



# Nuclear Energy Policy

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## Summary

Nuclear energy issues facing Congress include reactor safety and regulation, radioactive waste management, research and development priorities, federal incentives for new commercial reactors, nuclear weapons proliferation, and security against terrorist attacks.

The earthquake and resulting tsunami that severely damaged Japan's Fukushima Daiichi nuclear power plant on March 11, 2011 raised questions in Congress about the disaster's possible implications for nuclear safety regulation, U.S. nuclear energy expansion, and radioactive waste policy. The tsunami knocked out electric power at the six-reactor plant, resulting in the overheating of several reactor cores, loss of cooling in spent fuel storage pools, major hydrogen explosions, and releases of radioactive material to the environment. The Nuclear Regulatory Commission (NRC) issued orders to U.S. nuclear plants March 12, 2012, to begin implementing safety improvements in response to Fukushima.

Significant incentives for new commercial reactors were included in the Energy Policy Act of 2005 (EPACT05, P.L. 109-58), such as tax credits and loan guarantees. Together with volatile fossil fuel prices and the possibility of greenhouse gas controls, the federal incentives for nuclear power helped spur renewed interest by utilities and other potential reactor developers. License applications for as many as 31 new reactors have been announced, and NRC issued licenses for four reactors at two plant sites in early 2012. However, falling natural gas prices, safety concerns raised by the Fukushima accident, and other changing circumstances have made it unlikely that many more of the proposed nuclear projects will move toward construction in the near term.

Four U.S. reactors have been permanently closed in 2013, and another shutdown has been announced for 2014. Three reactors were closed because of the need for major repairs, and the other two because electricity prices fell below their generating costs. All five had substantial time remaining in their NRC licenses, leading to speculation that further early shutdowns may occur.

DOE's nuclear energy research and development program includes advanced reactors, fuel cycle technology and facilities, and infrastructure support. The Obama Administration's FY2014 funding request totals \$735.5 million, \$22.0 million (3%) below the comparable FY2013 funding level (pre-sequestration). In the FY2014 Energy and Water Development Appropriations Act (H.R. 2609), the House voted for an increase of \$14.9 million from the Administration request and a decrease of \$37 million in comparable funding from FY2013. The Senate Appropriations Committee recommended the same total as the Administration request (S. 1245).

Disposal of highly radioactive waste has been one of the most controversial aspects of nuclear power. The Obama Administration halted work on a long-planned waste repository at Yucca Mountain, NV, and established the Blue Ribbon Commission on America's Nuclear Future (BRC) to recommend new approaches to the waste problem. The BRC issued its final report to the Secretary of Energy on January 26, 2012. In response to the BRC report, and to provide an outline for a new nuclear waste program, DOE issued a *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste* in January 2013. The DOE strategy calls for a new nuclear waste management entity to develop consent-based storage and disposal sites, similar to recommendations by the BRC. No funding was provided in FY2012 and FY2013 or requested for FY2014 to continue NRC licensing of the Yucca Mountain repository, although a federal appeals court on August 13, 2013, ordered NRC to continue the licensing process with previously appropriated funds.

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## Most Recent Developments

The first construction starts for new U.S. nuclear power reactors since the 1970s officially took place in March 2013 in South Carolina and Georgia. Pouring of the first “safety related” concrete, which marks the start of reactor construction, was completed on March 11, 2013, for V.C. Summer Unit 2 in Cayce, SC, and three days later for Vogtle Unit 3 in Waynesboro, GA. The Nuclear Regulatory Commission (NRC) had issued combined construction permits and operating licenses (COLs) for two new reactors at the Vogtle site on February 9, 2012, and for two identical reactors at the Summer plant on March 30, 2012. Each of the new Westinghouse AP1000 reactors, scheduled for completion between 2016 and 2019, is expected to cost from \$5 billion to \$7 billion.

Four U.S. reactors have been permanently closed during 2013, and the shutdown of a fifth unit was announced for late 2014. Crystal River 3 in Florida was retired in February because of cracks in its concrete containment structure. The single-unit Kewaunee plant in Wisconsin closed in May because regional electricity prices had dropped below the reactor’s generating costs. San Onofre 2 and 3 in California closed in June because of faulty steam generators (unit 1 had been shut previously). And the owner of the single-unit Vermont Yankee plant announced in August that the reactor would permanently close in the fourth quarter of 2014 for economic reasons. All of those units had substantial time remaining on their initial 40-year operating licenses or had received or applied for 20-year license extensions from NRC. The shutdowns prompted widespread discussion about the future of other aging U.S. reactors.

On March 12, 2012, NRC issued its first nuclear plant safety requirements based on lessons learned from the March 2011 Fukushima disaster in Japan. NRC ordered U.S. nuclear plant operators to begin implementing safety enhancements related to power blackouts, reactor containment venting, and monitoring the water levels of reactor spent fuel pools. The Fukushima nuclear plant was hit by an earthquake and tsunami that knocked out all electric power at the six-reactor plant, resulting in the overheating of the reactor cores in three of the units and a heightened overheating risk at several spent fuel storage pools at the site. The overheating of the reactor cores caused major hydrogen explosions and releases of radioactive material to the environment. NRC’s response to the accident has been the subject of continuing congressional oversight.

The Obama Administration requested \$735.5 million for nuclear energy research and development, including advanced reactors, fuel cycle technology and facilities, and infrastructure support, in its FY2014 budget. Submitted to Congress on April 10, 2013, the nuclear energy budget request is \$22.0 million (3%) below the comparable FY2013 funding level.<sup>1</sup> In the FY2014 Energy and Water Development Appropriations Act (H.R. 2609, H.Rept. 113-135), the House voted July 10, 2013, for an increase of \$14.9 million from the Administration request and a decrease of \$37 million in comparable funding from FY2013. The Senate Appropriations Committee on June 27, 2013, recommended the same total as the Administration request (S. 1245, S.Rept. 113-47).

The Blue Ribbon Commission on America’s Nuclear Future, established by the Obama Administration to recommend a new strategy for nuclear waste management, issued its final

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<sup>1</sup> All FY2013 figures are pre-sequestration.

report to the Secretary of Energy on January 26, 2012.<sup>2</sup> President Obama has moved to terminate previous plans to open a national nuclear waste repository at Yucca Mountain, NV. In its final report, the Blue Ribbon Commission recommended a “consent-based” approach to siting nuclear waste facilities and that the roles of local, state, and tribal governments be negotiated for each potential site. The development of consolidated waste storage and disposal facilities should begin as soon as possible, the Commission urged. A new waste management organization should be established to develop the repository, along with associated transportation and storage systems, according to the Commission. The new organization should have “assured access” to the Nuclear Waste Fund, which holds fees collected from nuclear power plant operators to pay for waste disposal. Under existing law, the Nuclear Waste Fund cannot be drawn down without congressional appropriations.

In response to the BRC report, and to provide an outline for a new nuclear waste program, DOE issued a *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste* in January 2013. The DOE strategy calls for a new nuclear waste management entity to develop consent-based storage and disposal sites, similar to the BRC recommendation. Under the DOE strategy, a pilot interim spent fuel storage facility would be opened by 2021 and a larger-scale storage facility, which could be an expansion of the pilot facility, by 2025. A geologic disposal facility would open by 2048—fifty years after the initial planned opening date for the Yucca Mountain repository.<sup>3</sup> Legislation to redirect the nuclear waste program along the lines recommended by the Blue Ribbon Commission was introduced by Senator Wyden on June 27, 2013 (S. 1240).

The House-passed Energy and Water bill would give DOE \$25 million for the Yucca Mountain project and direct NRC to use previously appropriated funds to continue the Yucca Mountain licensing process. The U.S. Court of Appeals for the District of Columbia Circuit ruled on August 13, 2013, that NRC must continue work on the Yucca Mountain license application as long as funding is available. The Court determined that NRC has at least \$11.1 million in previously appropriated funds for that purpose.<sup>4</sup>

NRC published a proposed rule September 13, 2013, on continued storage of spent nuclear fuel.<sup>5</sup> The proposed rule responds to a federal circuit court ruling on June 8, 2012, that struck down NRC’s Waste Confidence Decision, which contains the agency’s formal findings that waste generated by nuclear power plants will be disposed of safely. The court ruled that the Waste Confidence Decision required an environmental review under the National Environmental Policy Act and that NRC needed to consider the possibility that a permanent waste repository would never be built and examine potential problems with waste storage pools.

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<sup>2</sup> Blue Ribbon Commission on America’s Nuclear Future, *Report to the Secretary of Energy*, January 2012, [http://brc.gov/sites/default/files/documents/brc\\_finalreport\\_jan2012.pdf](http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf).

<sup>3</sup> DOE, *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste*, January 2013, <http://energy.gov/sites/prod/files/Strategy%20for%20the%20Management%20and%20Disposal%20of%20Used%20Nuclear%20Fuel%20and%20High%20Level%20Radioactive%20Waste.pdf>.

<sup>4</sup> 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](http://www.cadc.uscourts.gov/internet/opinions.nsf/BAE0CF34F762EBD985257BC6004DEB18/$file/11-1271-1451347.pdf).

<sup>5</sup> NRC, “Waste Confidence—Continued Storage of Spent Nuclear Fuel,” proposed rule, 78 *Federal Register* 56776, September 13, 2013.

## **Nuclear Power Status and Outlook**

After nearly 30 years in which no new orders had been placed for nuclear power plants in the United States, a series of license applications that began in 2007 prompted widespread speculation about a U.S. “nuclear renaissance.” The renewed interest in nuclear power largely resulted from the improved performance of existing reactors, federal incentives in the Energy Policy Act of 2005 (P.L. 109-58), the possibility of carbon dioxide controls that could increase costs at fossil fuel plants, and volatile prices for natural gas—the favored fuel for new power plants for the past two decades.

Four of the proposed new U.S. reactors received licenses from the Nuclear Regulatory Commission (NRC) in early 2012. NRC approved combined construction permit and operating licenses (COLs) for Southern Company to build and operate two new Westinghouse AP1000 reactors at the Vogtle nuclear power plant in Georgia on February 9, 2012. On March 30, 2012, NRC approved COLs for two additional AP1000 reactors at the existing Summer nuclear plant in South Carolina. Pouring of the first “safety related” concrete, which marks the start of reactor construction, was completed on March 11, 2013, for V.C. Summer Unit 2 and three days later for Vogtle Unit 3.

However, the future of all other proposed new U.S. reactors is uncertain. High construction cost estimates—a major reason for earlier reactor cancellations—continue to undermine nuclear power economics. A more recent obstacle to nuclear power growth has been the development of vast reserves of domestic natural gas from previously uneconomic shale formations, which has held gas prices low and reduced concern about future price spikes. Moreover, uncertainty over U.S. controls on carbon emissions may be further increasing caution by utility companies about future nuclear projects.

Four U.S. reactors have been permanently closed during 2013, and the shutdown of a fifth unit was announced for late 2014. Crystal River 3 in Florida was retired in February because of cracks in its concrete containment structure. The single-unit Kewaunee plant in Wisconsin closed in May because regional electricity prices had dropped below the reactor’s generating costs. San Onofre 2 and 3 closed in June because of faulty steam generators (unit 1 had been shut previously). And the owner of the single-unit Vermont Yankee plant announced in August that the reactor would permanently close in the fourth quarter of 2014 for economic reasons. All of those units had substantial time remaining on their initial 40-year operating licenses or had received or applied for 20-year license extensions from NRC. The shutdowns prompted widespread discussion about the future of other aging U.S. reactors.

