information-library/facts-and-figures/nuclear-generation-by-country.aspx.

[12] World Nuclear Association, "Nuclear Power in Japan," September 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx.

[13] Platts Nuclear News Flashes, "France's Environment Minister Delays 2025 Target to Reduce Nuclear Share of

Major Nuclear Energy Issues

Radioactive Waste

Highly radioactive spent nuclear fuel must regularly be removed from operating reactors and stored in adjacent pools of water. After several years of cooling, the spent fuel can be placed in dry casks for storage elsewhere on the plant site. When existing U.S. reactors were built, spent fuel had been expected to be taken away for reprocessing (separation of plutonium and uranium to make new fuel) or permanent disposal. However, reprocessing has not become commercialized in the United States, for economic and nonproliferation reasons, and central waste storage and disposal facilities have proven difficult to site. As a result, the vast majority of U.S. commercial spent fuel remains at the nuclear plants where it was generated—estimated at 79,389 metric tons at the end of 2017 and increasing at the rate of about 2,000 metric tons per year.[14]

Recent Events

The Nuclear Waste Policy Act (P.L. 97-425, NWPA), as amended in 1987, named Yucca Mountain, NV, as the nation's sole candidate site for a permanent high-level nuclear waste repository. NWPA required the Department of Energy (DOE) to study the site and seek a license from NRC to build a repository there. Citing opposition from the State of Nevada, the Obama Administration decided to halt the Yucca Mountain project, and no funding has been appropriated for it since FY2010. The Trump Administration included funding to restart Yucca Mountain licensing in its FY2018 and FY2019 budget submissions to Congress, but the funding was not included in the enacted appropriations measures for either year. The House had approved the requested funding for FY2018 and $100 million more than the request for FY2019, but the Senate approved no funding either year. The enacted versions did not include the Yucca Mountain funding.

The Obama Administration appointed the Blue Ribbon Commission on America's Nuclear Future to develop an alternative nuclear waste policy, and its final report was issued in January 2012. DOE responded in January 2013 with a waste strategy that called for a "consent-based" process to select nuclear waste storage and disposal sites and for a surface storage pilot facility to open by 2021.[15] DOE issued a *Draft Consent-Based Siting Process* shortly before the end of the Obama Administration.[16]

A federal appeals court on August 13, 2013, ordered NRC to continue the Yucca Mountain licensing process with previously appropriated funds.[17] In response, NRC issued the final volumes of the Yucca Mountain Safety Evaluation Report (SER), which provided the NRC staff's

Generation," November 7, 2017.

[14] Nuclear Waste Technical Review Board, "Commercial Spent Nuclear Fuel," November 2017, p. 3, http://www.nwtrb.gov/docs/default-source/facts-sheets/commercial_snf.pdf?sfvrsn=12.

[15] DOE, *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, January 2013, http://energy.gov/sites/prod/files/2013%201-15%20Nuclear_Waste_Report.pdf.

[16] DOE, Draft Consent-Based Siting Process for Consolidated Storage and Disposal Facilities for Spent Nuclear Fuel and High-Level Radioactive Waste, January 12, 2017, https://energy.gov/sites/prod/files/2017/01/f34/Draft%20Consent-Based%20Siting%20Process%20and%20Siting%20Considerations.pdf.

[17] U.S. Court of Appeals for the District of Columbia Circuit, In re: Aiken County et al., No. 11-1271, writ of mandamus, August 13, 2013, http://www.cadc.uscourts.gov/internet/opinions.nsf/BAE0CF34F762EBD985257BC6004DEB18/$file/11-1271-1451347.pdf.

determination that the repository would meet all applicable standards. However, the staff said upon completing the SER that NRC should not authorize construction of the repository until all land and water rights requirements were met and a supplement to DOE's environmental impact statement (EIS) was completed.[18] NRC completed the supplemental EIS in May 2016 and made its database of Yucca Mountain licensing documents publicly available, using nearly all the remaining previously appropriated licensing funds.[19]

Recent Congressional Action

Nuclear Waste Policy Amendments Act of 2018 (H.R. 3053, Shimkus)

Addresses a major condition for licensing the Yucca Mountain repository by withdrawing the repository site from use under public lands laws and placing it solely under DOE's control. Would also authorize DOE to store spent fuel at an NRC-licensed interim storage facility owned by a nonfederal entity and increase the capacity limit on the Yucca Mountain repository from 70,000 to 110,000 metric tons. Introduced June 26, 2017; referred to Committees on Energy and Commerce, Natural Resources, and Armed Services. Energy and Commerce Committee ordered reported June 28, 2017, by vote of 49-4 (H.Rept. 115-355). Passed House May 10, 2018, by a vote of 340-72.

Energy and Water Development Appropriations, 2019 (H.R. 5895, Simpson)

Provides FY2019 funding for nuclear energy programs, along with water development programs and other activities. Under the Administration's FY2019 budget request, DOE would have received $120 million to seek an NRC license for the repository and to develop interim nuclear waste storage capacity. NRC would have received $47.7 million to consider DOE's application. DOE's total of $120 million in nuclear waste funding was to come from two appropriations accounts: $90 million from Nuclear Waste Disposal and $30 million from Defense Nuclear Waste Disposal. (The defense waste appropriations account would pay for defense-related nuclear waste that would be disposed of in Yucca Mountain. In the FY2019 National Defense Authorization Act, the House voted to authorize $30 million for Defense Nuclear Waste Disposal, but the Senate included no such authorization, and the Senate prevailed in conference [H.R. 5515]). In the FY2019 appropriations bill, the House voted to provide $100 million more than requested for Yucca Mountain, but the Senate approved no Yucca Mountain funding. The Senate-passed bill included an authorization for a pilot program in FY2019 to develop an interim nuclear waste storage facility at a voluntary site (§304). The enacted FY2019 appropriations measure included neither the House-passed funding for Yucca Mountain nor the Senate interim storage authorization. Introduced and reported as an original measure by the House Appropriations Committee May 21, 2018 (H.Rept. 115-697). Combined with two other appropriations bills for floor consideration and passed by the House June 6, 2018, by vote of 235-179. Senate companion bill introduced and reported by the Senate Appropriations Committee as an original measure May 24, 2018 (S. 2975, S.Rept. 115-258). Text of Senate bill substituted for text of House-passed H.R. 5895 and passed by Senate June 25, 2018, by vote of 86-5. Conference report (H.Rept. 115-929)

[18] NRC, "NRC Publishes Final Two Volumes of Yucca Mountain Safety Evaluation," news release 15-005, January 29. 2015, http://www.nrc.gov/reading-rm/doc-collections/news/2015/.

[19] NRC, Supplement to the U.S. Department of Energy's Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, NUREG-2184, Final Report, May 2016, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2184/; "NRC Staff Issues Volume 3 of Yucca Mountain Safety Evaluation Report," news release 14-069, October 16, 2014, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1949/v3/.

passed by Senate September 12, 2018, by vote of 92-5, and by House September 13, 2018, by vote of 377-20. Signed into law September 21, 2018 (P.L. 115-244).

