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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 96 licensed nuclear power reactors at 57 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. Similar economic forces are affecting existing reactors. Nine U.S. reactors were permanently closed from 2013 through November 2019, and 10 more are planned for closure through the mid-2020s.

The Department of Energy (DOE) and its predecessor agencies for decades have conducted research on "advanced" reactor technologies, such as fast neutron reactors, that would differ significantly from existing commercial nuclear plants and potentially be far smaller. Proponents of advanced reactors contend that they would be safer, more efficient, and less expensive to build and operate than today's conventional light water reactors (LWRs).

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 Administration requested Yucca Mountain funding again for FY2020, but it was not approved by the House or by the Senate Appropriations Committee.

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, DOE 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 March 2011 disaster at the Fukushima Dai-ichi nuclear power plant in Japan increased attention to nuclear safety throughout the world. The 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.

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 the 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 96 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," August 2019, 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 proposal 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. Nine U.S. reactors were permanently closed from 2013 through November 2019. Three of those units closed because of the need for expensive repairs, and five were operating well but could not compete in their local wholesale electricity markets. New Jersey's Oyster Creek plant permanently shut down September 17, 2018, to avoid having to construct a cooling tower.[4] Two units retired in 2019: Pilgrim (MA) in May and Three Mile Island (PA) in October. All nine 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 10 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 96 licensed nuclear power reactors at 57 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 recently licensed was Watts Bar 2 in 2015. The most recent to start up before Watts Bar 2 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, all of today's operating reactors would have to shut down by 2050 except for the newly licensed Watts Bar 2.[6] The owners of six reactors have applied to NRC for "subsequent license renewals," which would allow operation for up to 80 years. Another two subsequent license renewal applications have been announced.[7] As noted above, 10 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," October 9, 2019, https://www.nrc.gov/reactors/operating/licensing/renewal/applications.html.

[7] Nuclear Regulatory Commission, "Status of Subsequent License Renewal Applications," December 10, 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 2023, the average cost of electricity generation from a nuclear power plant would be 7.8 cents per kilowatt-hour (kwh), while advanced combined-cycle gas-fired generation would cost 4.1 cents/kwh and a coal plant with 90% carbon capture and storage would cost 9.9 cents/kwh.[8] EIA estimates that, including tax credits, electricity from onshore wind would cost 5.0 cents/kwh, solar photovoltaics 4.6 cents/kwh, and geothermal 3.8 cents/kwh.[9] 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.[10] 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.[11] 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, 444 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 2018. Thirty-one countries in 2017 (plus Taiwan) generated at least some of their electricity from nuclear power.[12]

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 37 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

[8] Coal power plant 90% carbon capture and storage (sequestration) technology has not been commercialized. See discussion of a 33% capture and sequestration system at Energy Information Administration, "Petra Nova Is One of Two Carbon Capture and Sequestration Power Plants in the World," October 31, 2017, https://www.eia.gov/todayinenergy/detail.php?id=33552.

[9] Energy Information Administration, "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018," Table 1b, February 2019, 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.

[10] Georgia Power Company, "Georgia Power's New Vogtle Units Approximately 79% Complete," August 30, 2019, https://www.georgiapower.com/company/news-center/2019-articles/georgia-power-new-vogtle-units-approximately-79-percent-complete.html.

[11] Nuclear Regulatory Commission, "Combined License Applications for New Reactors," October 1, 2019, https://www.nrc.gov/reactors/new-reactors/col.html.

[12] World Nuclear Association, "Nuclear Share Figures, 2008-2018," http://www.world-nuclear.org/information-library/facts-and-figures/nuclear-generation-by-country.aspx; World Nuclear Association, "World Nuclear Power Reactors and Uranium Requirements," op. cit.

many of Japan's operable reactors will ultimately seek restart approval.[13] France had planned to reduce nuclear power to 50% of the country's total generation by 2025, although that goal has been delayed to 2035.[14]

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 81,609 metric tons at the end of 2018 and increasing at the rate of about 2,000 metric tons per year.[15]

Recent Events

The Nuclear Waste Policy Act of 1982 (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 Administration requested Yucca Mountain funding again for FY2020, but it was not approved by the House or by the Senate Appropriations Committee.