The March 11, 2011, earthquake and tsunami that severely damaged Japan’s Fukushima Daiichi nuclear power plant could also affect plans for new U.S. reactors, although U.S. nuclear power growth was already expected to be modest in the near term. Following the Fukushima accident, preconstruction work was suspended on two planned reactors at the South Texas Project. Tokyo Electric Power Company (TEPCO), which owns the Fukushima plant, had planned to invest in the South Texas Project expansion, but TEPCO’s financial condition plunged after the accident. New U.S. safety requirements resulting from the Fukushima disaster could raise investor

concerns about higher costs. On the other hand, after the accident the Obama Administration reiterated its support for nuclear power expansion as part of its clean energy policy.<sup>6</sup>

The recent applications for new power reactors in the United States followed a long period of declining nuclear generation growth rates. Until the COLs were issued for the Vogtle and Summer projects, no nuclear power plants had been ordered in the United States since 1978, and more than 100 reactors had been canceled, including all ordered after 1973. The most recent U.S. nuclear unit to be completed was the Tennessee Valley Authority's (TVA's) Watts Bar 1 reactor, ordered in 1970 and licensed to operate in 1996. But largely because of better operation and capacity expansion at existing reactors, annual U.S. nuclear generation has risen by about 20% since the startup of Watts Bar 1.<sup>7</sup>

The U.S. nuclear power industry currently comprises 104 licensed reactors (including the four permanently closed in 2013) at 65 plant sites in 31 states and generates about 19% of the nation's electricity.<sup>8</sup> TVA's board of directors voted August 1, 2007, to resume construction on Watts Bar 2, which had been suspended in 1985; the renewed construction project was to cost about \$2.5 billion and be completed in 2013. However, TVA announced on April 5, 2012, that completing Watts Bar 2 would cost up to \$2 billion more than expected and take until 2015.<sup>9</sup> At TVA's request, NRC in March 2009 reinstated the construction authorization for the two-unit Bellefonte (AL) nuclear plant, which had been deferred in 1988 and canceled in 2006.<sup>10</sup> The TVA board voted on August 18, 2011, to complete construction of Bellefonte 1 after the Watts Bar 2 project is finished. Completing Bellefonte 1 was projected at that time to cost \$4.9 billion, with operation to begin by 2020.<sup>11</sup> Citing lower electricity sales, TVA on June 12, 2013, announced sharp cutbacks at the Bellefonte site.<sup>12</sup>

Annual electricity production from U.S. nuclear power plants is much greater than that from oil and hydropower and other renewable energy sources. Nuclear generation has been overtaken by natural gas in recent years, and it remains well behind coal, which accounted for about 38% of U.S. electricity generation in 2012.<sup>13</sup> Nuclear plants generated more than half the electricity in three states in 2012—New Jersey, South Carolina, and Vermont—and 12 states generated 25%-50% of their electricity from nuclear power.<sup>14</sup> The 769 billion net kilowatt-hours of nuclear

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<sup>6</sup> Oral Testimony of Energy Secretary Steven Chu at the House Energy and Commerce Committee – As Prepared for Delivery, March 16, 2011, <http://www.energy.gov/news/10178.htm>.

<sup>7</sup> Energy Information Administration, *Electricity Data Browser*, “Net Generation for All Sectors, Annual,” viewed September 4, 2013, <http://www.eia.gov/electricity/data/browser>.

<sup>8</sup> U.S. Nuclear Regulatory Commission, *Information Digest 2008-2009*, NUREG-1350, Vol. 20, August 2008, p. 32, <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/v20/sr1350v20.pdf>.

<sup>9</sup> Mary Powers, “Credit Agencies See Watts Bar-2 Cost Impact,” *Nucleonics Week*, April 12, 2012, p. 1.

<sup>10</sup> Nuclear Regulatory Commission, “In the Matter of Tennessee Valley Authority (Bellefonte Nuclear Plant Units 1 and 2),” 74 *Federal Register* 10969, March 13, 2009.

<sup>11</sup> Tennessee Valley Authority, “TVA Board Implements Vision,” press release, August 18, 2011, [http://www.tva.com/news/releases/julsep11/board\\_meeting/index.htm](http://www.tva.com/news/releases/julsep11/board_meeting/index.htm).

<sup>12</sup> Tennessee Valley Authority, “TVA Announces Budget Reduction for Bellefonte Plant,” press release, June 12, 2013, [http://www.tva.com/news/releases/aprjun13/bellefonte\\_budget.html](http://www.tva.com/news/releases/aprjun13/bellefonte_budget.html).

<sup>13</sup> Energy Information Administration, *Electric Power Monthly*, Net Generation by Energy Source, February 2012, [http://www.eia.gov/cneaf/electricity/epm/epm\\_sum.html](http://www.eia.gov/cneaf/electricity/epm/epm_sum.html). Net generation excludes electricity used for power plant operation.

<sup>14</sup> Nuclear Regulatory Commission, *Information Digest, 2012-2013*, NUREG-1350, Volume 24, <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/v24/sr1350v24.pdf>.

electricity generated in the United States during 2012<sup>15</sup> was about the same as the nation's entire electrical output in the early 1960s, when the oldest of today's operating U.S. commercial reactors were ordered.<sup>16</sup>

Reasons for the 30-year halt in U.S. nuclear plant orders included high capital costs, public concern about nuclear safety and waste disposal, and regulatory compliance issues.

High construction costs may pose the most serious obstacle to nuclear power expansion. Construction costs for reactors completed since the mid-1980s ranged from \$2 to \$6 billion, averaging more than \$3,900 per kilowatt of electric generating capacity (in 2011 dollars), far higher than commercial fossil fuel technologies. The nuclear industry predicts that new plant designs could be built for less than that if many identical plants were built in a series, but current estimates for new reactors show little if any reduction in cost.<sup>17</sup>

In contrast, average U.S. nuclear plant operating costs per kilowatt-hour dropped substantially since 1990, and expensive downtime has been steadily reduced. Licensed U.S. commercial reactors generated electricity at an average of 87% of their total capacity in 2012, according to the Energy Information Administration (EIA).<sup>18</sup>

Seventy-three commercial reactors have received 20-year license renewals from the Nuclear Regulatory Commission (NRC), giving them up to a total of 60 years of operation. License renewals for 12 additional reactors are currently under review, and more are anticipated, according to NRC.<sup>19</sup> However, as noted above, two reactors that have received license renewals, Vermont Yankee and Kewaunee, are being permanently closed for economic reasons.

## Possible New Reactors

Electric utilities and other firms have announced plans to apply for COLs for more than 30 reactors (see **Table 1**).<sup>20</sup> (For a discussion of COLs, see the "Licensing and Regulation" section below.)

As noted above, construction is currently underway on four of the proposed new reactors, at the Vogtle and Summer sites. COLs are being actively pursued for 14 additional reactors (shown in **Table 1**), whose owners have not committed to actual construction but are keeping the option available if conditions are more favorable in the future. The experience of the first few reactors to be constructed is likely to be crucial in determining whether a wave of subsequent units will move forward as the nuclear industry envisions.

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<sup>15</sup> EIA, *Electricity Data Browser*, op. cit.

<sup>16</sup> All of today's 104 operating U.S. commercial reactors were ordered from 1963 through 1973; see "Historical Profile of U.S. Nuclear Power Development," U.S. Council for Energy Awareness, 1992.

<sup>17</sup> For a comparison of generating costs, see CRS Report RL34746, *Power Plants: Characteristics and Costs*, by Stan Mark Kaplan.

<sup>18</sup> Energy Information Administration, "U.S. Nuclear Generation and Generating Capacity," [http://www.eia.gov/cneaf/nuclear/page/nuc\\_generation/gensum.html](http://www.eia.gov/cneaf/nuclear/page/nuc_generation/gensum.html).

<sup>19</sup> Nuclear Regulatory Commission, *Fact Sheet on Reactor License Renewal*, August 8, 2011, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-reactor-license-renewal.html>.

<sup>20</sup> Nuclear Regulatory Commission, *New Reactors*, <http://www.nrc.gov/reactors/new-reactors.html>.

The two new Vogtle reactors are scheduled to go on line in 2017 and 2018,<sup>21</sup> the same years now planned for startup of the new Summer units.<sup>22</sup> EIA estimates that construction costs of new nuclear power plants will average \$5,335 per kilowatt of capacity, or about \$6.1 billion for an AP1000 unit, not including interest costs.<sup>23</sup> The two Summer units are expected to cost about \$11.6 billion in 2012 dollars, according to regulatory filings,<sup>24</sup> while the two Vogtle units are projected by their primary owner to cost a total of \$13.35 billion.<sup>25</sup>

Duke Energy's Levy County project, with two AP1000 units, is scheduled by NRC to receive a final decision on its COL in early 2014, although Duke has terminated its engineering, procurement, and construction (EPC) contract for the project. Duke said it did not foresee a need for the plant as soon as previously planned, but "continues to regard the Levy site as a viable option for future nuclear generation."<sup>26</sup> COLs for five reactors at three other sites—Fermi (MI), South Texas Project, and William States Lee (SC)—are scheduled to be issued in 2015.

As shown in **Table 1**, the remaining five projects that are actively seeking COLs, with a total of seven proposed reactors, do not have firm licensing schedules from NRC. Several of those projects would use designs that have not received NRC certifications. As a result, these reactors appear unlikely to be completed before the early 2020s. This group includes the planned units 3 and 4 at the South Texas Project, where preconstruction work was suspended after the Fukushima Daiichi accident, as noted above. The joint venture developing the new South Texas Plant reactors, Nuclear Innovation North America (NINA), will focus solely on the COL and a DOE loan guarantee.<sup>27</sup> Several of these proposed nuclear projects may require additional partners in order to proceed to construction, according to recent company announcements.<sup>28</sup>

Several other COL applications have been suspended, withdrawn, or shifted to early site permits (ESPs) only. Entergy suspended further license review of its planned GE ESBWR reactors at River Bend, LA, and Grand Gulf, MS, although it still has a previously issued ESP for Grand Gulf. AmerenUE suspended review of a COL for its proposed new Callaway unit in Missouri, and Exelon withdrew its COL application for a proposed two-unit plant in Victoria County, TX. Most recently, Duke Energy suspended its application for two new AP1000s at its Shearon Harris plant.

<sup>21</sup> Southern Company, "Smart Power," [http://www.southerncompany.com/smart\\_energy/smart\\_power\\_vogtle-kemper.html](http://www.southerncompany.com/smart_energy/smart_power_vogtle-kemper.html).

<sup>22</sup> South Carolina Electric and Gas Company, "V.C. Summer Nuclear Station Units 2 and 3, Quarterly Report to the South Carolina Office of Regulatory Staff," June 30, 2013, <http://www.scana.com/NR/rdonlyres/FD5FC097-3956-48A6-9098-2C2D115C8512/0/NNDQuarterlyReport2013Q2FINAL81413PUBLIC.pdf>.

<sup>23</sup> Energy Information Administration, "Updated Capital Cost Estimates for Electricity Generation Plants," November 2010, [http://www.eia.gov/oiaf/beck\\_plantcosts/index.html](http://www.eia.gov/oiaf/beck_plantcosts/index.html).

<sup>24</sup> South Carolina Electric & Gas Company, "Petitions for Updates and Revisions to the Capital Cost Schedule and the Construction Schedule," before the Public Service Commission of South Carolina, February 29, 2012, <http://www.scana.com/NR/rdonlyres/35AAED95-5226-416A-8DC2-0743BC93B911/0/2012PetitionToUpdateCostSchedules.pdf>. Total cost based on SCE&G ownership of 55%.

<sup>25</sup> Southern Company, "Smart Power," [http://www.southerncompany.com/smart\\_energy/smart\\_power\\_vogtle-kemper.html](http://www.southerncompany.com/smart_energy/smart_power_vogtle-kemper.html). Total cost based on Southern Company's 45.7% ownership.

<sup>26</sup> Duke Energy, "Duke Energy Reaches Revised Multi-year Settlement with Florida Consumer Advocates," news release, August 1, 2013, <http://www.duke-energy.com/news/releases/2013080101.asp>.

<sup>27</sup> NRG Energy, "NRG Energy, Inc. Provides Greater Clarity on the South Texas Nuclear Development Project," press release, April 19, 2011, <http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9OTAwMzB8Q2hpbGRJRD0tMXxUeXBIPtM=&t=1>.

<sup>28</sup> Jeff Beattie, "Southeast Utilities Seek Partners to Hedge Nuclear Bets," *Energy Daily*, October 5, 2010, p. 1.