Other Selected Legislation

Sensible Nuclear Waste Disposition Act (H.R. 433, J. Wilson)

Prohibits DOE from developing a repository only for defense nuclear waste until NRC has issued a final decision on a construction permit for the Yucca Mountain repository. Introduced January 11, 2017, referred to Committee on Energy and Commerce.

Nuclear Waste Informed Consent Act (H.R. 456, Titus/S. 95, Heller)

Requires the Secretary of Energy to obtain the consent of affected state and local governments before making expenditures from the Nuclear Waste Fund for a nuclear waste repository. Both bills introduced January 11, 2017. House bill referred to Committee on Energy and Commerce; Senate bill referred to Committee on Environment and Public Works.

Interim Consolidated Storage Act of 2017 (H.R. 474, Issa)

Authorizes DOE to enter into contracts with privately owned spent fuel storage facilities. DOE would take title to all spent nuclear fuel from commercial reactors delivered to the private storage facility. Annual interest earned by the Nuclear Waste Fund could be used by DOE without further congressional appropriation to pay for private interim storage. Introduced January 12, 2017; referred to Committee on Energy and Commerce.

Energy and Water Development Appropriations, 2018 (H.R. 3266, Simpson/S. 1609, Alexander)

Provides funding for nuclear waste and other energy programs, as well as for water development projects and various independent agencies. H.R. 3266 was reported as an original measure by the House Committee on Appropriations July 17, 2017 (H.Rept. 115-230). It was combined with four other appropriations bills into H.R. 3219 and passed by the House on July 27, 2017. That measure was then combined with the remaining eight appropriations bills for FY2018 into H.R. 3354 and passed by the House on September 14, 2017. The House-passed omnibus bills included $120 million for DOE Yucca Mountain licensing activities ($90 million under Nuclear Waste Disposal and $30 million under Defense Nuclear Waste Disposal), plus $30 million for licensing activities by NRC. The Senate Appropriations Committee provided no funding for Yucca Mountain in its version of the FY2018 Energy and Water Development Appropriations bill (S. 1609), and instead included an authorization for a pilot program to develop an interim nuclear waste storage facility at a volunteer site (§307). The Senate panel approved the measure on July 20, 2017 (S.Rept. 115-132). Energy and Water Development Appropriations were provided in Division D of the Consolidated Appropriations Act, 2018, signed March 23, 2018 (P.L. 115-141). The nuclear waste provisions in the House and Senate bills were not included.

Stranded Nuclear Waste Accountability Act of 2017 (H.R. 3929, Courtney)

Authorizes DOE to make annual payments to local governments of up to $15 per kilogram of spent nuclear fuel stored at closed nuclear power plants within the governments' jurisdiction. Introduced October 3, 2017; referred to Committee on Energy and Commerce.

Sensible, Timely Relief for America's Nuclear Districts' Economic Development (STRANDED) Act (H.R. 3970, Schneider/S. 1903, Duckworth)

For communities with closed nuclear power plants that are storing spent nuclear fuel, authorizes payments of $15 for each kilogram of nuclear waste, revives an expired tax credit for first-time homebuyers, and adds eligibility for the existing New Markets tax credit. House bill introduced October 6, 2017; referred to committees on Energy and Commerce and Ways and Means. Senate bill introduced October 2, 2017; referred to Committee on Finance.

Removing Nuclear Waste from Our Communities Act of 2017 (H.R. 4442, Lowey)

Authorizes DOE to enter into contracts to store high-level radioactive waste and spent nuclear fuel at a private-sector interim consolidated storage facility. Such storage would be deemed to satisfy DOE's contractual obligations under NWPA to take spent fuel from nuclear plant sites. Introduced November 16, 2017; referred to Committee on Energy and Commerce.

Dry Cask Storage Act of 2017/2018 (S. 1265, Markey/H.R. 4891, Engel)

Requires spent fuel at nuclear power plants to be moved from spent fuel pools to dry casks after it has sufficiently cooled, pursuant to NRC-approved transfer plans. Emergency planning zones would have to be expanded from 10 to 50 miles in radius around any reactor determined by NRC to be out of compliance with its spent fuel transfer plan. NRC would be authorized to use interest earned by the Nuclear Waste Fund to provide grants to nuclear power plants to transfer spent fuel to dry storage. Senate bill introduced May 25, 2017; referred to Committee on Environment and Public Works. House bill introduced January 29, 2018; referred to Committee on Energy and Commerce.

Jobs, Not Waste Act (H.R. 5643, Rosen)

Prohibits the Secretary of Energy from taking any action relating to the licensing, planning, development, or construction of a nuclear waste repository until the Director of the Office of Management and Budget submits to Congress a study on the economic viability and job-creating benefits of alternative uses of the Yucca Mountain site. Introduced April 26, 2018; referred to Committee on Energy and Commerce.

CRS Reports

CRS Report RL33461, *Civilian Nuclear Waste Disposal*, by Mark Holt

CRS Report R42513, *U.S. Spent Nuclear Fuel Storage*, by James D. Werner

Additional References

Commercial Spent Nuclear Fuel, Nuclear Waste Technical Review Board, November 2017, http://www.nwtrb.gov/docs/default-source/facts-sheets/commercial_snf.pdf?sfvrsn=12

Commercial Nuclear Waste: Resuming Licensing of the Yucca Mountain Repository Would Require Rebuilding Capacity at DOE and NRC, Among Other Key Steps, GAO-17-340, April 26, 2017, https://www.gao.gov/products/GAO-17-340

Report to the Secretary of Energy, Blue Ribbon Commission on America's Nuclear Future, January 2012, http://cybercemetery.unt.edu/archive/brc/20120620211605/http:/brc.gov

Managing Spent Nuclear Fuel: Strategy Alternatives and Policy Implications, RAND Corporation, 2010, http://www.rand.org/pubs/monographs/MG970.html

Disposal of High-Level Nuclear Waste, Government Accountability Office, Key Issues website, https://www.gao.gov/key_issues/disposal_of_highlevel_nuclear_waste/issue_summary

Nuclear Plant Economic Viability

U.S. nuclear power plants are facing severe financial pressure caused primarily by competition from low-cost natural gas, growing supplies of renewable energy, and stagnant electricity demand. Seven U.S. reactors were permanently closed from 2013 through 2018, and 12 more are planned for closure through the mid-2020s (**Table 1**). Plans for up to 30 new U.S. reactors announced during the past 10 years have largely been put on hold, with only 2 currently under construction.

In light of that situation, Congress is considering whether federal action is needed to keep the existing nuclear fleet operating and to encourage the construction of new reactors. A key element of that debate is the appropriate role of nuclear power, if any, in meeting national energy and environmental goals. Nuclear power supporters generally point to the technology as crucial for providing a secure, domestic source of energy with low greenhouse gas and other emissions. Opponents generally counter that safety and proliferation risks, nuclear waste hazards, and high costs outweigh those benefits.

Potential mechanisms for increased federal support of nuclear power include loan guarantees, tax credits, clean energy mandates, emissions credits, and electricity market regulations.