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.[16] DOE issued a *Draft Consent-Based Siting Process* shortly before the end of the Obama Administration.[17]

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[13] World Nuclear Association, "Nuclear Power in Japan," August 2019, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx.

[14] World Nuclear Association, "Nuclear Power in France," June 2019, https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.

[15] Oak Ridge National Laboratory, Centralized Used Fuel Resource for Information Exchange (CURIE) Interactive Map, viewed October 23, 2019, https://curie.ornl.gov/map.

[16] 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.

[17] 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.

A federal appeals court on August 13, 2013, ordered NRC to continue the Yucca Mountain licensing process with previously appropriated funds.[18] In response, NRC issued the final volumes of the Yucca Mountain Safety Evaluation Report (SER), which provided the NRC staff's 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.[19] 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.[20]

Recent Congressional Action

Nuclear Waste Policy Amendments Act of 2019 (H.R. 2699, McNerney)

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 May 14, 2019; referred to Committees on Energy and Commerce; Natural Resources; Armed Services; Budget; and Rules. Approved by Energy and Commerce Committee's Environment and Climate Change Subcommittee September 26, 2019, by voice vote. Legislative hearing on similar discussion draft held May 1, 2019, by Senate Environment and Public Works Committee. Passed the House Energy and Commerce Committee by voice vote November 20, 2019.

Nuclear Waste Administration Act of 2019 (S. 1234, Murkowski)

Establishes an independent Nuclear Waste Administration (NWA), which would be authorized to develop nuclear waste storage and disposal facilities with the consent of the affected state, local, and tribal governments. In addition to receiving consent-based siting authority, NWA would take over DOE's authority under NWPA to construct and operate a repository at Yucca Mountain and DOE's waste disposal contractual obligations. The bill specifically provides that it would not affect the ongoing Yucca Mountain licensing process. Introduced April 30, 2019; referred to Committee on Energy and Natural Resources. Hearing held June 27, 2019.

Energy and Water Development Appropriations, 2020 (H.R. 2960, Kaptur/S. 2470, Alexander).

Provides FY2020 funding for nuclear energy programs, along with water development programs and other activities. Under the Administration's FY2020 budget request, DOE would receive

[18] 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.

[19] 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/.

[20] 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/.

$116 million to seek an NRC license for the repository and to develop interim nuclear waste storage capacity. NRC would receive $38.5 million to consider DOE's application. DOE's total of $116 million in nuclear waste site funding would come from two appropriations accounts: $90 million from Nuclear Waste Disposal and $26 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.) No waste site funding is included in the House and Senate bills. As reported by the Senate Appropriations Committee, S. 2470 includes an authorization for a pilot program in FY2020 to develop an interim nuclear waste storage facility at a voluntary site (§306). H.R. 2960 was introduced and reported as an original measure by the House Appropriations Committee May 23, 2019 (H.Rept. 116-83). It was combined with three other appropriations bills for floor consideration (H.R. 2740) and passed by the House June 19, 2019, by vote of 226-203. S. 2470 was introduced and reported by the Senate Appropriations Committee as an original measure September 12, 2019 (S.Rept. 116-102).

Other Selected Legislation

Nuclear Waste Informed Consent Act (H.R. 1544 , Titus/,S. 649, Cortez Masto)

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 March 5, 2019. House bill referred to Committee on Energy and Commerce; Senate bill referred to Committee on Environment and Public Works.

Sensible, Timely Relief for America's Nuclear Districts' Economic Development (STRANDED) Act (S. 1985, Duckworth)

For communities with closed nuclear power plants that are storing spent nuclear fuel, authorizes annual grants of $15 for each kilogram of nuclear waste "to offset the economic and social impacts of stranded nuclear waste." Authorizes DOE to establish a prize competition for alternative activities at closed reactor sites. Introduced June 26, 2019; referred to Committee on Environment and Public Works.

Jobs, Not Waste Act (H.R. 1619, Susie Lee/S. 721, 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 alternative economic uses of the Yucca Mountain site and congressional hearings are held on the subject. Both bills introduced March 7, 2019; House bill referred to Committee on Energy and Commerce and Senate bill referred to Committee on Environment and Public Works.