TVA decided to defer consideration of its COL application for two new Westinghouse AP1000 reactors at its Bellefonte plant in Alabama in favor of completing the first of two unfinished Babcock & Wilcox reactors at the site. TVA had submitted a COL application for the Bellefonte AP1000s in October 2007 as part of the NuStart consortium.<sup>29</sup>

Constellation Energy announced October 9, 2010, that it was abandoning negotiations with DOE for a loan guarantee for the planned Calvert Cliffs 3 reactor, which Constellation had been developing as part of its UniStar joint venture with the French national utility EDF.<sup>30</sup> Constellation sold its share of UniStar to EDF so that EDF could seek another U.S. partner to continue the Calvert Cliffs project.<sup>31</sup> (For more discussion of Constellation’s decision, see the “Loan Guarantees” section below.)

NRC anticipates that several more COL and other license applications will be submitted in the next two years. This includes a TVA plan to submit construction permit applications for six small modular reactors (SMRs) of about 160 megawatts each at its Clinch River, TN, site.

**Table I. Announced Nuclear Plant License Applications**

Announced Applicant	Site	Reactor Type	Units	Status
<b>COL issued</b>				
Southern	Vogtle (GA)	Westinghouse AP1000	2	COL application submitted 3/13/08; engineering, procurement, and construction (EPC) contract signed 4/8/08; ESP and limited construction approved 8/26/09; conditional DOE loan guarantee announced 2/16/10; NRC hearing held 9/27-28/11; COL approved 2/9/12; first “safety-related concrete” poured 3/14/13
SCE&G	Summer (SC)	Westinghouse AP1000	2	COL submitted 3/31/08; EPC contract signed 5/27/08; COL approved 3/30/12; first “safety-related concrete” poured 3/11/13
<b>COL scheduled for completion</b>				
Duke Energy	Levy County (FL)	Westinghouse AP1000	2	COL submitted 7/30/08; application scheduled for completion in 2014; termination of EPC contract announced 8/1/13
DTE Energy	Fermi (MI)	GE ESBWR	1	COL submitted 9/18/08; application scheduled for completion in 2015
Nuclear Innovation North America	South Texas Project	Toshiba ABWR	2	COL submitted 9/20/07; EPC contract signed with Toshiba 2/12/09; NRG Energy halted further investment 4/19/11; application scheduled for

<sup>29</sup> Tennessee Valley Authority, “Single Nuclear Unit at the Bellefonte Plant Site,” fact sheet, <http://www.tva.gov/environment/reports/blnp/index.htm>.

<sup>30</sup> Constellation Energy, “Constellation Energy Releases Statement Regarding U.S. Department of Energy Loan Guarantee,” press release, October 9, 2010, <http://ir.constellation.com/releasedetail.cfm?ReleaseID=516614>.

<sup>31</sup> Letter from Michael J. Wallace, Vice Chairman and Chief Operating Officer, Constellation Energy, to Thomas Piquemal, Group Executive Vice President, Finance, EDF, October 15, 2010, [http://files.shareholder.com/downloads/CEG/1036755503x0x410084/e27369a0-ce85-432f-bfad-e17ddce4f8f2/101510\\_-\\_EDF\\_letter.pdf](http://files.shareholder.com/downloads/CEG/1036755503x0x410084/e27369a0-ce85-432f-bfad-e17ddce4f8f2/101510_-_EDF_letter.pdf); Unistar, “EDF and Constellation Energy Announce Comprehensive Agreement,” press release, October 27, 2010, <http://press.edf.com/press-releases/all-press-releases/2010/edf-and-constellation-energy-announce-comprehensive-agreement-82018.html&return=42873>.

<b>Announced Applicant</b>	<b>Site</b>	<b>Reactor Type</b>	<b>Units</b>	<b>Status</b>
				completion in 2015
Duke Energy	William States Lee (SC)	Westinghouse AP1000	2	COL submitted 12/13/07; application scheduled for completion in 2015
<b>COL schedule under revision</b>				
FPL	Turkey Point (FL)	Westinghouse AP1000	2	COL submitted 6/30/09; preconstruction work being conducted
Luminant Power	Comanche Peak (TX)	Mitsubishi US-APWR	2	COL submitted 9/19/08
PPL	Bell Bend (PA)	Areva EPR	1	COL submitted 10/10/08
UniStar	Calvert Cliffs (MD)	Areva EPR	1	COL submitted 7/13/07 (Part 1), 3/13/08 (Part 2); Constellation withdrew from project 10/8/10
Dominion	North Anna	Mitsubishi US-APWR	1	COL submitted 11/27/07; ESP approved 11/20/07; reactor selection announced 5/7/10
<b>Licensing suspended</b>				
Entergy	Grand Gulf (MS)	Not specified	1	COL submitted 2/27/08; licensing suspended 1/9/09; ESP approved 3/27/07
Exelon	Victoria County (TX)	Not specified	2	COL application withdrawn and ESP application submitted 3/25/10; ESP application withdrawn 8/28/12
AmerenUE	Calloway (MO)	Areva EPR	1	COL submitted 7/24/08; license review suspended 6/23/09
Entergy	River Bend (LA)	Not specified	1	COL submitted 9/25/08; licensing suspended 1/9/09
TVA	Bellefonte	Westinghouse AP1000	2	COL submitted 10/30/07; licensing deferred 9/29/10
Unistar	Nine Mile Point (NY)	Areva EPR	1	COL submitted 9/30/08; licensing suspended 12/1/09
Duke Energy	Harris (NC)	Westinghouse AP1000	2	COL submitted 2/19/08; EPC contract signed 1/5/09; licensing suspended 5/2/13
<b>Anticipated license applications</b>				
TVA	Clinch River (TN)	mPower small modular reactor	6	Construction permit application expected in 2015
AmerenUE	Missouri	Westing. SMR	1	COL application expected in 2015
<b>Total units announced</b>			<b>38</b>	
<b>Total currently active COLs</b>			<b>18</b>	

**Sources:** NRC, *Nucleonics Week*, *Nuclear News*, Nuclear Energy Institute, company news releases.

**Note:** Applications are for COLs unless otherwise specified.

# Nuclear Power Plant Safety and Regulation

## Safety

Worldwide concern about nuclear power plant safety rose sharply after the Fukushima accident, which is generally considered to be much worse than the March 1979 Three Mile Island accident in Pennsylvania but not as severe as the April 1986 Chernobyl disaster in the former Soviet Union. Total radioactive releases from the Fukushima accident have been estimated at 25 million curies,<sup>32</sup> compared with 140 million curies from Chernobyl<sup>33</sup> and 43,000 curies from Three Mile Island.<sup>34</sup>

The Fukushima disaster resulted in similar levels of radioactive contamination per square meter to that of Chernobyl, but the Fukushima contamination was much less widespread and affected a smaller number of people.<sup>35</sup> (For more background on the Fukushima accident, see CRS Report R41694, *Fukushima Nuclear Disaster*, by Mark Holt, Richard J. Campbell, and Mary Beth D. Nikitin.)<sup>36</sup>

The Fukushima accident has raised particular policy questions for the United States because, unlike Chernobyl, the Fukushima reactors are similar to common U.S. designs. Although the Fukushima accident resulted from a huge tsunami that incapacitated the power plant's emergency diesel generators, the accident dramatically illustrated the potential consequences of any natural catastrophe or other situation that could cause an extended "station blackout" – the loss of alternating current (AC) power. Safety issues related to station blackout include standards for backup batteries, which had been required to provide power for 4-8 hours, and additional measures that may be required to assure backup power.

Safety concerns at U.S. reactors were also raised by hydrogen explosions at three of the Fukushima reactors—resulting from a high-temperature reaction between steam and nuclear fuel cladding—and the loss of cooling at the Japanese plant's spent fuel storage pools. Other safety issues that have been raised in the wake of Fukushima include the vulnerability of U.S. nuclear plants to earthquakes, floods, and other natural disasters, the availability of iodine pills to prevent absorption of radioactive iodine released during nuclear accidents, and the adequacy of nuclear accident emergency planning.

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<sup>32</sup> World Nuclear Association, "Fukushima Accident 2011," September 9, 2013, <http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Fukushima-Accident-2011>.

<sup>33</sup> World Nuclear Association, "Chernobyl Accident 1986," June 2013, <http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Chernobyl-Accident>.

<sup>34</sup> Nuclear Regulatory Commission, "Backgrounder on the Three Mile Island Accident," February 11, 2013, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>.

<sup>35</sup> French Institut de Radioprotection et de Surete Nucleaire (IRSN), Assessment on the 66<sup>th</sup> Day of Projected External Doses for Populations Living in the North-West Fallout Zone of the Fukushima Nuclear Accident, Report DRPH/2011-10, p. 27, <http://www.irsn.fr/EN/news/Documents/IRSN-Fukushima-Report-DRPH-23052011.pdf>.

<sup>36</sup> See also Institute of Nuclear Power Operations, *Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station*, INPO 11-005, November 2011, available from the Nuclear Energy Institute at <http://www.nei.org/resourcesandstats/documentlibrary/safetyandsecurity/reports/special-report-on-the-nuclear-accident-at-the-fukushima-daiichi-nuclear-power-station>.

In response to such concerns, NRC on March 23, 2011, established a task force “made up of current senior managers and former NRC experts” to “conduct both short- and long-term analysis of the lessons that can be learned from the situation in Japan.”<sup>37</sup> The Near-Term Task Force issued its report July 12, 2011, making recommendations ranging from specific safety improvements to broad changes in NRC’s overall regulatory approach.<sup>38</sup> NRC staff subsequently identified several of those actions that “can and should be initiated without delay.”<sup>39</sup> The NRC Commissioners largely agreed with the recommendations on October 18, 2011, and instructed the agency’s staff to “strive to complete and implement the lessons learned from the Fukushima accident within five years—by 2016.”<sup>40</sup> Tier 1 regulatory actions, which are now being implemented, include<sup>41</sup>

- *Seismic and flood hazard reevaluations and walkdowns.* Nuclear plant operators must evaluate the implications of updated seismic and flooding models, including all potential flooding sources. Plant operators must identify and verify the adequacy of flood and seismic protection features at their sites.
- *Station blackout regulatory actions.* NRC issued an order on March 12, 2012, that required U.S. reactors to implement mitigation strategies “that will allow them to cope without their permanent electrical power sources for an indefinite amount of time.” Under the order, installed equipment at each plant must be sufficient to maintain or restore cooling until portable on-site equipment and supplies could take over. The portable on-site equipment would have to provide sufficient cooling until “sufficient offsite resources” could be brought in to maintain cooling indefinitely. Enough equipment and personnel would be required to protect all affected reactors at a multi-unit plant. NRC is currently preparing permanent regulations based on the mitigation strategies order.
- *Reliable hardened vents for Mark I containments.* NRC on March 12, 2012, ordered nuclear plants to install “reliable, hardened” vents for the containments in Mark I reactors (the type at Fukushima). The vents would be designed to reduce containment pressure before damage occurs to the reactor core. NRC modified the order in June 2013 to require that the vents continue to function after core damage occurs, which could prevent hydrogen generated by overheated fuel cladding from leaking into the reactor building, as occurred at Fukushima. Because venting after core damage has occurred could release radioactive core material into the environment, NRC is also considering a requirement that vents include filters or that other strategies be implemented to reduce such emissions.

<sup>37</sup> Nuclear Regulatory Commission, “Nuclear Regulatory Commission Directs Staff on Continuing Agency Response to Japan Events; Adjust Commission Schedule,” press release, March 23, 2011, <http://pbadupws.nrc.gov/docs/ML1108/ML110821123.pdf>.

<sup>38</sup> Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, *Recommendations for Enhancing Reactor Safety in the 21<sup>st</sup> Century*, Nuclear Regulatory Commission, Washington, DC, July 12, 2011, <http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf>.

<sup>39</sup> NRC, “Recommended Actions to Be Taken Without Delay from the Near-Term Task Force Report,” SECY-11-0124, September 9, 2011.

<sup>40</sup> NRC, “Staff Requirements – SECY-11-0124 – Recommended Actions to Be Taken Without Delay from the Near-Term Task Force Report,” October 18, 2011, <http://pbadupws.nrc.gov/docs/ML1126/ML11269A204.pdf>.