Some states have taken action to prevent nuclear plant closures. New York and Illinois provided "zero emission credits" to seven reactors that had been at risk of retirement by 2018.[20] Connecticut enacted legislation in 2017 to make nuclear reactors eligible for a state procurement process for zero-emission electricity sources, upon certification of financial need. New Jersey enacted zero-emission credits for nuclear power in 2018.[21]

Table 1. Announced U.S. Commercial Reactor Shutdowns

Reactor	State	Shutdown Date	Net Summer Generating Capacity (Megawatts)	Start-Up Year	Major Factors Contributing to Shutdown
Pilgrim	Massachusetts	May 2019	685	1972	Operating losses, rising capital expenditures
Three Mile Island 1	Pennsylvania	October 2019	803	1974	Operating losses

[20] *Zero-Emission Credits*, Nuclear Energy Institute, April 2018, https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/zero-emission-credits-201804.pdf.

[21] *Solutions for Maintaining the Existing Nuclear Fleet*, Center for Climate and Energy Solutions, May 2018, https://www.c2es.org/site/assets/uploads/2018/05/solutions-for-maintaining-existing-nuclear-fleet.pdf.

Reactor	State	Shutdown Date	Net Summer Generating Capacity (Megawatts)	Start-Up Year	Major Factors Contributing to Shutdown
Indian Point 2	New York	April 30, 2020	1,020	1974	Low electricity prices; settlement with state
Davis-Besse	Ohio	May 31, 2020	894	1978	Operating losses
Duane Arnold	Iowa	Late 2020	601	1975	Lower-cost alternative power
Indian Point 3	New York	April 30, 2021	1,035	1976	Low electricity prices; settlement with state
Perry	Ohio	May 31, 2021	1,240	1987	Operating losses
Beaver Valley 1	Pennsylvania	May 31, 2021	892	1976	Operating losses
Beaver Valley 2	Pennsylvania	October 31, 2021	885	1987	Operating losses
Palisades	Michigan	April 2022	784	1971	Operating losses, end of power purchase agreement
Diablo Canyon 1	California	November 2024	1,122	1985	Settlement with labor and environmental groups
Diablo Canyon 2	California	August 2025	1,118	1986	Settlement with labor and environmental groups

Source: Company news releases.

Recent Events

Energy Secretary Rick Perry submitted a proposed regulation to the Federal Energy Regulatory Commission (FERC) on October 10, 2017, to ensure that coal and nuclear power plants could recover their costs in wholesale power markets. To be eligible for cost recovery, power plants would be required to "have a 90-day fuel supply on site in the event of supply disruptions caused by emergencies, extreme weather, or natural or man-made disasters," a criterion that coal and nuclear plants would typically meet.[22] DOE contended that such plants were crucial in ensuring the resilience of the bulk power system. FERC rejected the proposal on January 8, 2018, but initiated a new proceeding to evaluate bulk power system resilience.[23] President Trump directed

[22] Department of Energy, *Grid Resiliency Pricing Rule*, Notice of Proposed Rulemaking, October 10, 2017, 82 *Federal Register* 46940, https://www.gpo.gov/fdsys/pkg/FR-2017-10-10/pdf/2017-21396.pdf.

[23] Federal Energy Regulatory Commission, "Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures," January 8, 2018, https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf.

Perry on June 1, 2018, to recommend additional actions to prevent "impending retirements of fuel-secure power facilities," such as coal and nuclear power plants.[24]

Federal tax credits for electricity production from new nuclear plants were extended by the Bipartisan Budget Act of 2018 (P.L. 115-123), signed into law February 9, 2018. Before the extension, new nuclear plants had been required to begin operation before January 1, 2021, to qualify for the production tax credit, which is limited to 6,000 megawatts of total generating capacity. The extension allows new reactors to use the credit after that date if the capacity limit has not been reached. Along with the extension, the tax credit was modified to allow non-taxpaying partners in a nuclear project, such as public power agencies, to transfer their credits to a project's taxpaying partners. Only two U.S. reactors are currently under construction, at the Vogtle nuclear power plant in Georgia, totaling about 2,300 megawatts of capacity, well within the limit. Construction delays have pushed the planned completion dates of the new Vogtle reactors beyond the 2021 deadline, and the production tax credits are widely considered crucial for their financial viability.

Georgia Power, the lead partner in the Vogtle consortium, announced August 8, 2018, that its share of the estimated construction cost of the two new reactors had risen from $7.3 billion to $8.4 billion.[25] That estimate does not include costs covered by Georgia Power's $1.7 billion share of a Westinghouse contract settlement and $188 million in customer refunds. Adding those amounts brings the Georgia Power construction share to about $10.3 billion.[26] With Georgia Power holding a 45.7% share of the project, the total construction cost of the new reactors is estimated to be about $22.5 billion, or $11.25 billion per reactor.

The two new reactors at the Vogtle plant received loan guarantees from DOE totaling $8.33 billion, as authorized by Title 17 of the Energy Policy Act of 2005 (P.L. 109-58). Energy Secretary Ernest Moniz announced the issuance of $6.5 billion in loan guarantees on February 19, 2014, to two of the three utility partners in the project, Georgia Power and Oglethorpe Power. The final $1.8 billion loan guarantee for another partner, Municipal Electric Authority of Georgia, was issued June 24, 2015.

Energy Secretary Rick Perry announced a conditional commitment for an additional $3.7 billion in loan guarantees to the three partners in the Vogtle project on September 29, 2017.[27] However, the Trump Administration has proposed to rescind DOE's authority to issue further Title 17 loan guarantees in FY2019. The loan guarantee rescission was not included in the FY2019 Energy and Water Development Appropriations Act (P.L. 115-244, Division A), and Congress did not approve a similar rescission request for FY2018. No other proposed nuclear plants have received any commitments for DOE loan guarantees.

DOE's Light Water Reactor Sustainability Program manages cost-shared research projects "to solve significant highest priority cost and technical problems threatening existing plants."[28] The

[24] White House, "Statement from the Press Secretary on Fuel-Secure Power Facilities," June 1, 2018, https://www.whitehouse.gov/briefings-statements/statement-press-secretary-fuel-secure-power-facilities.

[25] Georgia Power, "Significant Progress Made on Vogtle 3 & 4 Construction," press release, August 8, 2018, https://www.georgiapower.com/company/news-center/press-releases.html.

[26] Securities and Exchange Commission, Form 10-Q for quarter ending June 30, 2018, The Southern Company and related corporations, August 8, 2018, p. 17, available at https://investor.southerncompany.com/information-for-investors/investor-information/sec-filings/default.aspx.

[27] Department of Energy, "Secretary Perry Announces Conditional Commitment to Support Continued Construction of Vogtle Advanced Nuclear Energy Project," news release, September 29, 2017, https://energy.gov/articles/secretary-perry-announces-conditional-commitment-support-continued-construction-vogtle.

[28] Department of Energy, "Reactor Technology Program Overview," presentation by R. Shane Johnson, Deputy

program includes research on materials used in nuclear plants, modeling of plant aging, and plant upgrades. The Trump Administration had proposed cutting the program's funding by more than half for FY2019, but P.L. 115-244 continued its $47 million annual appropriation.