Spent Fuel Prioritization Act of 2019 (H.R. 2995, Mike Levin)

Requires DOE to give the highest priority for storage or disposal of spent nuclear fuel to reactors that have permanently shut down, have the highest surrounding population, and have the highest earthquake hazard. Introduced May 23, 2019; referred to Committee on Energy and Commerce.

Storage and Transportation Of Residual and Excess (STORE) Nuclear Fuel Act of 2019 (H.R. 3136, Matsui)

Authorizes DOE to develop nuclear waste storage facilities and enter into a contract to store waste at a nonfederal facility. DOE would have to obtain state, local, and tribal consent for storage facilities. Financial and technical assistance authorized to states, local governments, and tribes. DOE would be required to give storage priority to waste from closed reactors and to waste shipments required to address emergencies. Introduced June 5, 2019; referred to Committee on Energy and Commerce.

Dry Cask Storage Act of 2019 (S. 2854, Markey)

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. Introduced November 13, 2019; referred to Committee on Environment and Public Works.

CRS Reports

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

CRS In Focus IF11201, *Nuclear Waste Storage Sites in the United States*, by Lance N. Larson

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

Additional References

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

Reset of America's Nuclear Waste Management: Strategy and Policy, Stanford University Center for International Security and Cooperation and George Washington University Elliott School of International Affairs, October 15, 2018, https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/reset_report_2018_final.pdf

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

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. Nine U.S. reactors were permanently closed from 2013 through November 2019, and 10 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.[21] 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.[22] Ohio enacted subsidies in July 2019 that could result in continued operation of the state's two commercial reactors, Davis-Besse and Perry, which had been previously planned for retirement.[23]

Table 1. Recent and Announced U.S. Commercial Reactor Shutdowns

Reactor	State	Shutdown Date	Net Summer Generating Capacity (Megawatts)	Start-Up Year	Major Factors Contributing to Shutdown
Permanent Shutdowns Since 2012					
Crystal River 3	Florida	February 2013	860	1977	Cost of major repairs to reactor containment
Kewaunee	Wisconsin	May 2013	566	1974	Operating losses
San Onofre 2	California	June 2013	1,070	1983	Cost of replacing new steam generators
San Onofre 3	California	June 2013	1,080	1984	Cost of replacing new steam generators
Vermont Yankee	Vermont	December 2014	620	1972	Operating losses
Fort Calhoun	Nebraska	October 2016	479	1973	Operating losses

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

[22] *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.

[23] DeBus, Bill, "Gov. Mike DeWine Signs Bill to Subsidize Perry, Davis-Besse Nuclear Power Plants," *News-Herald*, July 23, 2019, https://www.news-herald.com/news/gov-mike-dewine-signs-bill-to-subsidize-perry-davis-besse/article_b58f5a3c-ad86-11e9-9ebb-8776ac6d0cb0.html.

Reactor	State	Shutdown Date	Net Summer Generating Capacity (Megawatts)	Start-Up Year	Major Factors Contributing to Shutdown
Oyster Creek	New Jersey	September 2018	614	1969	Agreement with state to avoid building cooling towers
Pilgrim	Massachusetts	May 2019	685	1972	Operating losses, rising capital expenditures
Three Mile Island 1	Pennsylvania	October 2019	803	1974	Operating losses
Announced Shutdowns					
Indian Point 2	New York	April 30, 2020	1,020	1974	Low electricity prices; settlement with state
Davis-Besse[a]	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[a]	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.

a. May continue operating under recent state legislation.

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.[24] DOE contended that such plants were crucial in ensuring

[24] Department of Energy, *Grid Resiliency Pricing Rule*, Notice of Proposed Rulemaking, October 10, 2017, 82 *Federal*

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.[25] President Trump directed 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.[26]

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.