<sup>41</sup> NRC, “What Are the Lessons Learned from Fukushima?,” June 26, 2013, <http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/priorities.html>.

- *Spent fuel pool instrumentation.* NRC ordered nuclear plants on March 12, 2012, to install safety instrumentation to monitor spent fuel pool conditions, such as water level, temperature, and radiation levels, from the plant control room.
- *Strengthening and integrating accident procedures and guidelines.* NRC issued an Advanced Notice of Proposed Rulemaking on April 18, 2012, to require integrated emergency procedures, including clear command-and-control strategies and training qualifications for emergency decisionmakers.
- *Emergency preparedness regulatory actions.* NRC has asked nuclear plants how many workers would be needed to respond to large accidents affecting multiple reactors at the same site. In addition, plants were asked to assess and ensure the operability of emergency communications systems during such accidents.

The NRC staff slightly modified its proposals for top priority actions and divided the remaining Task Force proposals into two lower tiers, which were determined to require further assessment and potentially long-term study. Included in the lower-tier actions were requirements for emergency water supply systems for spent fuel pools, secure power for emergency communications and data systems, confirmation of seismic and flooding hazards, and modifications to NRC's regulatory process.<sup>42</sup>

## Emergency Planning

Following the Three Mile Island accident, which revealed severe weaknesses in preparations for nuclear plant emergencies, Congress mandated that emergency plans be prepared for all licensed power reactors (P.L. 96-295, Sec. 109). NRC was required to develop standards for emergency plans and review the adequacy of each plant-specific plan in consultation with the Federal Emergency Management Agency (FEMA).

NRC's emergency planning requirements focus on a "plume exposure pathway emergency planning zone (EPZ)," encompassing an area within about 10 miles of each nuclear plant. Within the 10-mile EPZ, a range of responses must be developed to protect the public from radioactive releases, including evacuation, sheltering, and the distribution of non-radioactive iodine (as discussed above). The regulations also require a 50-mile "ingestion pathway EPZ," in which actions are developed to protect food supplies.<sup>43</sup> Nuclear plants are required to conduct emergency preparedness exercises every two years. The exercises, which are evaluated by FEMA and NRC, may include local, state, and federal responders and may involve both the plume and ingestion EPZs.<sup>44</sup>

The size of the plume exposure EPZ has long been a subject of controversy, particularly after the 9/11 terrorist attacks on the United States, in which nuclear plants were believed to have been a potential target. Attention to the issue was renewed by the Fukushima accident, in which some of the highest radiation dose rates have been measured beyond 10 miles from the plant.<sup>45</sup>

<sup>42</sup> R.W. Borchardt, NRC Executive Director for Operations, "Prioritization of Recommended Actions to Be Taken in Response to Fukushima Lessons Learned," SECY-11-0137, October 3, 2011.

<sup>43</sup> 10 CFR 50.47, Emergency Plans.

<sup>44</sup> Nuclear Regulatory Commission, "Emergency Preparedness & Response," website, <http://www.nrc.gov/about-nrc/emerg-preparedness.html>.

<sup>45</sup> Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT), "Readings of Integrated Dose at (continued...)"

Controversy over the issue intensified after NRC recommended on March 16, 2011, the evacuation of U.S. citizens within 50 miles of the Fukushima plant. The NRC recommendation was based on computer models that, using meteorological data and estimates of plant conditions, found that potential radiation doses 50 miles from the plant could exceed U.S. protective action guidelines.<sup>46</sup>

In response to the 9/11 terrorist attacks, NRC modified its nuclear plant emergency planning requirements and began a comprehensive review of emergency planning regulations and guidance. The NRC staff sent a proposed final rule based on that review to the NRC Commissioners for approval on April 8, 2011, and the rule took effect December 23, 2011.<sup>47</sup> Among the changes included in the rule are new requirements for periodic updates of EPZ evacuation time estimates, mandatory backups for public alert systems, and protection of emergency responders during terrorist attacks. The new emergency planning regulations were prepared before the Fukushima accident, but the NRC staff recommended approval of the changes without waiting for further changes that might result from the lessons of the Japanese accident. Emergency planning changes resulting from Fukushima should be implemented later, the staff recommended.<sup>48</sup>

## Domestic Reactor Safety Experience

Nuclear power safety has been a longstanding issue in the United States. Safety-related shortcomings have been identified in the construction quality of some plants, plant operation and maintenance, equipment reliability, emergency planning, and other areas. In one serious case, it was discovered in March 2002 that leaking boric acid had eaten a large cavity in the top of the reactor vessel in Ohio's Davis-Besse nuclear plant. The corrosion left only the vessel's quarter-inch-thick stainless steel inner liner to prevent a potentially catastrophic loss of reactor cooling water. Davis-Besse remained closed for repairs and other safety improvements until NRC allowed the reactor to restart in March 2004.

NRC's oversight of the nuclear industry is a subject of contention as well; nuclear utilities often complain that they are subject to overly rigorous and inflexible regulation, but nuclear critics charge that NRC frequently relaxes safety standards when compliance may prove difficult or costly to the industry.

In terms of public health consequences, the safety record of the U.S. nuclear power industry in comparison with other major commercial energy technologies has been excellent. During more than 3,500 reactor-years of operation in the United States,<sup>49</sup> the only incident at a commercial

(...continued)

Monitoring Post out of 20 Km Zone of Fukushima Dai-ichi NPP," data series, <http://www.mext.go.jp/english/incident/1304275.htm>.

<sup>46</sup> Nuclear Regulatory Commission, "NRC Provides Protective Action Recommendations Based on U.S. Guidelines," press release, March 16, 2011, <http://pbadupws.nrc.gov/docs/ML1108/ML110800133.pdf>.

<sup>47</sup> Nuclear Regulatory Commission, "Enhancements to Emergency Planning Regulations," Final rule, *Federal Register*, November 23, 2011, p. 72560.

<sup>48</sup> Nuclear Regulatory Commission, "Final Rule: Enhancements to Emergency Preparedness Regulations," SECY-11-0053, April 8, 2011, <http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2011/2011-0053scy.pdf>.

<sup>49</sup> Nuclear Energy Institute, "Myths and Facts About Nuclear Energy," January 2012, p. 12, <http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/factsheet/myths—facts-about-nuclear-energy-january-2012>.

nuclear power plant that might lead to any deaths or injuries to the public has been the Three Mile Island accident, in which more than half the reactor core melted.<sup>50</sup> A study of 32,000 people living within five miles of the reactor when the accident occurred found no significant increase in cancer rates through 1998, although the authors noted that some potential health effects “cannot be definitively excluded.”<sup>51</sup>

The relatively small amounts of radioactivity released by nuclear plants during normal operation are not generally believed to pose significant hazards, although some groups contend that routine emissions are unacceptably risky. There is substantial scientific uncertainty about the level of risk posed by low levels of radiation exposure; as with many carcinogens and other hazardous substances, health effects can be clearly measured only at relatively high exposure levels. In the case of radiation, the assumed risk of low-level exposure has been extrapolated mostly from health effects documented among persons exposed to high levels of radiation, particularly Japanese survivors of nuclear bombing in World War II, medical patients, and nuclear industry workers.<sup>52</sup>

NRC announced April 7, 2010, that it had asked the National Academy of Sciences (NAS) to “perform a state-of-the-art study on cancer risk for populations surrounding nuclear power facilities.” Unlike in previous studies, NAS is to examine cancer diagnosis rates, rather than cancer deaths, potentially increasing the amount of data. The new study would also use geographic units smaller than counties to determine how far members of the study group are located from reactors, to more clearly determine whether there is a correlation between cancer cases and distance from reactors.<sup>53</sup>

NRC’s 1986 Safety Goal Policy Statement declared that nuclear power plants should not increase the risk of accidental or cancer deaths among the nearby population by more than 0.1%.<sup>54</sup> Later NRC guidance established a “subsidiary benchmark” for the probability of accidental core damage (fuel melting): Core damage frequency should average no more than one in 10,000 per reactor per year.<sup>55</sup> In addition, NRC set a benchmark that reactor containments should be successful at least 90% of the time in preventing major radioactive releases during a core-damage accident. Therefore, the benchmark probability of a major release from containment failure during a core melt accident would average less than one in 100,000 per reactor per year.<sup>56</sup> (For the

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<sup>50</sup> Nuclear Regulatory Commission, “Backgrounder on the Three Mile Island Accident,” March 15, 2011, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>.

<sup>51</sup> Evelyn O. Talbott et al., “Long Term Follow-Up of the Residents of the Three Mile Island Accident Area: 1979-1998,” *Environmental Health Perspectives*, published online October 30, 2002, at <http://ehp.niehs.nih.gov/docs/2003/5662/abstract.html>.

<sup>52</sup> National Research Council, Committee to Assess the Health Risks from Exposure to Low Levels of Ionizing Radiation, *Beir VII: Health Risks from Exposure to Low Levels of Ionizing Radiation, Report in Brief*, [http://dels-old.nas.edu/dels/rpt\\_briefs/beir\\_vii\\_final.pdf](http://dels-old.nas.edu/dels/rpt_briefs/beir_vii_final.pdf).

<sup>53</sup> Nuclear Regulatory Commission, “NRC Asks National Academy of Sciences to Study Cancer Risk in Populations Living Near Nuclear Power Facilities,” press release, April 7, 2010, <http://www.nrc.gov/reading-rm/doc-collections/news/2010/10-060.html>.

<sup>54</sup> NRC, “Safety Goals for the Operations of Nuclear Power Plants,” policy statement, *Federal Register*, August 21, 1986, p. 30028, <http://www.nrc.gov/reading-rm/doc-collections/commission/policy/51fr30028.pdf>.

<sup>55</sup> NRC Staff Requirements Memorandum on SECY-89-102, “Implementation of the Safety Goals,” Memorandum to James M. Taylor from Samuel J. Chilk, June 15, 1990, <http://pbadupws.nrc.gov/docs/ML0037/ML003707881.pdf>.

<sup>56</sup> U.S. NRC, Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Revision 1, November 2002, <http://www.nrc.gov/reading-rm/doc-collections/reg-guides/power-reactors/rg/01-174>.

current U.S. fleet of about 100 reactors, that rate would yield an average of one core-damage accident every 100 years and a major release every 1,000 years.) On the other hand, some groups challenge the complex calculations that go into predicting such accident frequencies, contending that accidents with serious public health consequences may be more frequent.<sup>57</sup>

## Reactor Safety in the Former Soviet Bloc

The Chernobyl accident was by far the worst nuclear power plant accident to have occurred anywhere in the world. At least 31 persons died quickly from acute radiation exposure or other injuries, and thousands of additional cancer deaths among the tens of millions of people exposed to radiation from the accident may occur during the next several decades.

According to a 2006 report by the Chernobyl Forum organized by the International Atomic Energy Agency, the primary observable health consequence of the accident was a dramatic increase in childhood thyroid cancer. The Chernobyl Forum estimated that about 4,000 cases of thyroid cancer have occurred in children who after the accident drank milk contaminated with high levels of radioactive iodine, which concentrates in the thyroid. Although the Chernobyl Forum found only 15 deaths from those thyroid cancers, it estimated that about 4,000 other cancer deaths may have occurred among the 600,000 people with the highest radiation exposures, plus an estimated 1% increase in cancer deaths among persons with less exposure. The report estimated that about 77,000 square miles were significantly contaminated by radioactive cesium.<sup>58</sup> Greenpeace issued a report in 2006 estimating that 200,000 deaths in Belarus, Russia, and Ukraine resulted from the Chernobyl accident between 1990 and 2004.<sup>59</sup>

## Licensing and Regulation

For many years, a top priority of the U.S. nuclear industry was to modify the process for licensing new nuclear plants. No electric utility would consider ordering a nuclear power plant, according to the industry, unless licensing became quicker and more predictable, and designs were less subject to mid-construction safety-related changes required by NRC. The Energy Policy Act of 1992 (P.L. 102-486) largely implemented the industry's licensing goals.