Federal policy on carbon dioxide emissions could also have a significant impact on the expansion of nuclear power and the economic viability of existing reactors. Under the Trump Administration, the Environmental Protection Agency is proposing to repeal the Obama Administration's Clean Power Plan regulations,[29] which require states to reduce carbon dioxide emissions from existing power plants. Nuclear power would be a potential element in state plans for meeting the Clean Power Plan standards.

Selected Congressional Action

Nuclear Utilization of Keynote Energy Act (H.R. 1320, Kinzinger)

Caps annual fees assessed by NRC on nuclear power plants and other licensees at their FY2015 levels, adjusted for inflation, unless higher fees are necessary to avoid compromising the NRC' safety and security mission. NRC would be required to limit corporate support costs to specified percentages of its total annual budget request, declining to a maximum of 28% in FY2025 and thereafter. Establishes "streamlining" requirements for NRC review of nuclear power plant license applications and establishes deadlines. Introduced March 2, 2017; referred to Committee on Energy and Commerce. Approved by Committee by voice vote July 12, 2018 (H.Rept. 115-924).

Nuclear Energy Innovation and Modernization Act (S. 512, Barrasso)

Includes a provision that caps NRC fees on operating commercial reactors at the FY2015 level, adjusted for inflation, unless higher fees are necessary to avoid compromising the NRC's safety and security mission. NRC would be required to limit its requests for corporate support costs to 28% of its total budget after FY2023. Introduced March 2, 2017; referred to Committee on Environment and Public Works. Approved by committee March 22, 2017 (S.Rept. 115-86).

Biennial Commission on Energy Policy Act of 2017 (H.R. 4228, McKinley)

Establishes a commission to "analyze the accessibility, affordability, reliability, resiliency, and sustainability of the energy sources in the United States, including coal, oil, natural gas, wind, solar, nuclear, hydropower, geothermal, and biofuels," among other tasks. Introduced November 3, 2017; referred to Committee on Energy and Commerce.

Nuclear Powers America Act of 2018 (H.R. 5732, LaHood)

Establishes a tax credit for investments in nuclear energy plants placed in service before January 1, 2024, and that have submitted license extensions to NRC before January 1, 2024, or have certified to DOE that extensions will be submitted by that date. Introduced May 9, 2018; referred

Assistant Secretary for Nuclear Technology Demonstration and Deployment, to the Nuclear Energy Advisory Committee, July 9, 2018, https://www.energy.gov/sites/prod/files/2018/07/f53/RSJ%20Brief%20to%20NEAC%20-%20July%209%202018_0.pdf.

[29] Environmental Protection Agency, "EPA Takes Another Step to Advance President Trump's America First Strategy, Proposes Repeal of 'Clean Power Plan,'" news release, October 10, 2017, https://www.epa.gov/newsreleases/epa-takes-another-step-advance-president-trumps-america-first-strategy-proposes-repeal.

to Committee on Ways and Means. Related to Nuclear Powers America Act of 2017 (H.R. 4614, Meehan), introduced December 11, 2017, and referred to Committee on Ways and Means.

Advancing U.S. Civil Nuclear Competitiveness and Jobs Act (H.R. 6351, Bill Johnson)

Requires DOE to conduct a study of "current legal, regulatory, policy, and commercial practices of the United States with respect to the civilian nuclear industry of the United States" and "the impacts of such practices on such civilian nuclear industry in the United States and in international markets." Introduced July 12, 2018, referred to committees on Foreign Affairs and Energy and Commerce; ordered reported by Energy and Commerce July 18, 2018, by vote of 33-16.

Nuclear Energy Leadership Act (S. 3422, Murkowski)

Requires DOE to enter into at least one agreement to purchase power from a commercial nuclear reactor by the end of 2023. The maximum length of federal power purchase agreements would be extended from 10 years to 40 years. Requires DOE to prepare a 10-year strategic plan for the Office of Nuclear Energy. Introduced September 9, 2018; referred to Committee on Energy and Natural Resources.

Troubled Nuclear Power Plants Communities Assistance Act (H.R. 6814, Kaptur)

Requires DOE to establish a program to provide financial assistance to units of local government who have experienced, or are predicted to experience, a reduction in tax revenue from "troubled" nuclear power plants. Introduced September 13, 2018; referred to Committee on Energy and Commerce.

Legislative Hearing: Nuclear Energy and Modernization Act, S. 512

Hearing by the Senate Committee on Environment and Public Works, March 8, 2017, on S. 512, described above. Witnesses included representatives from the nuclear industry, the Government Accountability Office, and environmental groups. Video, written statements, and other material can be found at https://www.epw.senate.gov/public/index.cfm/hearings?ID=004FC325-6ED4-433F-8E39-D5735FD2E7AA.

Legislative Hearing: Nuclear Utilization of Keynote Energy Act, H.R. 1320, and draft nuclear bills

Hearing by the House Energy and Commerce Committee Subcommittee on Energy, May 22, 2018, on H.R. 1320, described above, and draft bills on nuclear energy competitiveness and advanced nuclear technology. Witnesses included DOE officials and representatives of industry and environmental groups. Video, transcript, witness statements, draft bill text, and other materials can be found at https://energycommerce.house.gov/hearings/doe-modernization-legislation-addressing-development-regulation-and-competitiveness-of-advanced-nuclear-energy-technologies/.

CRS Reports

CRS Report R44715, *Financial Challenges of Operating Nuclear Power Plants in the United States*, by Phillip Brown and Mark Holt

CRS Insight IN10806, *DOE's Grid Resiliency Pricing Rule*, by Richard J. Campbell

CRS Insight IN10813, *Energy Tax Provisions in the Tax Cuts and Jobs Act (H.R. 1)*, by Molly F. Sherlock and Joseph S. Hughes

CRS Insight IN10750, *Rising Costs and Delays Doom New Nuclear Reactors in South Carolina*, by Mark Holt

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The Nuclear Power Dilemma: Declining Profits, Plant Closures, and the Threat of Rising Carbon Emissions, Union of Concerned Scientists, November 2018, https://www.ucsusa.org/sites/default/files/attach/2018/11/Nuclear-Power-Dilemma-full-report.pdf

Promising Market and Federal Solutions for Existing Nuclear Power, Center for Climate and Energy Solutions, October 2018, https://www.c2es.org/document/promising-market-and-federal-solutions-for-existing-nuclear-power/

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Economic and Market Challenges Facing the U.S. Nuclear Commercial Fleet—Cost and Revenue Study, Idaho National Laboratory, September 2017, https://gain.inl.gov/SiteAssets/Teresa/Market%20Challenges%20for%20Nuclear%20Fleet-ESSAI%20Study%20Sept2017.pdf

Keeping the Lights on at America's Nuclear Power Plants, Jeremy Carl and David Fedor, Shultz-Stephenson Task Force on Energy Policy, Hoover Institution Press, 2017

Advanced Nuclear Technology

Existing commercial nuclear power plants in the United States are based on light water reactor (LWR) technology, in which ordinary (light) water is used to cool the reactor and to moderate, or slow, the neutrons in the nuclear chain reaction. The federal government developed LWRs for naval propulsion in the 1950s and funded the commercialization of the technology for electricity generation. DOE and its predecessor agencies for decades have also conducted research on "advanced" reactor technologies that use different coolants and moderators, as well as fast neutron reactors that have no moderator. Proponents of advanced reactors contend that they would be safer, more efficient, and less expensive to build and operate than today's conventional LWRs. Some concepts are also intended to produce less long-lived radioactive waste than existing reactors, such as by separating the uranium, plutonium, and other elements in spent nuclear fuel and then using long-lived elements as new fuel for fast reactors.