Recent filings by Georgia Power, the lead partner in the Vogtle consortium, with the Georgia Public Service Commission indicate that the company's share of the project's construction and financing costs will total about $10.4 billion. That estimate does not include costs covered by Georgia Power's $1.5 billion share of a Westinghouse contract settlement and $700 million in unrecovered costs. Adding those amounts would bring the Georgia Power construction and financing cost share to about $12.6 billion.[27] With Georgia Power holding a 45.7% share of the project, the total construction and financing cost of the new reactors is estimated to be about $27.6 billion, or $13.8 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 the finalization of an additional $3.7 billion in loan guarantees to the three partners in the Vogtle project on March 22, 2019.[28] The Trump Administration has proposed to rescind DOE's authority to issue further Title 17 loan guarantees in FY2020. Similar proposals by the Administration in FY2019 and FY2018 were not approved

Register 46940, https://www.gpo.gov/fdsys/pkg/FR-2017-10-10/pdf/2017-21396.pdf.

[25] 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.

[26] 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.

[27] Georgia Power, *Twentieth/Twenty-first Semi-annual Vogtle Construction Monitoring Report*, Docket No. 29849, August 2019, p. 11, https://psc.ga.gov/search/facts-document/?documentId=178224.

[28] Department of Energy, "Secretary Perry Announces Financial Close on Additional Loan Guarantees During Trip to Vogtle Advanced Nuclear Energy Project," news release, March 22, 2019, https://www.energy.gov/articles/secretary-perry-announces-financial-close-additional-loan-guarantees-during-trip-vogtle.

by Congress. 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."[29] The program includes research on materials used in nuclear plants, modeling of plant aging, and plant upgrades. The Trump Administration has proposed reducing the program's funding by about one-third for FY2020;[30] similar cuts proposed for FY2018 and 2019 were not approved by Congress.

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,[31] 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 Powers America Act of 2019 (S. 1134, Cramer/H.R. 2314, LaHood)

Provides a 30% tax credit for fuel and capital expenses incurred by nuclear power plants. The credit would phase out from December 31, 2023, through January 1, 2026. To receive the credit, nuclear power plants must have submitted a license renewal to NRC or certified to DOE that a license renewal would be submitted. Senate bill introduced April 10, 2019; referred to Committee on Finance. House bill introduced April 12, 2019; referred to Committee on Ways and Means.

Nuclear Energy Renewal Act of 2019 (S. 2368, Coons)

Authorizes appropriations of $60 million per year for DOE Light Water Reactor Sustainability Program through FY2029, as well as appropriations for DOE advanced nuclear R&D programs. Introduced September 11, 2019; referred to Committee on Energy and Natural Resources.

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 Report R44852, *The Value of Energy Tax Incentives for Different Types of Energy Resources*, by Molly F. Sherlock

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

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

[30] Department of Energy, *FY 2020 Congressional Budget Justification*, vol. 3, part 2, DOE/CF-0153, March 2019, p. 279, https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-Part-2.pdf.

[31] 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.

Additional References

World Nuclear Industry Status Report 2019, Mycle Schneider and Antony Froggat, September 27, 2019, https://www.worldnuclearreport.org/

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/

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.[32]

Very small SMRs are often called "microreactors," defined by DOE as having thermal energy capacity below 20 MW. They could provide heat or electric power at remote locations. Self-contained microreactor power units would be assembled in a factory, transported to a site in a

[32] 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.

shipping container, and set up to generate power within a week, according to DOE. Microreactors would be "self regulating," in that their designs would prevent overheating even without operator intervention.[33]

Recent Events

Legislation to stimulate the development of advanced nuclear technology, the Nuclear Energy Innovation Capabilities Act of 2017 (NEICA), 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. The Nuclear Energy Innovation and Modernization Act (P.L. 115-439), signed into law January 14, 2019, requires NRC to develop a new licensing framework for advanced nuclear technology. Proponents of the law 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). The enacted FY2019 funding measure (P.L. 115-244) provided $1.326 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 to begin development of the Versatile Advanced Test Reactor (VATR) at Idaho National Laboratory. Advanced reactor developers assert that the VATR would be crucial in testing advanced nuclear fuels and materials.