Nuclear plant licensing under the Atomic Energy Act of 1954 (P.L. 83-703; U.S.C. 2011-2282) had historically been a two-stage process. NRC first issued a construction permit to build a plant and then, after construction was finished, an operating license to run it. Each stage of the licensing process involved adjudicatory proceedings. Environmental impact statements also are required under the National Environmental Policy Act.

Over the vehement objections of nuclear opponents, the Energy Policy Act of 1992 provided a clear statutory basis for one-step nuclear licenses. Under the new process, NRC can issue combined construction permits and operating licenses (COLs) and allow completed plants to operate without delay if they meet all construction requirements—called “inspections, tests,

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<sup>57</sup> Public Citizen Energy Program, “The Myth of Nuclear Safety,” [http://www.citizen.org/cmep/energy\\_enviro\\_nuclear/nuclear\\_power\\_plants/reactor\\_safety/articles.cfm?ID=4454](http://www.citizen.org/cmep/energy_enviro_nuclear/nuclear_power_plants/reactor_safety/articles.cfm?ID=4454).

<sup>58</sup> The Chernobyl Forum: 2003-2005, *Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts*, International Atomic Energy Agency, April 2006.

<sup>59</sup> Greenpeace. *The Chernobyl Catastrophe: Consequences on Human Health*, April 2006, p. 10.

analyses, and acceptance criteria,” or ITAAC. NRC would hold preoperational hearings on the adequacy of plant construction only in specified circumstances.

DOE’s Nuclear Power 2010 program had paid up to half the cost of several COLs and early site permits to test the revised licensing procedures. However, the COL process cannot be fully tested until construction of new reactors is completed. At that point, it could be seen whether completed plants will be able to operate without delays or whether adjudicable disputes over construction adequacy may arise. Section 638 of the Energy Policy Act of 2005 (EPACT05, P.L. 109-58) authorizes federal payments to the owner of a completed reactor whose operation is held up by regulatory delays. The nuclear industry is asking Congress to require NRC to use informal procedures in determining whether ITAAC have been met, eliminate mandatory hearings on uncontested issues before granting a COL, and make other changes in the licensing process.<sup>60</sup>

A fundamental concern in the nuclear regulatory debate is the performance of NRC in issuing and enforcing nuclear safety regulations. The nuclear industry and its supporters have regularly complained that unnecessarily stringent and inflexibly enforced nuclear safety regulations have burdened nuclear utilities and their customers with excessive costs. But many environmentalists, nuclear opponents, and other groups charge NRC with being too close to the nuclear industry, a situation that they say has resulted in lax oversight of nuclear power plants and routine exemptions from safety requirements.

Primary responsibility for nuclear safety compliance lies with nuclear plant owners, who are required to find any problems with their plants and report them to NRC. Compliance is also monitored directly by NRC, which maintains at least two resident inspectors at each nuclear power plant. The resident inspectors routinely examine plant systems, observe the performance of reactor personnel, and prepare regular inspection reports. For serious safety violations, NRC often dispatches special inspection teams to plant sites.

NRC’s reactor safety program is based on “risk-informed regulation,” in which safety enforcement is guided by the relative risks identified by detailed individual plant studies. NRC’s risk-informed reactor oversight system, inaugurated April 2, 2000, relies on a series of performance indicators to determine the level of scrutiny that each reactor should receive.<sup>61</sup>

## **Reactor Security**

Nuclear power plants have long been recognized as potential targets of terrorist attacks, and critics have long questioned the adequacy of requirements for nuclear plant operators to defend against such attacks. All commercial nuclear power plants licensed by NRC have a series of physical barriers against access to vital reactor areas and are required to maintain a trained security force to protect them.

A key element in protecting nuclear plants is the requirement that simulated terrorist attacks, monitored by NRC, be carried out to test the ability of the plant operator to defend against them.

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<sup>60</sup> Nuclear Energy Institute, *Legislative Proposal to Help Meet Climate Change Goals by Expanding U.S. Nuclear Energy Production*, Washington, DC, October 28, 2009, p. 5, <http://www.nei.org/resourcesandstats/documentlibrary/newplants/policybrief/2009-nuclear-policy-initiative>.

<sup>61</sup> For more information about the NRC reactor oversight process, see <http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/index.html>.

The severity of attacks that plant security must prepare for is specified in the “design basis threat” (DBT).

EPACT05 required NRC to revise the DBT based on an assessment of terrorist threats, the potential for multiple coordinated attacks, possible suicide attacks, and other criteria. NRC approved the DBT revision based on those requirements on January 29, 2007. The revised DBT does not require nuclear power plants to defend against deliberate aircraft attacks. NRC contended that nuclear facilities were already required to mitigate the effects of large fires and explosions, no matter what the cause, and that active protection against airborne threats was being addressed by U.S. military and other agencies.<sup>62</sup> After much consideration, NRC voted February 17, 2009, to require all new nuclear power plants to incorporate design features that would ensure that, in the event of a crash by a large commercial aircraft, the reactor core would remain cooled or the reactor containment would remain intact, and radioactive releases would not occur from spent fuel storage pools.<sup>63</sup> The rule change was published in the Federal Register June 12, 2009.<sup>64</sup>

NRC rejected proposals that existing reactors also be required to protect against aircraft crashes, such as by adding large external steel barriers. However, NRC did impose some additional requirements related to aircraft crashes on all reactors, both new and existing, after the 9/11 terrorist attacks of 2001. In 2002, as noted above, NRC ordered all nuclear power plants to develop strategies to mitigate the effects of large fires and explosions that could result from aircraft crashes or other causes. An NRC regulation on fire mitigation strategies, along with requirements that reactors establish procedures for responding to specific aircraft threats, was approved December 17, 2008.<sup>65</sup> The fire mitigation rules were published in the Federal Register March 27, 2009.<sup>66</sup>

Other ongoing nuclear plant security issues include the vulnerability of spent fuel pools, which hold highly radioactive nuclear fuel after its removal from the reactor, standards for nuclear plant security personnel, and nuclear plant emergency planning. NRC’s March 2009 security regulations addressed some of those concerns and included a number of other security enhancements.

EPACT05 required NRC to conduct force-on-force security exercises at nuclear power plants every three years (which was NRC’s previous policy), authorized firearms use by nuclear security personnel (preempting some state restrictions), established federal security coordinators, and required fingerprinting of nuclear facility workers.

(For background on security issues, see CRS Report RL34331, *Nuclear Power Plant Security and Vulnerabilities*, by Mark Holt and Anthony Andrews.)

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<sup>62</sup> NRC Office of Public Affairs, *NRC Approves Final Rule Amending Security Requirements*, News Release No. 07-012, January 29, 2007.

<sup>63</sup> Nuclear Regulatory Commission, *Final Rule—Consideration of Aircraft Impacts for New Nuclear Power Reactors, Commission Voting Record*, SECY-08-0152, February 17, 2009.

<sup>64</sup> Nuclear Regulatory Commission, “Consideration of Aircraft Impacts for New Nuclear Power Reactors,” Final Rule, 74 *Federal Register* 28111, June 12, 2009. This provision is codified at 10 CFR 50.150.

<sup>65</sup> Nuclear Regulatory Commission, “NRC Approves Final Rule Expanding Security Requirements for Nuclear Power Plants,” press release, December 17, 2008, <http://www.nrc.gov/reading-rm/doc-collections/news/2008/08-227.html>.

<sup>66</sup> Nuclear Regulatory Commission, “Power Reactor Security Requirements,” Final Rule, 74 *Federal Register* 13925, March 27, 2009.

## Decommissioning

When nuclear power plants reach the end of their useful lives, they must be safely removed from service, a process called *decommissioning*. NRC requires nuclear utilities to make regular contributions to dedicated funds to ensure that money is available to remove radioactive material and contamination from reactor sites after they are closed.

The first full-sized U.S. commercial reactors to be decommissioned were the Trojan plant in Oregon, whose decommissioning completion received NRC approval on May 23, 2005, and the Maine Yankee plant, for which NRC approved most of the site cleanup on October 3, 2005. The Trojan decommissioning cost \$429 million, according to reactor owner Portland General Electric, and the Maine Yankee decommissioning cost about \$500 million.<sup>67</sup> Decommissioning of the Connecticut Yankee plant cost \$790 million and was approved by NRC on November 26, 2007.<sup>68</sup> NRC approved the cleanup of the decommissioned Rancho Seco reactor site in California on October 7, 2009.<sup>69</sup> The decommissioning of Rancho Seco was estimated to cost \$500 million, excluding future demolition of the cooling towers and other remaining plant structures.<sup>70</sup>

When a reactor is permanently shut down, the owner (licensee) has 30 days to notify NRC. The licensee then certifies with NRC when spent fuel has been permanently removed from the reactor vessel. By two years after shutdown, the licensee must submit a Post Shutdown Decommissioning Activities Report (PSDAR). The PSDAR specifies which of the two primary decommissioning options will be pursued:

- DECON: Plant and equipment are dismantled and removed, or decontaminated to the level required for release from NRC licensing.
- SAFSTOR: The plant is placed in a safe, stable condition for future dismantlement and decontamination.

According to NRC, nine reactors are currently in SAFSTOR: Dresden 1 (IL), Indian Point 1 (NY), La Crosse (WI), Millstone 1 (CT), Peach Bottom 1 (PA), San Onofre 1 (CA), GE Vallecitos (CA), NS Savannah (MD), and Three Mile Island 2 (PA). Four units are in DECON: Fermi 1 (MI), Humboldt Bay (CA), and Zion 1 and 2 (IL).<sup>71</sup>

After nuclear reactors are decommissioned, the spent nuclear fuel (SNF) accumulated during their operating lives remains stored in pools or dry casks at the plant sites. About 2,800 metric tons of spent fuel is currently stored at nine closed nuclear power plants. Another 3,100 metric tons is stored at the four plants announced for closure in 2013.<sup>72</sup> “Until this SNF is removed from these nine sites, the sites cannot be fully decommissioned and made available for other purposes,” DOE

<sup>67</sup> Sharp, David, “NRC Signs Off on Maine Yankee’s Decommissioning,” *Associated Press*, October 3, 2005.

<sup>68</sup> E-mail communication from Bob Capstick, Connecticut Yankee Atomic Power Company, August 28, 2008.

<sup>69</sup> Nuclear Regulatory Commission, “NRC Releases Rancho Seco Nuclear Plant for Unconditional Use,” press release, October 7, 2009, <http://www.nrc.gov/reading-rm/doc-collections/news/2009/09-165.html>.

<sup>70</sup> “20 Years Later, Rancho Seco Ready for Final Shutdown,” *Sacramento County Herald*, June 9, 2009, <http://m.news10.net/news.jsp?key=190656>.

<sup>71</sup> NRC, *Information Digest, 2013-2014*, NUREG-1350, Volume 25, Appendix C, <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350>.

<sup>72</sup> Gutherman Technical Service, “2011 Used Fuel Data,” January 14, 2012.

noted in a 2008 report.<sup>73</sup> President Obama’s decision to terminate development of an underground spent fuel repository at Yucca Mountain, NV, has increased concerns about the ultimate disposition of spent fuel at decommissioned sites. (For more information, see CRS Report R42513, *U.S. Spent Nuclear Fuel Storage*, by James D. Werner.)

## Nuclear Accident Liability

Liability for damages to the general public from nuclear incidents is addressed by the Price-Anderson Act (primarily Section 170 of the Atomic Energy Act of 1954, 42 U.S.C. 2210). EPACT05 extended the availability of Price-Anderson coverage for new reactors and new DOE nuclear contracts through the end of 2025. (Existing reactors and contracts were already covered.)