Another characteristic of advanced reactors is that they are generally planned to be far smaller than today's commercial LWRs, which average about 1,000 megawatts (MW) of electric generating capacity. Most proposed advanced reactors would be considered "small modular reactors" (SMRs), which DOE defines as having generating capacity of 300 MW or below. SMRs using LWR technology are also being designed. Supporters of SMRs contend that they would be small enough to be assembled in factories and shipped to reactor sites to reduce construction costs. In addition, SMRs could reduce the financial risks of building a new nuclear power plant, because each module would cost less than today's large reactors and revenues could begin when the first module was complete, rather than after completion of a much larger unit. However, some

analysts contend that SMRs would be too small to achieve the economies of scale needed for economic viability.[30]

Recent Events

Legislation to stimulate the development of advanced nuclear technology, the Nuclear Energy Innovation Capabilities Act of 2017, was signed by the President on September 28, 2018 (P.L. 115-248). Key provisions authorize the construction of demonstration reactors funded by the private sector at DOE sites, authorize DOE to construct a "versatile" test reactor for advanced nuclear fuels and materials, and authorize grants to help pay for advanced reactor licensing. Other legislation (not included in P.L. 115-248) would require NRC to develop a new licensing framework for advanced nuclear technology. Proponents contend that NRC's existing licensing system is too focused on LWR technology and would potentially cause delays in non-LWR applications.

DOE's nuclear energy research and development program includes reactor modeling and simulation, experimental processing of spent nuclear fuel, development of advanced reactor concepts, and testing of "accident tolerant fuel" for existing LWRs. The Trump Administration proposed reducing the nuclear R&D budget by 37.2% in FY2019 from the FY2018 funding level—from $1.205 billion to $757 million. Nuclear R&D funding for FY2019 is included in a bill that combines the annual Energy and Water Development Appropriations bill with two other appropriations bills (H.R. 5895), as described above. The House-passed version of the bill would have increased nuclear R&D by 11.7% over the FY2018 level, while the Senate voted to provide nearly flat funding. The enacted FY2019 funding measure (P.L. 115-244) provided $1.35 billion for nuclear energy, 10% above the FY2018 level. The conference report (H.Rept. 115-929) directs DOE to prepare a report on producing high-assay, low enriched uranium (HA-LEU) for advanced reactors and authorizes expenditures of up to $20 million in preparation and testing for HA-LEU production. It also includes $65 million "for research and development to support efforts to develop a versatile fast test reactor."

Selected Congressional Action

Nuclear Energy Innovation Capabilities Act (H.R. 431, Weber/S. 97, Crapo)

Requires the Department of Energy to support development of nuclear fission and fusion technologies through computer modeling and simulation, and through testing and demonstration at DOE national laboratories and other sites. The Secretary of Energy would determine the need for a reactor-based fast neutron source, as described above. Bills introduced January 11, 2017; referred to House Committee on Science, Space, and Technology and Senate Committee on Energy and Natural Resources. Included as Title IV of the Department of Energy Research and Innovation Act (H.R. 589), passed by the House under suspension of the rules January 24, 2017, and passed by the Senate July 23, 2018, without the nuclear provisions. S. 97 was passed by the Senate committee June 21, 2017 (S.Rept. 115-115), and by the Senate March 7, 2018, by voice vote. Passed House under suspension of the rules September 13, 2018, and signed into law September 28, 2018 (P.L. 115-248).

[30] Deign, Jason, "Interest in Small Modular Nuclear Reactors Is Growing. So Are Fears They Aren't Viable," Greentech Media, March 14, 2018, https://www.greentechmedia.com/articles/read/interest-in-small-modular-nuclear-grows#gs.ph5LRao.

Advanced Nuclear Technology Development Act of 2017 (H.R. 590, Latta)

Requires NRC and DOE to enter into a memorandum of understanding to provide technical and licensing support for civilian advanced reactor projects, including advanced reactor modeling and simulation and access to DOE research facilities. NRC would be required to develop a regulatory framework for advanced reactor licensing and include the status of advanced reactor design certification applications in its annual budget requests to Congress. The nuclear industry would not have to pay fees to cover NRC's costs for developing an advanced reactor regulatory infrastructure. Introduced January 20, 2017; referred to committees on Energy and Commerce and Science, Space, and Technology. Passed by House under suspension of the rules January 23, 2017. Referred to Senate Committee on Environment and Public Works.

Nuclear Energy Innovation and Modernization Act (S. 512, Barrasso)

Includes requirements for NRC to create a new licensing framework for advanced reactor technologies. This would include a staged licensing process that would allow applicants to use NRC approval at each stage to help attract private-sector investment to move to the next stage. A DOE cost-sharing program for advanced reactor license applicants would also be authorized. Introduced March 2, 2017; referred to Committee on Environment and Public Works. Approved by committee March 22, 2017 (S.Rept. 115-86).

Nuclear Utilization of Keynote Energy Act (H.R. 1320, Kinzinger)

Exempts NRC expenditures on developing a regulatory framework for advanced nuclear reactors from fee recovery requirements, which generally require the nuclear industry to pay for 90% of NRC's costs. Introduced March 2, 2017; referred to Committee on Energy and Commerce. Approved by Committee by voice vote July 12, 2018 (H.Rept. 115-924).

Energy and Natural Resources Act of 2017 (S. 1460, Murkowski)

Includes authorization of DOE nuclear energy research and development programs, including modeling and simulation. DOE would determine the need for a fast neutron research reactor. Construction and operation of privately funded experimental reactors would be authorized at DOE sites. NRC would be required to develop a new regulatory framework for advanced reactors. Introduced June 28, 2017; placed on the Senate Legislative Calendar. Hearings held September 19, 2017.

Advanced Nuclear Energy Technologies Act (S. 1457, Flake/H.R. 5260, Higgins)

Requires DOE to enter into agreements to conduct at least four advanced reactor demonstration projects by 2028. The projects could include cost-sharing with private-sector partners to conduct work at DOE sites, such as national laboratories. Senate bill introduced October 3, 2017; referred to Committee on Energy and Natural Resources. Approved by committee May 21, 2018 (S.Rept. 115-251). House bill introduced March 13, 2018; referred to Committee on Science, Space, and Technology.

Nuclear Energy Research Infrastructure Act of 2017 (H.R. 4378, Weber)

Authorizes DOE to construct a fast neutron research reactor by the end of 2025. Introduced November 13, 2017; referred to Committee on Science, Space, and Technology. Approved by committee November 15, 2017 (H.Rept. 115-557). Passed House by voice vote under suspension of the rules February 13, 2018. Referred to Senate Committee on Energy and Natural Resources. As noted above, the FY2019 Energy and Water Development Appropriations Act (P.L. 115-244, Division A) includes $65 million for research to support development of a versatile fast test reactor.