Selected Congressional Action

Energy and Water Development Appropriations, 2020 (H.R. 2960, Kaptur/S. 2470, Alexander)

Provides FY2020 funding for nuclear energy programs, along with other DOE programs, water development programs, and related agencies. The Administration's FY2020 budget request would reduce DOE nuclear energy R&D funding by 38% below the FY2019 level, from $1.326 billion to $824 million. The House approved a 2% increase for FY2020, while the Senate Appropriations Committee recommended a 9% reduction. The House-passed nuclear funding includes $100 million for advanced SMR R&D, including $10 million for the new Joint Use Modular Program (JUMP), in which DOE would pay to use demonstration SMR modules for R&D. The House-passed funding also includes $5 million to establish the National Reactor Innovation Center (NRIC) authorized by NEICA, $65 million for conceptual design work for the VATR, and $40 million for HA-LEU. The Senate Appropriations Committee recommended $100 million for SMR development and deployment, no funding for JUMP, and $40 million for VATR. The Senate panel recommended $300 million for an Advanced Reactor Demonstration Program, including $200 million for the first year of two demonstrations, to be 50/50 cost-shared with industry. The other

[33] DOE Office of Nuclear Energy, "What Is a Nuclear Microreactor?," October 23, 2018, https://www.energy.gov/ne/articles/what-nuclear-microreactor.

$100 million would be used for cost-shared R&D on other advanced reactor concepts, addressing regulatory challenges to advanced reactor licensing, and evaluation of advanced reactor nonproliferation issues. House bill reported by the Appropriations Committee as an original measure May 23, 2019 (H.Rept. 116-83) by vote of 31-21. Passed House as part of a four-bill "minibus" (H.R. 2740) June 19, 2019, by vote of 226-203. Senate bill reported as an original measure September 12, 2019 (S. 2470, S.Rept. 116-102).

Advanced Nuclear Fuel Availability Act (H.R. 1760, Flores)

Requires DOE to establish a program to support the availability of HA-LEU as fuel for advanced nuclear reactors. Introduced March 14, 2019; referred to Committee on Energy and Commerce. Passed House by voice vote September 9, 2019.

Nuclear Energy Leadership Act (S. 903, Murkowski/H.R. 3306, Luria)

Authorizes federal agencies to sign power purchase agreements (PPAs) with electric utilities for up to 40 years and requires DOE to establish a pilot PPA program for new nuclear reactors. Directs DOE to demonstrate advanced reactor technologies, prepare a nuclear energy strategic plan, and make HA-LEU available for advanced nuclear reactors. DOE and NRC are required to establish a program to support university research on advanced nuclear technologies. Senate bill introduced March 27, 2019; referred to Committee on Energy and Natural Resources. Legislative hearings held April 30, 2019. Approved by Committee July 16, 2019 (S.Rept. 116-114). House bill introduced June 19, 2019; referred to Committees on Science, Space, and Technology; Energy and Commerce; Oversight and Reform; and Armed Services.

Advanced Nuclear Energy Technologies Act (H.R. 3358, Higgins)

Directs DOE to carry out two advanced nuclear reactor demonstrations by the end of 2025, to the extent practicable, and up to four additional demonstrations by the end of 2035. The demonstrations would be cost-shared with nonfederal entities. Requires DOE to submit a nuclear energy strategic plan to specified congressional committees. Introduced June 19, 2019; referred to Committee on Science, Space, and Technology.

Nuclear Energy Renewal Act of 2019 (S. 2368, Coons)

Authorizes appropriations for DOE advanced nuclear R&D programs through FY2029. Appropriations for the Advanced Reactor Technologies Development Program authorized at $120 million per year; Fuel Cycle Research and Development Program at $200 million per year; Material Recovery and Waste Form Development at $50 million per year; Advanced Fuels at $120 million per year; Nuclear Energy Enabling Technologies at $150 million per year; Radiological Facilities Management at $30 million per year; and International Nuclear Energy Cooperation at $10 million per year. Authorizes DOE and NRC to develop certification and licensing criteria for advanced reactors and to provide assistance to advanced reactor license applicants. Appropriations authorized at $15 million per year through FY2029. The Light Water Reactor Sustainability Program, aimed at existing reactors, would also be authorized through FY2029. Allows an exemption to the existing minimum of 20% private-sector cost sharing for programs authorized by the bill. Introduced September 11, 2019; referred to Committee on Energy and Natural Resources.