Under Price-Anderson, the owners of commercial reactors must assume all liability for nuclear damages awarded to the public by the court system, and they must waive most of their legal defenses following a severe radioactive release (“extraordinary nuclear occurrence”). To pay any such damages, each licensed reactor with at least 100 megawatts of electric generating capacity must carry the maximum liability insurance reasonably available, which was raised from \$300 million to \$375 million on January 1, 2010.<sup>74</sup> Any damages exceeding \$375 million are to be assessed equally against all 100-megawatt-and-above power reactors, up to \$121.3 million per reactor (increased for inflation from \$111.9 million on September 10, 2013).<sup>75</sup> Those assessments—called “retrospective premiums”—would be paid at an annual rate of no more than \$19.0 million per reactor (up from \$17.5 million), to limit the potential financial burden on reactor owners following a major accident. According to NRC, 104 commercial reactors, including the four closed in 2013, are currently covered by the Price-Anderson retrospective premium requirement.<sup>76</sup>

For each nuclear incident, the Price-Anderson liability system currently would provide up to \$13 billion in public compensation. That total includes \$121.3 million in retrospective premiums from each of the 104 currently covered reactors, totaling \$12.6 billion, plus the \$375 million in insurance coverage carried by the reactor that suffered the incident. On top of those payments, a 5% surcharge may also be imposed, raising the total per-reactor retrospective premium to \$127.4 million and the total available compensation to about \$13.6 billion. Under Price-Anderson, the nuclear industry’s liability for an incident is capped at that amount, which varies over time depending on the number of covered reactors, the amount of available insurance, and the inflation adjustment. Payment of any damages above that liability limit would require congressional approval under special procedures in the act.

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<sup>73</sup> DOE Office of Civilian Radioactive Waste Management, *Report to Congress on the Demonstration of the Interim Storage of Spent Nuclear Fuel from Decommissioned Nuclear Power Reactor Sites*, DOE/RW-0596, Washington, DC, December 2008, p. 1, [http://www.energy.gov/media/ES\\_Interim\\_Storage\\_Report\\_120108.pdf](http://www.energy.gov/media/ES_Interim_Storage_Report_120108.pdf).

<sup>74</sup> American Nuclear Insurers, “Need for Nuclear Liability Insurance,” January 2010, <http://www.nuclearinsurance.com/library/Nuclear%20Liability%20in%20the%20US.pdf>.

<sup>75</sup> NRC, “Inflation Adjustments to the Price-Anderson Financial Protection Regulations,” 79 *Federal Register* 41835, July 12, 2013.

<sup>76</sup> Reactors smaller than 100 megawatts must purchase an amount of liability coverage determined by NRC but are not subject to retrospective premiums. Total liability for those reactors is limited to \$560 million, with the federal government indemnifying reactor operators for the difference between that amount and their liability coverage (Atomic Energy Act Sec. 170 b. and c.).

EPACT05 increased the limit on per-reactor annual payments to \$15 million from the previous \$10 million, and required the annual limit to be adjusted for inflation every five years. As under previous law, the total retrospective premium limit is adjusted every five years as well. For the purposes of those payment limits, a nuclear plant consisting of multiple small reactors (100-300 megawatts, up to a total of 1,300 megawatts) would be considered a single reactor. Therefore, in the event of a severe release a power plant with six 120-megawatt small modular reactors would be liable for retrospective premiums of up to \$121.3 million, rather than \$727.8 million (excluding the 5% surcharge).

The Price-Anderson Act also covers contractors who operate DOE nuclear facilities. EPACT05 set the liability limit on DOE contractors at \$10 billion per accident, to be adjusted for inflation every five years. The first adjustment under EPACT, raising the liability limit to \$11.961 billion, took effect October 14, 2009.<sup>77</sup> The liability limit for DOE contractors previously had been the same as for commercial reactors, excluding the 5% surcharge, except when the limit for commercial reactors dropped because of a decline in the number of covered reactors. Price-Anderson authorizes DOE to indemnify its contractors for the entire amount of their liability, so that damage payments for nuclear incidents at DOE facilities would ultimately come from the Treasury. However, the law also allows DOE to fine its contractors for safety violations, and contractor employees and directors can face criminal penalties for “knowingly and willfully” violating nuclear safety rules. EPACT05 limited the civil penalties against a nonprofit contractor to the amount of management fees paid under that contract.

The Price-Anderson Act’s limits on liability were crucial in establishing the commercial nuclear power industry in the 1950s. Supporters of the Price-Anderson system contend that it has worked well since that time in ensuring that nuclear accident victims would have a secure source of compensation, at little cost to the taxpayer. Extension of the act was widely considered a prerequisite for new nuclear reactor construction in the United States. Opponents contend that Price-Anderson inappropriately subsidizes the nuclear power industry by reducing its insurance costs and protecting it from some of the financial consequences of the most severe conceivable accidents. Projections that damages to the public from the Fukushima accident will greatly exceed the Price-Anderson liability limits have prompted new calls for reexamination of the law.<sup>78</sup>

The U.S. government is supporting the establishment of an international liability system that, among other purposes, would cover U.S. nuclear equipment suppliers conducting foreign business. The Convention on Supplementary Compensation for Nuclear Damage (CSC) will not enter into force until at least five countries with a specified level of installed nuclear capacity have enacted implementing legislation. Such implementing language was included in the Energy Independence and Security Act of 2007 (P.L. 110-140, section 934), signed by President Bush December 19, 2007. Supporters of the Convention hope that more countries will join now that the United States has acted. Aside from the United States, three countries have submitted the necessary instruments of ratification, but the remaining nine countries that so far have signed the convention do not have the required nuclear capacity for it to take effect. Ratification by a large nuclear energy producer such as Japan would allow the treaty to take effect, as would ratification by two significant but smaller producers such as South Korea, Canada, Russia, or Ukraine.

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<sup>77</sup> Department of Energy, “Adjusted Indemnification Amount,” 74 *Federal Register* 52793, October 14, 2009.

<sup>78</sup> Ellen Vancko, Union of Concerned Scientists, “The Impact of Fukushima on the US Nuclear Power Industry,” presentation to the Center for Strategic and International Studies Conference on Nuclear Safety and Fukushima, April 7, 2011, [https://csis.org/files/attachments/110407\\_vancko\\_nuclear\\_safety\\_0.pdf](https://csis.org/files/attachments/110407_vancko_nuclear_safety_0.pdf).

Under the U.S. implementing legislation, the CSC would not change the liability and payment levels already established by the Price-Anderson Act. Each party to the convention would be required to establish a nuclear damage compensation system within its borders analogous to Price-Anderson. For any damages not covered by those national compensation systems, the convention would establish a supplemental tier of damage compensation to be paid by all parties. P.L. 110-140 requires the U.S. contribution to the supplemental tier to be paid by suppliers of nuclear equipment and services, under a formula to be developed by DOE. Supporters of the convention contend that it will help U.S. exporters of nuclear technology by establishing a predictable international liability system. For example, U.S. nuclear equipment sales to the growing economies of China and India would be facilitated by those countries' participation in the CSC liability regime.

## Federal Incentives for New Nuclear Plants

The nuclear power industry contends that support from the federal government would be needed for “a major expansion of nuclear energy generation.”<sup>79</sup> Significant incentives for building new nuclear power plants were included in the Energy Policy Act of 2005 (EPACT05, P.L. 109-58), signed by President Bush on August 8, 2005. These include production tax credits, loan guarantees, insurance against regulatory delays, and extension of the Price-Anderson Act nuclear liability system (discussed in the previous section on “Nuclear Accident Liability”). Relatively low prices for natural gas—nuclear power’s chief competitor—and rising estimated nuclear plant construction costs have decreased the likelihood that new reactors would be built without federal support. Any regulatory delays and increased safety requirements resulting from the Fukushima accident could also pose an obstacle to nuclear construction plans.

As a result, numerous bills have been introduced in recent years to strengthen or add to the EPACT05 incentives (see “Legislation in the 113<sup>th</sup> Congress” at the end of this report). Nuclear power critics have denounced the federal support programs and proposals as a “bailout” of the nuclear industry, contending that federal efforts should focus instead on renewable energy and energy efficiency.<sup>80</sup>

## Nuclear Production Tax Credit

EPACT05 provides a 1.8-cents/kilowatt-hour tax credit for up to 6,000 megawatts of new nuclear capacity for the first eight years of operation, up to \$125 million annually per 1,000 megawatts. The credit is not adjusted for inflation.

The Treasury Department published interim guidance for the nuclear production tax credit on May 1, 2006.<sup>81</sup> Under the guidance, the 6,000 megawatts of eligible capacity (enough for about four or five reactors) are to be allocated among reactors that filed license applications by the end

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<sup>79</sup> Nuclear Energy Institute, “NEI Unveils Package of Policy Initiatives Needed to Achieve Climate Change Goals,” press release, October 26, 2009, <http://www.nei.org/newsandevents/newsreleases/nei-unveils-package-of-policy-initiatives-needed-to-achieve-climate-change-goals/>.

<sup>80</sup> Nuclear Information and Resource Service, “Senate Appropriators Lard President Obama’s Stimulus Package with up to \$50 Billion in Nuclear Reactor Pork,” press release, January 30, 2009, <http://www.nirs.org/press/01-30-2009/1>.

<sup>81</sup> Department of the Treasury, Internal Revenue Service, *Internal Revenue Bulletin*, No. 2006-18, “Credit for Production From Advanced Nuclear Facilities,” Notice 2006-40, May 1, 2006, p. 855.

of 2008. If more than 6,000 megawatts of nuclear capacity ultimately qualify for the production tax credit, then the credit is to be allocated proportionally among any of the qualifying reactors that begin operating before 2021.

By the end of 2008, license applications had been submitted to NRC for more than 34,000 megawatts of nuclear generating capacity,<sup>82</sup> so if all those reactors were built before 2021 they would receive less than 20% of the maximum tax credit. However, the reactor licensing status shown in **Table 1** indicates that only four new units, totaling about 4,600 megawatts of capacity, are currently licensed for construction and likely to be completed before 2021. Seven other units, totaling about 9,000 megawatts, are scheduled to receive their licenses by 2015 and could possibly go into service by 2021.

The Nuclear Energy Institute (NEI) has urged Congress to remove the 6,000 megawatt capacity limit for the production tax credit, index it for inflation, and extend the deadline for plants to begin operation to the start of 2025. NEI is also proposing that a 30% investment tax credit be available for new nuclear construction as an alternative to the production credit.<sup>83</sup>

## Standby Support

Because the nuclear industry has often blamed licensing delays for past nuclear reactor construction cost overruns, EPACT05 authorizes the Secretary of Energy to provide “standby support,” or regulatory risk insurance, to help pay the cost of regulatory delays at up to six new commercial nuclear reactors. For the first two reactors that begin construction, the DOE payments could cover all the eligible delay-related costs, such as additional interest, up to \$500 million each. For the next four reactors, half of the eligible costs could be paid by DOE, with a payment cap of \$250 million per reactor. Delays caused by the failure of a reactor owner to comply with laws or regulations would not be covered. Project sponsors will be required to pay the “subsidy cost” of the program, consisting of the estimated present value of likely future government payments. DOE published a final rule for the “standby support” program August 11, 2006.<sup>84</sup>

Under the program’s regulations, a project sponsor may enter into a conditional agreement for standby support before NRC issues a combined operating license. The first six conditional agreements to meet all the program requirements, including the issuance of a COL and payment of the estimated subsidy costs, can be converted to standby support contracts. However, no applicant has pursued the incentive.<sup>85</sup>

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<sup>82</sup> Energy Information Administration, *Status of Potential New Commercial Nuclear Reactors in the United States*, February 19, 2009.

<sup>83</sup> Nuclear Energy Institute, *Legislative Proposal to Help Meet Climate Change Goals by Expanding U.S. Nuclear Energy Production*, Washington, DC, October 28, 2009, p. 4, <http://www.nei.org/resourcesandstats/documentlibrary/newplants/policybrief/2009-nuclear-policy-initiative>.

<sup>84</sup> Department of Energy, “Standby Support for Certain Nuclear Plant Delays,” *Federal Register*, August 11, 2006, p. 46306.

<sup>85</sup> Freebairn, William, “Nuclear Tax Credits, Previously Low-Profile, Might Draw Scrutiny: Lobbyists,” *Nucleonics Week*, May 17, 2012.

## Loan Guarantees

Title XVII of EPACT05 authorizes federal loan guarantees for up to 80% of construction costs for advanced energy projects that reduce greenhouse gas emissions, including new nuclear power plants. Under such loan guarantee agreements, the federal government would repay all covered loans if the borrower defaulted. This would reduce the risk to lenders and allow them to provide financing at low interest rates. The Title XVII loan guarantees are widely considered crucial by the nuclear industry to obtain financing for new reactors. However, opponents contend that nuclear loan guarantees would provide an unjustifiable subsidy to a mature industry and shift investment away from environmentally preferable energy technologies.<sup>86</sup> The authorized ceiling on nuclear power plant loan guarantees is currently \$18.5 billion.