Advanced Nuclear Fuel Availability Act (H.R. 6140, Flores)

Requires DOE to carry out a program to support the availability of high-assay, low enriched uranium (HA-LEU) for use in commercial advanced reactors. HA-LEU would have enrichment above 5% uranium-235, as used by existing commercial reactors, but below the 20% level of highly enriched uranium. Introduced June 19, 2018; referred to Committee on Energy and Commerce. Ordered reported by voice vote July 12, 2018. As noted above, the FY2019 Energy and Water Development Appropriations Act (P.L. 115-244, Division A) includes $20 million for HA-LEU preparation and testing.

Nuclear Energy Leadership Act (S. 3422, Murkowski)

Requires DOE to enter into at least one agreement to purchase power from a commercial nuclear reactor by the end of 2023. The maximum length of federal power purchase agreements would be extended from 10 years to 40 years. Requires DOE to prepare a 10-year strategic plan for the Office of Nuclear Energy. Introduced September 9, 2018; referred to Committee on Energy and Natural Resources.

Legislative Hearing: Nuclear Energy and Modernization Act, S. 512

Hearing by the Senate Committee on Environment and Public Works on S. 512, described above, March 8, 2017. Witnesses included representatives from the nuclear industry, the Government Accountability Office, and environmental groups. Video, written statements, and other material can be found at https://www.epw.senate.gov/public/index.cfm/hearings?ID=004FC325-6ED4-433F-8E39-D5735FD2E7AA.

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CRS Insight IN10765, *Small Modular Nuclear Reactors: Status and Issues*, by Mark Holt

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Examination of Federal Financial Assistance in the Renewable Energy Market: Implications and Opportunities for Commercial Deployment of Small Modular Reactors, Scully Capital and Kutak Rock for the U.S. Department of Energy, October 2018, https://www.energy.gov/ne/downloads/report-examination-federal-financial-assistance-renewable-energy-market

Advanced Nuclear 101, Third Way, December 1, 2015, http://www.thirdway.org/report/advanced-nuclear-101

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Leading on SMRs, Nuclear Innovation Alliance, October 2017, https://docs.wixstatic.com/ugd/5b05b3_d163208371134cc590a234100429a6fd.pdf

Strategies for Advanced Reactor Licensing, Nuclear Innovation Alliance, April 2016, https://docs.wixstatic.com/ugd/5b05b3_71d4011545234838aa27005ab7d757f1.pdf

Safety

The 2011 Fukushima Dai-ichi nuclear plant disaster in Japan, triggered by a huge earthquake and tsunami, greatly increased concerns about safety in the nuclear policy debate. The accident clearly demonstrated the potential consequences of a total loss of power (or "station blackout") at today's commercial nuclear plants. Even when a reactor shuts down, as did the Fukushima plant after the initial earthquake, residual radioactivity in the reactor core continues to generate "decay heat" that must be removed, typically by electrically driven or controlled cooling systems.

When the tsunami knocked out power at the three Fukushima Dai-ichi reactors that had been operating when the earthquake struck, the buildup of heat and pressure from residual radioactivity became so great that it melted the reactors' nuclear fuel and exceeded the limits of their containment structures. The decay heat also caused steam to chemically react with the nuclear fuel cladding in the reactor cores, generating additional heat along with hydrogen that escaped into the upper part of the reactor buildings and exploded. Cooling was also lost in Fukushima's spent fuel storage pools, causing concern that they could overheat, although later examination indicated that they did not.

Safety requirements for nuclear power plants are established and enforced in the United States by NRC, an independent regulatory agency. NRC safety regulations address the effects of external events such as earthquakes and floods, equipment failure such as breaks in coolant pipes, and other problems that could lead to radioactive releases into the environment. Critics of nuclear power contend that NRC is often reluctant to impose necessary safety requirements that would be costly or disruptive to the nuclear industry. However, the industry has frequently contended that costly safety proposals are unnecessary and would not significantly increase large existing safety margins.

Recent Events

Following the Fukushima disaster, NRC established a task force to identify lessons applicable to U.S. reactors and recommend safety improvements. The task force's report led to NRC's first Fukushima-related regulatory requirements, on March 12, 2012. NRC ordered all reactors to develop strategies to maintain cooling and containment integrity during external events, such as floods and earthquakes, that were more severe than anticipated by the plants' designs ("beyond design basis"). In addition, NRC required that U.S. reactors of similar design to the Fukushima reactors have "reliable hardened vents" to remove excess pressure from their primary containments, and that better instrumentation be installed to monitor the condition of spent fuel pools during accidents.[31] The NRC commissioners on March 19, 2013, required NRC staff to study whether to require the newly mandated containment vents to include filters or other means

[31] Nuclear Regulatory Commission, "Actions in Response to the Japan Nuclear Accident: March 12, 2012," updated May 30, 2012, http://www.nrc.gov/reactors/operating/ops-experience/japan/timeline/03122012.html.

to reduce the release of radioactive material if the vents have to be used. The idea of requiring filters had drawn praise from nuclear critics but opposition from the industry on cost grounds.[32] NRC voted on August 19, 2015, not to proceed with rulemaking on filtered vents.[33] U.S. nuclear power plants are continuing to implement NRC's post-Fukushima regulations and orders.[34]

Selected Congressional Action

Hudson River Protection Act (H.R. 1504, Sean Patrick Maloney)

Prohibits the establishment of anchorage grounds for vessels carrying hazardous or flammable cargo within five miles of a nuclear power plant and other designated facilities. Introduced March 10, 2017; referred to Committee on Transportation and Infrastructure.

Nuclear Plant Decommissioning Act of 2018 (S. 2388, Sanders/H.R. 4975, Welch)

Requires nuclear reactor owners to consult with affected state, local, and tribal governments before submitting reactor decommissioning (permanent shutdown) plans to NRC. NRC would have a 90-day period to solicit public comments and hold meetings about decommissioning plans after they were submitted. NRC would have to include any change recommended by the host state in a reactor decommissioning plan unless the change violated a law or if the costs of the change outweighed its safety, economic, or environmental benefits. Senate bill introduced February 7, 2018; referred to Committee on Environment and Public Works. House bill introduced February 9, 2018; referred to Committee on Energy and Commerce.

Low-Dose Radiation Research Act of 2018 (H.R. 4675, Marshall)

Authorizes a DOE research program on the effects of exposure to low-dose radiation. Introduced December 18, 2017; referred to Committee on Science, Space, and Technology. Approved by Committee February 13, 2018 (H.Rept. 115-554). Passed House by voice vote under suspension of the rules February 13, 2018.

CRS Reports

CRS Report R41694, *Fukushima Nuclear Disaster*, by Mark Holt, Richard J. Campbell, and Mary Beth D. Nikitin

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Nuclear Power Accidents, Union of Concerned Scientists, web page, https://www.ucsusa.org/nuclear-power/nuclear-power-accidents#.W2RshNJKiUk

[32] NRC, "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments," staff requirements memorandum, SECY-12-0157, March 19, 2013, http://www.nrc.gov/reading-rm/doc-collections/commission/srm/2012/2012-0157srm.pdf; Freebairn, William, "NRC Staff Recommends Ordering Filtered Vents for 31 Power Reactors," *Inside NRC*, November 5, 2012, p. 1.