Hearing: Advanced Nuclear Technology: Protecting U.S. Leadership and Expanding Opportunities for Licensing New Nuclear Energy Technologies

Hearing by the Senate Committee on Environment and Public Works Subcommittee on Clean Air and Nuclear Safety on the international and domestic outlook for advanced nuclear technologies, June 4, 2019. Witnesses included William D. Magwood, Director General of the Organization for Economic Cooperation and Development Nuclear Energy Agency, and representatives of advanced nuclear technology companies and public policy organizations. Video, written statements, and other material can be found at https://www.epw.senate.gov/public/index.cfm/2019/6/advanced-nuclear-technology-protecting-u-s-leadership-and-expanding-opportunities-for-licensing-new-nuclear-energy-technologies.

CRS Reports

CRS Report R45706, *Advanced Nuclear Reactors: Technology Overview and Current Issues*, by Danielle A. Arostegui and Mark Holt

Additional References

Raising the Next Generation of Nuclear: A Road Map for Deployment, Third Way, October 17, 2019, https://www.thirdway.org/memo/raising-the-next-generation-of-nuclear-a-road-map-for-deployment

Metric and Method for Comparing Investments to Decarbonize the Electricity System, Rocky Mountain Institute, September 24, 2019, https://rmi.org/insight/decarbonizing-the-electricity-system

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

Gateway for Accelerated Innovation in Nuclear (GAIN), U.S. Department of Energy website, https://gain.inl.gov/SitePages/Home.aspx

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.[34]

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 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.[35] NRC voted on August 19, 2015, not to proceed with rulemaking on filtered vents.[36]

Controversy was also raised by the NRC's final rule for Mitigation of Beyond-Design-Basis Events (MBDBE), announced January 24, 2019.[37] The MBDBE regulation requires nuclear power plants to implement strategies to maintain reactor core cooling when electric power is lost, as occurred during the Fukushima accident. The MBDBE proposed rule, published November 13,

[34] 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.

[35] 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.

[36] 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.

[37] NRC, "NRC To Issue Final Rule for Mitigating Severe Events at U.S. Reactors," news release, January 24, 2019, https://www.nrc.gov/reading-rm/doc-collections/news/2019/19-005.pdf.

2015,[38] and the draft final rule, released by NRC on January 5, 2017,[39] would have required the equipment used in those strategies to be able to withstand newly evaluated flooding and seismic risks, and that regular drills and exercises be conducted. The final rule excluded those requirements, among other changes.[40] In supporting those exclusions, the Commission majority asserted that the deleted requirements did not meet NRC's cost-benefit standards.[41] NRC is continuing to monitor the implementation of all post-Fukushima regulations and orders.[42]

Selected Congressional Action

Energy and Water Development Appropriations, 2020 (H.R. 2960, Kaptur/S. 2470, Alexander)

Provides FY2020 funding for NRC and for DOE nuclear energy programs, along with other DOE programs, water development programs, and related agencies. DOE research on nuclear fuel with improved resistance to accident conditions ("accident tolerant fuels") would receive $75.6 million under the House-passed bill and $115.0 million under the Senate Appropriations Committee recommendation. House bill reported by the Appropriations Committee as an original measure May 23, 2019 (H.Rept. 116-83) by vote of 31-21. Passed House as part of a four-bill "minibus" (H.R. 2740) June 19, 2019, by vote of 226-203. Senate bill reported as an original measure September 12, 2019 (S. 2470, S.Rept. 116-102).

Low-Dose Radiation Research Act of 2019 (H.R. 4733, Posey)

Authorizes a DOE research program on the effects of exposure to low-dose radiation. Introduced October 18, 2019; referred to Committee on Science, Space, and Technology.

Department of Energy and Nuclear Regulatory Commission Whistleblower Protection Act of 2019 (S. 1330, Duckworth)

Specifically protects all DOE and NRC employees from retaliation for raising nuclear safety concerns (whistleblowing). Introduced May 6, 2019; referred to Committee on Energy and Natural Resources.