The Administration announced the first conditional nuclear power plant loan guarantee on February 16, 2010, totaling \$8.33 billion for two proposed new reactors at Georgia's Vogtle nuclear plant site. Owners of the Vogtle project have reportedly estimated that the loan guarantee could reduce their financing costs by as much as \$2 billion.<sup>87</sup> Although DOE has made conditional agreements, these loan agreements had not been finalized as of September 2013.

## Subsidy Costs

Title XVII requires the estimated future government costs resulting from defaults on guaranteed loans to be covered up-front by appropriations or by payments from project sponsors, such as the utility planning to build a plant. These "subsidy costs" are calculated as the present value of the average possible future net costs to the government for each loan guarantee. If those calculations are accurate, the subsidy cost payments for all the guaranteed projects together should cover the future costs of the program, including default-related losses. However, the Congressional Budget Office has predicted that the up-front subsidy cost payments will prove too low by at least 1% and is scoring bills accordingly.<sup>88</sup> For example, appropriations bills that provide loan guarantee authorizations include an adjustment equal to 1% of the loan guarantee ceiling. (For more information on loan guarantee subsidy costs, see CRS Report R42152, *Loan Guarantees for Clean Energy Technologies: Goals, Concerns, and Policy Options*, by Phillip Brown.)

DOE loan guarantees for renewable energy and electricity transmission projects under EPACT05 section 1705, added by the American Recovery and Reinvestment Act of 2009 (P.L. 111-5), do not require subsidy cost payments by project sponsors, because potential losses are covered by advance appropriations in the act. No such appropriations are currently available for nuclear power projects, so it is anticipated that nuclear loan guarantee subsidy costs would be paid by the project sponsors. As a result, the level of the subsidy costs could have a powerful effect on the viability of nuclear power projects, which are currently expected to cost between \$5 billion and \$10 billion per reactor. For example, a 10% subsidy cost for a \$7 billion loan guarantee would require an up-front payment of \$700 million.

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<sup>86</sup> Thomas B. Cochran and Christopher E. Paine, *Statement on Nuclear Developments Before the Committee on Energy and Natural Resources, United States Senate*, Natural Resources Defense Council, March 18, 2009, [http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing\\_ID=f25ddd10-c1f5-9e2e-528e-c4321cca4c1b&Witness\\_ID=9f14a78d-58d0-43fb-bf5b-21426d1d888e](http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=f25ddd10-c1f5-9e2e-528e-c4321cca4c1b&Witness_ID=9f14a78d-58d0-43fb-bf5b-21426d1d888e).

<sup>87</sup> K. Steiner-Dicks, "Weekly Intelligence Brief 7-13 June 2012," *Nuclear Energy Insider*, June 13, 2012.

<sup>88</sup> Congressional Budget Office, *S. 1321, Energy Savings Act of 2007*, CBO Cost Estimate, Washington, DC, June 11, 2007, pp. 7-9, <http://www.cbo.gov/ftpdocs/82xx/doc8206/s1321.pdf>.

No subsidy cost amount has yet been established for any nuclear loan guarantee, including the lead Vogtle project in Georgia. The Administration's continuing internal deliberations over that question may reflect its importance and the amount of controversy being generated. Internal DOE documents released May 23, 2012, pursuant to the Freedom of Information Act show that Southern Company, the lead partner in the Vogtle project, has been offered a subsidy cost of 0.5%-1.5%, subject to other conditions that are still under negotiation. Higher subsidy costs are being offered to two other partners in the project.<sup>89</sup>

The nuclear industry contends that historical experience indicates defaults are likely to be minimal and that nuclear plant subsidy costs should therefore be low.<sup>90</sup> However, nuclear power critics contend that nuclear power plants are likely to experience delays and cost overruns that could lead to much larger losses under the loan guarantee program. The Center for American Progress concluded that nuclear subsidy costs "should be at least 10 percent and possibly much more."<sup>91</sup>

Constellation Energy informed DOE on October 8, 2010, that it was withdrawing from loan guarantee negotiations on Calvert Cliffs 3, blaming "the Office of Management and Budget's inability to address significant problems with its methodology for determining the project's credit subsidy cost." Constellation's letter to DOE said OMB's "shockingly high" estimate of the subsidy cost for Calvert Cliffs 3 was 11.6%, or about \$880 million. "Such a sum would clearly destroy the project's economics (or the economics of any nuclear project for that matter), and was dramatically out of line with both our own and independent assessments of what the figure should reasonably be," the letter stated.<sup>92</sup> Although OMB has not released its subsidy cost methodology, it may consider the default risk for a "merchant plant" such as Calvert Cliffs to be significantly higher than that of a rate-regulated plant such as Vogtle. A plant under traditional rate regulation is allowed to pass all prudently incurred costs through to utility ratepayers, while a merchant plant charges market rates for its power. A merchant plant, therefore, could potentially earn higher profits than a rate-regulated plant, but it also runs the risk of being unable to cover its debt payments if market rates for wholesale electric power drop too low or if its costs are higher than anticipated.

## Congressionally Authorized Ceilings

Under the Federal Credit Reform Act (FCRA), federal loan guarantees cannot be provided without an authorized level in an appropriations act. The Senate-passed version of omnibus energy legislation in the 110<sup>th</sup> Congress (H.R. 6) would have explicitly eliminated FCRA's applicability to DOE's planned loan guarantees under EPACT05 (Section 124(b)). That provision would have given DOE essentially unlimited loan guarantee authority for guarantees whose

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<sup>89</sup> Southern Alliance for Clean Energy, "Secret Documents Highlight Nuclear's Risk," press release, May 23, 2012, [http://www.cleanenergy.org/index.php?/Press-Update.html?form\\_id=8&item\\_id=299](http://www.cleanenergy.org/index.php?/Press-Update.html?form_id=8&item_id=299).

<sup>90</sup> Statement of Leslie C. Kass, Nuclear Energy Institute, to the Subcommittee on Domestic Policy, House Committee on Oversight and Government Reform, April 20, 2010, <http://www.nei.org/newsandevents/speechesandtestimony/april-20-2010-kass>. DOE is treating final subsidy cost determinations as proprietary, prompting some groups to call for the amounts to be made public.

<sup>91</sup> Richard Caperton, *Protecting Taxpayers from a Financial Meltdown*, Center for American Progress, Washington, DC, March 8, 2010, p. 2, [http://www.americanprogress.org/issues/2010/03/nuclear\\_financing.html](http://www.americanprogress.org/issues/2010/03/nuclear_financing.html).

<sup>92</sup> Letter from Michael J. Wallace, Vice Chairman and Chief Operating Officer, Constellation Energy, to Dan Poneman, Deputy Secretary of Energy, October 8, 2010, <http://media.washingtonpost.com/wp-srv/hp/ssi/wpc/constellationenergy.PDF?sid=ST2010100900005>.

subsidy costs were paid by project sponsors, but it was dropped from the final legislation (P.L. 110-140). Pursuant to FCRA, the FY2007 continuing resolution (P.L. 110-5) established an initial cap of \$4 billion on loan guarantees under the program, without allocating that amount among the various eligible technologies. The explanatory statement for the FY2008 omnibus funding act (P.L. 110-161) increased the loan guarantee ceiling to \$38.5 billion through FY2009, including \$18.5 billion specifically for nuclear power plants and \$2 billion for uranium enrichment plants.<sup>93</sup>

The FY2009 omnibus funding act increased DOE's total loan guarantee authority for specified technology categories to \$47 billion, in addition to the \$4 billion in general authority provided in FY2007. Of the \$47 billion, \$18.5 billion continued to be reserved for nuclear power, \$18.5 billion was for energy efficiency and renewables, \$6 billion was for coal, \$2 billion was for carbon capture and sequestration, and \$2 billion was for uranium enrichment. The time limits on the loan guarantee authority were eliminated.

## Nuclear Solicitations

DOE issued a solicitation for up to \$20.5 billion in nuclear power and uranium enrichment plant loan guarantees on June 30, 2008.<sup>94</sup> According to the nuclear industry, 10 nuclear power projects applied for \$93.2 billion in loan guarantees, and two uranium enrichment projects asked for \$4.8 billion in guarantees, several times the amount available.<sup>95</sup> Under the program's regulations, a conditional loan guarantee commitment cannot become a binding loan guarantee agreement until the project receives a COL and all other regulatory requirements are met, as noted above; and the first COLs were issued in early 2012.

In the uranium enrichment solicitation, DOE in July 2009 informed USEC Inc., which plans to build a new plant in Ohio, that its technology needed further testing before a loan guarantee could be issued.<sup>96</sup> DOE notified Congress in March 2010 that it would reprogram \$2 billion of its unused FY2007 loan guarantee authority toward uranium enrichment, increasing the uranium enrichment total to \$4 billion. The move would potentially allow guarantees to be provided to both USEC and the other applicant in the uranium enrichment solicitation, the French firm Areva, which is planning a plant in Idaho.<sup>97</sup> DOE offered a \$2 billion conditional loan guarantee to Areva on May 20, 2010.<sup>98</sup>

DOE informed USEC in October 2011 that the centrifuge technology for its proposed new enrichment plant still needed further testing and offered to provide up to \$300 million to help build a demonstration "train" of 720 centrifuges.<sup>99</sup> The FY2013 Continuing Appropriations

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<sup>93</sup> *Congressional Record*, December 17, 2007, p. H15585.

<sup>94</sup> <http://www.lgprogram.energy.gov/keydocs.html>.

<sup>95</sup> Marvin S. Fertel, *Statement for the Record to the Committee on Energy and Natural Resources, U.S. Senate*, Nuclear Energy Institute, March 18, 2009, p. 9, [http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing\\_ID=f25ddd10-c1f5-9e2e-528e-c4321cca4c1b&Witness\\_ID=4de5e2df-53fe-49ba-906e-9b69d3674e41](http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=f25ddd10-c1f5-9e2e-528e-c4321cca4c1b&Witness_ID=4de5e2df-53fe-49ba-906e-9b69d3674e41).

<sup>96</sup> Department of Energy, "800 to 1000 New Jobs Coming to Picketon," press release, July 28, 2009, <http://www.lgprogram.energy.gov/press/072809.pdf>.

<sup>97</sup> Maureen Conley, "DOE Finds \$2 Billion More for SWU Plant Loan Guarantees," *NuclearFuel*, April 5, 2010, p. 3.

<sup>98</sup> Department of Energy, "DOE Offers Conditional Loan Guarantee for Front End Nuclear Facility in Idaho," press release, May 20, 2010, <http://www.energy.gov/news/8996.htm>.

<sup>99</sup> Maureen Conley, "Congress 'Frustrated' by Inaction on USEC Loan Guarantee," *NuclearFuel*, October 31, 2011, p. 8.

Resolution (P.L. 112-175) included \$100 million for the USEC demonstration program.<sup>100</sup> For FY2014, the House provided \$48 million for the program through special reprogramming authority (H.Rept. 113-135).

DOE has recently provided other assistance to USEC. DOE agreed on May 15, 2012, to provide depleted uranium stockpiles (material left over from the enrichment process) to Energy Northwest for reenrichment at USEC's plant in Paducah, KY, for use as reactor fuel.<sup>101</sup> DOE agreed on March 13, 2012, to acquire low-enriched uranium from USEC in exchange for taking responsibility for low-value depleted uranium tails that USEC would otherwise have to dispose of, freeing \$44 million of USEC's funds for the centrifuge project.<sup>102</sup> DOE announced June 13, 2012, that it would provide \$88 million for the centrifuge demonstration program by taking over responsibility for disposal of additional depleted uranium from USEC. In return, DOE will take ownership of the equipment and technology used in the demonstration and lease it to USEC.<sup>103</sup>

## Global Climate Change

Global climate change that may be caused by carbon dioxide and other greenhouse gas emissions is cited by nuclear power supporters as an important reason to develop a new generation of reactors. Nuclear power plants emit relatively little carbon dioxide, mostly from nuclear fuel production and auxiliary plant equipment. This "green" nuclear power argument has received growing attention in think tanks and academia. As stated by the Massachusetts Institute of Technology in its major study *The Future of Nuclear Power*: "Our position is that the prospect of global climate change from greenhouse gas emissions and the adverse consequences that flow from these emissions is the principal justification for government support of the nuclear energy option."<sup>104</sup> The Obama Administration is including nuclear power as part of its clean energy strategy.