[33] NRC, "Hardened Vents and Filtration (for Boiling Water Reactors with Mark I and Mark II containment designs)," http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/hardened-vents.html.

[34] NRC, "Plant-Specific Japan Lessons-Learned Activities," August 13, 2018, https://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/japan-plants.html.

What Are the Lessons Learned from Fukushima?, Nuclear Regulatory Commission, web page, reviewed/updated May 8, 2018, http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/priorities.html

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State-of-the-Art Reactor Consequence Analyses (SOARCA) Report, Nuclear Regulatory Commission, NUREG-1935, November 2012, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1935

Security and Emergency Response

The level of security that must be provided at nuclear power plants has been a high-profile issue since the 9/11 terrorist attacks on the United States in 2001. Since those attacks, NRC issued a series of orders and regulations that substantially increased nuclear plant security requirements, although industry critics contend that those measures are still insufficient. Key measures include an increase in the level of attacks that nuclear plant security forces must be able to repel, requirements for mitigating the effects of large fires and explosions, and a requirement that new reactors be capable of withstanding aircraft crashes without releasing radioactive material. NRC also modified its planning requirements for evacuations and other emergency responses after the 9/11 attacks, and the Fukushima disaster illustrated the importance of emergency response to radioactive releases from any cause.

NRC issued wide-ranging revisions to its emergency preparedness regulations on November 1, 2011, dealing with duties of emergency personnel and the inclusion of hostile actions in emergency planning drills.[35] In response to Fukushima, NRC staff recommended that nuclear emergency plans be required to address events affecting multiple reactors and prolonged station blackout. NRC told nuclear power plants on March 12, 2012, to provide specific information and analysis on those issues.[36]

The NRC Cyber Security Directorate was established in June 2013 to coordinate rulemaking, guidance, and oversight of cybersecurity at nuclear power plants and other regulated nuclear facilities. As part of the Directorate, NRC's Cyber Assessment Team responds to cybersecurity events at NRC-licensed facilities and coordinates threat assessments with other federal agencies.[37]

Recent Events

NRC issued a draft final rule June 7, 2018, on "Enhanced Weapons, Firearms Background Checks, and Security Event Notifications."[38] The draft final rule, which is awaiting Commission approval, would establish procedures for nuclear power plants and other licensed nuclear

[35] NRC, "Enhancements to Emergency Preparedness Regulations," final rule, *Federal Register*, November 23, 2011, p. 72560.

[36] NRC, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," March 12, 2012, http://pbadupws.nrc.gov/docs/ML1205/ML12053A340.pdf.

[37] NRC, "Backgrounder on Cyber Security," October 2016, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/cyber-security-bg.html.

[38] NRC, "Enhanced Weapons, Firearms Background Checks, and Security Event Notifications," draft final rule, SECY-18-0058, June 7, 2018, https://www.nrc.gov/docs/ML1626/ML16264A000.html.

facilities to apply for NRC authorization to arm their security personnel with "enhanced" weapons, such as semiautomatic assault weapons and machine guns, despite any state laws prohibiting such weapons. NRC is authorized to preempt state laws for this purpose under Atomic Energy Act Section 161A, enacted by the Energy Policy Act of 2005 (P.L. 109-58). The draft final rule would also modify NRC requirements for nuclear power plants and other licensed facilities to report events related to physical security and would add requirements for reporting suspicious activities.

Selected Congressional Action

Promoting Resilience and Efficiency in Preparing for Attacks and Responding to Emergencies Act (H.R. 2922, Donovan)

Requires the Department of Homeland Security to develop and maintain a medical countermeasures stockpile for nuclear and other types of attacks and disasters, among other provisions. Introduced June 28, 2017; referred to Committees on Homeland Security; Transportation and Infrastructure; and Energy and Commerce.

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CRS In Focus IF10821, *Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases*, by Mark Holt

CRS Report RL34331, *Nuclear Power Plant Security and Vulnerabilities*, by Mark Holt

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Protecting Our Nation, Nuclear Regulatory Commission, NUREG/BR-0314, Rev. 4, August 2015, https://www.nrc.gov/docs/ML1523/ML15232A263.pdf

Backgrounder on Nuclear Security, Nuclear Regulatory Commission, web page, last reviewed/updated December 12, 2014, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.html

Nuclear Weapons Nonproliferation

Encouraging exports of U.S. civilian nuclear products, services, and technology while making sure they are not used for foreign nuclear weapons programs has long been a fundamental goal of U.S. nuclear energy policy. Section 123 of the Atomic Energy Act requires that any country receiving U.S. nuclear technology, equipment, or materials implement a peaceful nuclear cooperation agreement with the United States. These so-called 123 agreements are intended to ensure that U.S. nuclear cooperation with other countries does not result in the production of weapons materials or otherwise encourage the proliferation of nuclear weapons. Section 123 allows nuclear cooperation agreements to take effect after 90 days of continuous congressional session if they adhere to specified criteria.

International controls and inspections are intended to ensure the peaceful use of civilian nuclear facilities and prevent the proliferation of nuclear weapons. However, recent proposals to build

nuclear power plants in as many as 18 countries[39] that have not previously used nuclear energy, including several in the Middle East and elsewhere in the less developed world, have prompted concerns that international controls may prove inadequate. Numerous recommendations have been made in the United States and elsewhere to create new incentives for nations to forgo the development of uranium enrichment and spent nuclear fuel reprocessing facilities that could produce weapons materials as well as civilian nuclear fuel.

Recent Events

Iran's nuclear energy program is a major example of the tension between peaceful and weapons uses of nuclear technology. Longstanding world concern had focused on the Iranian uranium enrichment program, which Iran contended was solely for peaceful purposes but which the United States and other countries suspected was for producing weapons material. The U.N. Security Council had imposed sanctions and passed several resolutions calling on Iran to suspend its enrichment program and other sensitive nuclear activities. Iran finalized the Joint Comprehensive Plan of Action (JCPOA) on July 14, 2015, with the United States and five major European countries to lift the U.N. sanctions in return for specified Iranian actions to preclude nuclear weapons development. President Trump strongly criticized the JCPOA during the 2016 presidential campaign and announced on May 8, 2018, that the Administration would cease implementing the agreement and reimpose sanctions. Other parties to the JCPOA have pledged to continue abiding by it, however.[40]

Recent extensions of U.S. peaceful nuclear cooperation agreements with China and South Korea generated controversy but no congressional action to block them. During negotiations on the U.S.-South Korea nuclear cooperation extension, which entered into force November 25, 2015, South Korea had sought advance U.S. consent for spent fuel reprocessing and uranium enrichment. The United States did not provide such consent, on general nonproliferation grounds and because such consent could affect other ongoing issues on the Korean peninsula. The new agreement does, however, establish a bilateral "high level commission" to further consider those issues. The extension of the U.S.-China peaceful nuclear cooperation agreement includes advance consent for reprocessing and enrichment, which raised some controversy, although both countries are internationally recognized nuclear weapons states. The agreement with China entered into force after the mandatory congressional review period ended on July 31, 2015.