Hearing: Preserving and Expanding Clean, Reliable Nuclear Power: U.S. Commercial Nuclear Reactor Performance Trends and Safety Initiatives

Hearing by the Senate Committee on Environment and Public Works on the safety of existing and potential future nuclear power plants and other issues relating to commercial nuclear power. Witnesses came from industry, government, and advocacy organizations. Video, written statements, and other material can be found at https://www.epw.senate.gov/public/index.cfm/

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[38] NRC, "Mitigation of Beyond-Design-Basis Events," Proposed Rule, *Federal Register*, November 13, 2015, Vol. 80, No. 219, p. 70610, https://www.govinfo.gov/content/pkg/FR-2015-11-13/pdf/2015-28589.pdf.

[39] NRC, Final Rule: Mitigation of Beyond-Design-Basis Events, SECY-16-0142, Enclosure 1, January 5, 2017, https://www.nrc.gov/docs/ML1630/ML16301A005.html.

[40] NRC, "Staff Requirements—Affirmation Session," SRM-M190124A, Enclosure 1, January 24, 2019, https://www.nrc.gov/docs/ML1902/ML19023A038.html.

[41] Ibid., "Views of the Commission."

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

2019/11/preserving-and-expanding-clean-reliable-nuclear-power-u-s-commercial-nuclear-reactor-performance-trends-and-safety-initiatives.

CRS Reports

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

Additional References

Post-Fukushima Safety Enhancements, Nuclear Regulatory Commission, web page, reviewed/updated August 14, 2019, https://www.nrc.gov/reactors/operating/ops-experience/post-fukushima-safety-enhancements.html

Safety of Nuclear Power Reactors, World Nuclear Association, June 2019, https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx

Nuclear Safety: Countries' Regulatory Bodies Have Made Changes in Response to the Fukushima Daiichi Accident, Report to the Chairman, Subcommittee on Transportation and Infrastructure, Committee on Environment and Public Works, U.S. Senate, Government Accountability Office, GAO-14-109, March 2014, http://www.gao.gov/products/GAO-14-109

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.[43] 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.[44]

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

[44] 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.

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.[45]

Recent Events

NRC issued a draft final rule June 7, 2018, on "Enhanced Weapons, Firearms Background Checks, and Security Event Notifications."[46] The draft final rule, which is awaiting Commission approval, would establish procedures for nuclear power plants and other licensed nuclear 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.

CRS Reports

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

Additional References

Update on Radiological Emergency Preparedness Enhancement Activities Resulting from Lessons Learned Following September 11, 2001, and Other Recent Natural Disasters, Nuclear Regulatory Commission, July 19, 2019, https://www.nrc.gov/docs/ML1911/ML19116A159.pdf

"Backgrounder on Nuclear Security," Nuclear Regulatory Commission, web page, last reviewed/updated May 31, 2019, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.html

"Nuclear Plant Security," Union of Concerned Scientists, web page, updated February 25, 2016, https://www.ucsusa.org/nuclear-power/nuclear-plant-security#.W2RtxtJKiUk

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

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

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

[46] 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.

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[47] 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.[48]

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.[49]

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

[48] 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.

[49] 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/

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.[50] 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 has substantial stockpiles of previously separated plutonium that could potentially be used for weapons as well as reactor fuel.[51] 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.[52]

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.[53] 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.[54] 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.[55] Energy Secretary Rick Perry told reporters at a meeting in September 2019 that the United States also would condition any U.S.-Saudi 123 Agreement on Saudi acceptance of the Additional Protocol, which allows strengthened international safeguards on nuclear facilities.[56]

266975.htm.

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

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

[52] 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.

[53] 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.

[54] 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.

[55] 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.

[56] Natter, Ari, "U.S. Says Saudis Must Forgo Enrichment for Nuclear Sharing Deal," *Bloomberg*, September 18, 2019, https://www.bloomberg.com/news/articles/2019-09-19/u-s-says-saudis-must-forgo-enrichment-for-nuclear-sharing-deal.