Japan's longstanding nuclear cooperation agreement with the United States automatically renewed on July 17, 2018, and will remain in force indefinitely unless terminated by either side.[41] The agreement allows Japan to reprocess spent nuclear fuel from its U.S.-designed reactors, separating plutonium and uranium for use in new fuel. A commercial reprocessing plant at Rokkasho is scheduled to be completed in 2021.[42] Some nuclear nonproliferation groups had urged the United States to use the renewal of the U.S.-Japan nuclear cooperation agreement as an opportunity to urge Japan not to begin its reprocessing program. They noted that Japan already

[39] World Nuclear Association, "World Nuclear Power Reactors and Uranium Requirements," November 2018, http://www.world-nuclear.org/info/reactors.html.

[40] European Union, "Joint Statement on the Re-imposition of U.S. Sanctions Due to its Withdrawal from the Joint Comprehensive Plan of Action (JCPOA)," June 8, 2018, https://eeas.europa.eu/headquarters/headquarters-homepage/49141/joint-statement-re-imposition-us-sanctions-due-its-withdrawal-joint-comprehensive-plan-action_en.

[41] U.S. Department of State, "U.S. Bilateral Agreements For Peaceful Nuclear Cooperation Pursuant to Section 123 of the U.S. Atomic Energy Act of 1954, As Amended," January 20, 2017, https://www.state.gov/t/isn/rls/fs/2017/266975.htm.

[42] Japan Nuclear Fuel Limited, "Reprocessing," October 31, 2018, https://www.jnfl.co.jp/en/business/reprocessing.

has substantial stockpiles of previously separated plutonium that could potentially be used for weapons as well as reactor fuel.[43] Japan approved a new Strategic Energy Plan July 3, 2018, that includes a pledge to reduce Japanese plutonium inventories, reportedly following pressure from the United States and other countries.[44]

Recent discussions between the United States and Saudi Arabia toward drafting a peaceful nuclear cooperation agreement have prompted substantial controversy. The U.S. nuclear industry strongly supports an agreement so that it could supply reactors and other nuclear technology to Saudi Arabia.[45] However, nuclear nonproliferation groups want any nuclear cooperation agreement to include a binding commitment from Saudi Arabia to forswear uranium enrichment and spent fuel reprocessing on its territory.[46] Secretary of State Mike Pompeo testified to the Senate Foreign Relations Committee May 24, 2018, that the United States was insisting that Saudi Arabia accept such a commitment as part of any 123 agreement, despite Saudi arguments that the country has a right to enrich and reprocess under international inspections.[47] It has also been proposed that a U.S.-Saudi 123 Agreement be conditioned on Saudi acceptance of the Additional Protocol, which allows strengthened international safeguards on nuclear activities.[48]

Selected Congressional Action

Nuclear Cooperation Reform Act of 2018 (H.R. 5357, Ros-Lehtinen)

Requires that peaceful nuclear cooperation agreements, in order to take effect without congressional approval, include a commitment by the cooperating country to not engage in enrichment or reprocessing in its territory. Other requirements for nuclear cooperation would also be added. Introduced March 21, 2018; referred to Committees on Foreign Affairs and Rules.

To Require a Report on Saudi Arabia Obtaining Nuclear Fuel Enrichment Capabilities (H.R. 6894, Schneider)

Requires the President to submit a report to the House Committee on Foreign Affairs and the Senate Committee on Foreign Relations on the national security impact of Saudi Arabia obtaining uranium enrichment capability through a commercial sale. Introduced September 25, 2018; referred to Committee on Foreign Affairs.

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[43] Nonproliferation Policy Education Center, "Tokyo and Washington Have Another Nuclear Problem," August 17, 2017, http://npolicy.org/article.php?aid=1341&rid=2.

[44] Japanese Ministry of Economy, Trade, and Industry, "Cabinet Decision on the New Strategic Energy Plan," July 3, 2018, http://www.meti.go.jp/english/press/2018/0703_002.html; Reuters, "Japan Pledges to Cut Plutonium Stockpile Amid Growing Concern by Neighbours," July 31, 2018, https://af.reuters.com/article/commoditiesNews/idAFL4N1UQ3WD.

[45] Nuclear Energy Institute, "As Saudi Arabia Considers New Reactors, NEI Conducts Trade Mission," April 26, 2018, https://www.nei.org/news/2018/saudi-arabia-considers-new-reactors.

[46] Nonproliferation Policy Education Center, "Letter to Congress on Nuclear Cooperation with Saudi Arabia," May 24, 2018, http://npolicy.org/article.php?aid=1395&rtid=4.

[47] Mufson, Steven, "Pompeo: Saudis Must Not Enrich Uranium If It Seeks Civilian Nuclear Cooperation," May 24, 2018, https://www.washingtonpost.com/business/economy/pompeo-saudis-must-not-enrich-uranium-if-it-seeks-civilian-nuclear-cooperation/2018/05/24/714c5e30-5f92-11e8-a4a4-c070ef53f315_story.html.

[48] Statement before the U.S. House Committee on Foreign Affairs, Subcommittee on Middle East and North Africa, hearing on "The Implications of Nuclear Cooperation with Saudi Arabia," by Sharon Squassoni, Elliott School of International Affairs, George Washington University, March 21, 2018, https://docs.house.gov/meetings/FA/FA13/20180321/108057/HHRG-115-FA13-Wstate-SquassoniS-20180321.pdf.

Hearing: Confronting the Iranian Challenge

Hearing by the House Committee on Foreign Affairs, May 8, 2018. Examined President Trump's pending decision on withdrawing from the JCPOA and efforts to modify the agreement. Witnesses included former State Department officials and leaders of foreign policy organizations. Video and testimony can be found at https://foreignaffairs.house.gov/hearing/hearing-confronting-the-iranian-challenge.

Hearing: Implications of a U.S.-Saudi Arabia Nuclear Cooperation Agreement for the Middle East

Hearing by the House Committee on Foreign Affairs, Subcommittee on Middle East and North Africa, March 21, 2018. Examined issues related to U.S. discussions with Saudi Arabia toward reaching a peaceful nuclear cooperation agreement. Witnesses included representatives of nuclear nonproliferation organizations and academic institutions. Video, testimony, and hearing transcript available at https://foreignaffairs.house.gov/hearing/subcommittee-hearing-implications-u-s-saudi-arabia-nuclear-cooperation-agreement-middle-east.

Hearing: The President's Iran Decision: Next Steps

Hearing by the House Committee on Foreign Affairs, Subcommittee on the Middle East and North Africa, October 25, 2017. Examined President Trump's decision not to certify Iran as in compliance with the JCPOA. Witnesses represented nuclear nonproliferation and foreign affairs organizations. Video, testimony, and background material can be found at https://foreignaffairs.house.gov/hearing/subcommittee-hearing-presidents-iran-decision-next-steps/.

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