Selected Congressional Action

Expressing the sense of Congress that any United States-Saudi Arabia civilian nuclear cooperation agreement must prohibit the Kingdom of Saudi Arabia from enriching uranium or separating plutonium on its own territory, in keeping with the strongest possible nonproliferation "gold standard" (S.Con.Res. 2, Merkley/H.Con.Res. 23, Andy Levin)

Expresses the sense of Congress that a 123 agreement with Saudi Arabia should prohibit uranium enrichment and plutonium separation in Saudi territory and require Saudi acceptance of the Additional Protocol for nuclear facility inspections. Senate resolution introduced February 12, 2019; referred to Committee on Foreign Relations. House resolution introduced February 28, 2019; referred to Committee on Foreign Affairs.

Saudi Nuclear Nonproliferation Act of 2019 (H.R. 1471, Sherman/S. 612, Markey)

Establishes additional criteria for any 123 agreement with Saudi Arabia and prohibits such an agreement from taking effect without enactment of a joint resolution of Congress. Both bills introduced February 28, 2018. House bill referred to Committee on Foreign Affairs; Senate bill referred to Committee on Foreign Relations.

Preventing Nuclear Proliferation in Saudi Arabia Act of 2019 (S. 2338, Van Hollen)

Prohibits the U.S. Export-Import Bank from financing nuclear exports to Saudi Arabia unless Saudi Arabia signs the Additional Protocol and commits not to enrich uranium or separate plutonium in its territory. Introduced July 30, 2019; referred to Committee on Banking, Housing, and Urban Affairs.

Hearing: Oversight of the Trump Administration's Iran Policy

Hearing by the House Committee on Foreign Affairs Subcommittee on the Middle East, North Africa, and International Terrorism, June 19, 2019, with the U.S. Special Representative for Iran. Video can be found at https://foreignaffairs.house.gov/2019/6/oversight-of-the-trump-administration-s-iran-policy.

Hearing: An Examination of U.S.-Iran Policy

Hearing by the Senate Committee on Foreign Relations, October 16, 2019, with the U.S. Special Representative for Iran. Video and testimony can be found at https://www.foreign.senate.gov/hearings/an-examination-of-us-iran-policy.

CRS Reports

CRS Report R41910, *Nuclear Energy Cooperation with Foreign Countries: Issues for Congress*, by Paul K. Kerr, Mary Beth D. Nikitin, and Mark Holt

CRS Report RS22937, *Nuclear Cooperation with Other Countries: A Primer*, by Paul K. Kerr and Mary Beth D. Nikitin

CRS Report RL33192, *U.S.-China Nuclear Cooperation Agreement*, by Mark Holt, Mary Beth D. Nikitin, and Paul K. Kerr

CRS Report R44942, *U.S. Decision to Cease Implementing the Iran Nuclear Agreement*, by Kenneth Katzman, Paul K. Kerr, and Valerie Heitshusen

CRS In Focus IF10799, *Prospects for Enhanced U.S.-Saudi Nuclear Energy Cooperation*, by Christopher M. Blanchard and Paul K. Kerr

Other References

Nuclear Nonproliferation, Government Accountability Office, Key Issues website, https://www.gao.gov/key_issues/nuclear_nonproliferation/issue_summary

Nuclear Cooperation Agreements, Nuclear Energy Institute website, https://www.nei.org/advocacy/compete-globally/nuclear-cooperation-agreements.

The Nonproliferation Gold Standard: The New Normal?, Arms Control Association, October 2019, https://www.armscontrol.org/act/2019-10/features/nonproliferation-gold-standard-new-normal

Abstinence or Tolerance: Managing Nuclear Ambitions in Saudi Arabia, Elliott School of International Affairs, George Washington University, *Washington Quarterly*, Summer 2018, https://twq.elliott.gwu.edu/sites/g/files/zaxdzs2121/f/downloads/TWQ_Summer2018_MillerVolpe.pdf

The Case for a Pause in Reprocessing in East Asia: Economic Aspects, Nuclear Threat Initiative, August 9, 2016, http://www.nti.org/analysis/reports/case-pause-reprocessing-east-asiaeconomic-aspects/

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