However, some environmental groups have contended that nuclear power's potential greenhouse gas benefits are modest and must be weighed against the technology's safety risks, its potential for nuclear weapons proliferation, and the hazards of radioactive waste.<sup>105</sup> They also contend that energy efficiency and renewable energy would be far more productive investments for reducing greenhouse gas emissions.<sup>106</sup>

<sup>100</sup> All FY3013 figures are pre-sequester.

<sup>101</sup> USEC Inc., "Five-Party Arrangement Extends Paducah Gaseous Diffusion Plant Enrichment Operations," press release, May 15, 2012, <http://www.usec.com/news/five-party-arrangement-extends-paducah-gaseous-diffusion-plant-enrichment-operations>. The depleted uranium consists of "high assay" tails, which have relatively high levels of fissile U-235.

<sup>102</sup> USEC Inc., "Funding," web page, <http://www.usec.com/american-centrifuge/what-american-centrifuge/plant/funding>.

<sup>103</sup> Department of Energy, "Obama Administration Announces Major Step Forward for the American Centrifuge Plant," press release, June 13, 2012, <http://energy.gov/articles/obama-administration-announces-major-step-forward-american-centrifuge-plant>.

<sup>104</sup> Interdisciplinary MIT Study, *The Future of Nuclear Power*, Massachusetts Institute of Technology, 2003, p. 79.

<sup>105</sup> Gronlund, Lisbeth, David Lochbaum, and Edwin Lyman, *Nuclear Power in a Warming World*, Union of Concerned Scientists, December 2007.

<sup>106</sup> Travis Madsen, Tony Dutzik, and Bernadette Del Chiaro, et al., *Generating Failure: How Building Nuclear Power Plants Would Set America Back in the Race Against Global Warming*, Environment America Research and Policy Center, November 2009, <http://www.environmentamerica.org/uploads/39/62/3962c378b66c4552624d09cbd8ebba02/Generating-Failure—Environment-America—Web.pdf>.

Proposals to reduce carbon dioxide emissions – through taxation, a cap-and-trade system, or other regulatory controls – could significantly increase the cost of generating electricity with fossil fuels and improve the competitive position of nuclear power. A federal Clean Energy Standard that includes nuclear power, as proposed in President Obama’s January 2011 State of the Union Address, could provide a similar boost to nuclear energy expansion. Utilities that have applied for nuclear power plant licenses have often cited the possibility of federal greenhouse gas controls or other mandates as one of the reasons for pursuing new reactors.

## **Nuclear Power Research and Development**

The Obama Administration’s FY2014 funding request for nuclear energy research and development totals \$735.5 million. Including advanced reactors, fuel cycle technology, infrastructure support, and safeguards and security, the total nuclear energy request is \$22.0 million (3%) below the FY2013 funding level. Funding for safeguards and security at DOE’s Idaho facilities in FY2013 was provided under a separate appropriations account, Other Defense Activities, but it is included under the Nuclear Energy account in the FY2014 request. In contrast, funding for space and defense infrastructure, totaling \$64.1 million in the FY2013 nuclear energy appropriation, would be shifted to the National Aeronautics and Space Administration (NASA) by the Administration’s request.

The House-passed Energy and Water Development Appropriations bill for FY2014 (H.R. 2609) would provide \$656.4 million for nuclear energy. That total excludes the Administration’s proposed shift of \$94.0 million for Idaho safeguards and security from Other Defense Activities and includes the space and defense funding transfer to NASA. For the programs that would remain in nuclear energy, therefore, the House bill would provide an increase of \$14.9 million from the Administration request and a decrease of \$37 million from FY2013. The Senate Appropriations Committee (S. 1245) recommended the same total as the Administration request, including the proposed funding transfers.

The Administration’s FY2014 nuclear R&D budget request is consistent with DOE’s Nuclear Energy Research and Development Roadmap issued in April 2010. The Roadmap lays out the following four main goals for the program:

- Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors;
- Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration’s energy security and climate change goals;
- Develop sustainable nuclear fuel cycles; and
- Understand and minimize the risks of nuclear proliferation and terrorism.

The Senate Appropriations Committee directed DOE to update the Roadmap within 180 days after enactment of the FY2014 energy and water bill to reflect lessons learned from the Fukushima nuclear accident, advances in small modular reactors, and the Administration’s new nuclear waste strategy.

## Reactor Concepts

The Reactor Concepts program area includes the Next Generation Nuclear Plant (NGNP) demonstration project and research on other advanced reactors (often referred to as Generation IV reactors). This area also includes funding for developing advanced small modular reactors (discussed in the next section) and to enhance the “sustainability” of existing commercial light water reactors. The total FY2014 funding request for this program is \$72.5 million, a reduction of \$41.6 million from FY2013. The House voted to provide \$86.5 million, while the Senate Appropriations Committee approved the Administration’s funding level.

Most of the Administration’s proposed reduction in Reactor Concepts would be for NGNP, a high-temperature gas-cooled reactor demonstration project authorized by the Energy Policy Act of 2005. The reactor is intended to produce high-temperature heat that could be used to generate electricity, help separate hydrogen from water, or be used in other industrial processes. DOE is not requesting any funding specifically for the NGNP project in FY2014. Under EPACT05, the Secretary of Energy was to decide by the end of FY2011 whether to proceed toward construction of a demonstration plant. Secretary of Energy Steven Chu informed Congress on October 17, 2011, that DOE would not proceed with a demonstration plant design “at this time” but would continue research on the technology. Potential obstacles facing NGNP include low prices for natural gas, the major competing fuel, and private-sector unwillingness to share the project’s costs as required by EPACT05. According to the DOE budget justification, some research activities now conducted under the NGNP program will be shifted to the Advanced Reactor Concepts subprogram in FY2014.

Funding for the Advanced Reactor Concepts subprogram would be increased by the Administration request to \$31.0 million in FY2014, up from \$21.7 million in FY2012. The increase would cover research on high-temperature gas reactors previously conducted under the NGNP Program. Reactor concepts being developed by the Advanced Reactor Concepts subprogram are generally classified as “Generation IV” reactors, as opposed to the existing fleet of commercial light water reactors, which are generally classified as generations II and III. Such advanced reactors “could dramatically improve nuclear power performance including sustainability, economics, and safety and proliferation resistance,” according to the FY2014 justification. Nuclear technology development under this program includes “fast reactors,” using high-energy neutrons, and reactors that would use a variety of heat-transfer fluids, such as liquid sodium and supercritical carbon dioxide. International research collaboration in this area would continue under the Generation IV International Forum (GIF). The House bill would boost Advanced Reactor Concepts funding to \$45 million, with the increase focused on high-temperature gas reactor fuel development formerly conducted under the NGNP program.

DOE’s FY2014 request for the Light Water Reactor Sustainability subprogram is \$21.5 million, \$3.3 million below the FY2012 appropriation. The program conducts research on extending the life of existing commercial light water reactors beyond 60 years, the maximum operating period currently licensed by the Nuclear Regulatory Commission. The program, which is to be cost-shared with the nuclear industry, is to study the aging of reactor materials and analyze safety margins of aging plants. Other research under this program is to focus on improving the efficiency of existing plants, through such measures as increasing plant capacity and upgrading instrumentation and control systems. Research on longer-life LWR fuel is aimed at eliminating radioactive leakage from nuclear fuel and increasing its accident tolerance, along with other “post-Fukushima lessons learned,” according to the budget justification. The House approved the Administration funding level, as did the Senate committee.

## Small Modular Reactors

Rising cost estimates for large conventional nuclear reactors—widely projected to be \$6 billion or more—have contributed to growing interest in proposals for small modular reactors (SMRs). Ranging from about 40 to 300 megawatts of electrical capacity, such reactors would be only a fraction of the size of current commercial reactors. Several modular reactors would be installed together to make up a power block with a single control room, under most concepts. Current SMR proposals would use a variety of technologies, including the high-temperature gas technology described above and the light water (LWR) technology used by today’s commercial reactors.

DOE requested \$70.0 million for FY2014 to provide technical support for licensing small modular reactors, about \$3 million above the FY2013 funding level. This program has focused on LWR designs because they are believed most likely to be deployed in the near term, according to DOE. The FY2014 budget justification states that the SMR licensing and technical support program will last six years and cost DOE a total of \$452 million. The program is similar to DOE’s support for larger commercial reactor designs under the Nuclear Power 2010 Program, which ended in FY2010. DOE will provide support for design certification, standards, and licensing. As with the Nuclear Power 2010 Program, at least half the costs of the SMR design and licensing program are to be covered by industry partners, according to DOE.

A consortium led by Babcock & Wilcox (B&W) was announced by DOE in November 2012 as the first award recipient under the program. DOE and the B&W consortium signed a cooperative agreement in April 2013 to implement the award, allowing for federal payments of around \$226 million over five years to design and license a commercial demonstration plant that could open by 2022. DOE announced a second award solicitation in March 2013 for innovative SMR designs that could begin commercial operation around 2025.

The House bill would increase funding for SMR design and licensing support to \$110.0 million, while the Senate Appropriations Committee recommended the Administration level.

An additional \$20.0 million for FY2014 was requested by DOE under the Reactor Concepts program (described in the section above) for SMR advanced concepts R&D—\$4.5 million below the FY2012 funding level. Unlike the SMR licensing support program, which focuses on near-term technology, the SMR advanced concepts program would conduct research on technologies that might be deployed in the longer term, according to the budget justification. The House approved the Administration funding level, as did the Senate panel.

Small modular reactors would go against the overall trend in nuclear power technology toward ever-larger reactors intended to spread construction costs over a greater output of electricity. Proponents of small reactors contend that they would be economically viable despite their far lower electrical output because modules could be assembled in factories and shipped to plant sites, with minimal on-site fabrication, and because their smaller size would allow for simpler safety systems. In addition, although modular plants might have similar or higher costs per kilowatt-hour than conventional large reactors, their ability to be constructed in smaller increments could reduce electric utilities’ financial commitment and risk.

## **Fuel Cycle Research and Development**

The Fuel Cycle Research and Development Program conducts “long-term, science-based” research on a wide variety of technologies for improving the management of spent nuclear fuel, according to the DOE budget justification. The total FY2014 funding request for this program is \$165.1 million, \$10.1 million below the FY2013 appropriation. The House bill would provide \$91.1 million, while the Senate Appropriations Committee recommended \$175.1 million.

The range of fuel cycle technologies being studied by the program includes direct disposal of spent fuel (the “once through” cycle) and partial and full recycling, according to the FY2014 budget justification. The Fuel Cycle R&D Program “will research and develop a suite of technology options that will enable future decision-makers to make informed decisions about how best to manage nuclear waste and used fuel from reactors,” the budget justification says.

Much of the Administration’s planned research on spent fuel management options would address the near-term recommendations of the Blue Ribbon Commission on America’s Nuclear Future, which issued its final report on January 26, 2012. The commission was chartered to develop alternatives to the planned Yucca Mountain, NV, spent fuel repository, which President Obama wants to terminate. DOE released its Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste in January 2013 in response to the Blue Ribbon Commission report. Funding to begin implementing the strategy is included in the Used Nuclear Fuel Disposition subprogram, with a request of \$60.0 million, \$2.1 million above the FY2012 funding level. Activities in that area include developing plans for a “consent-based siting process” for nuclear storage and disposal facilities, waste transportation analyses, and research on potential waste repositories, including salt caverns and deep boreholes. (See the “Nuclear Waste Management” section, below, for more details.)

Other major research areas in the Fuel Cycle R&D Program include the development of accident-tolerant fuels for existing commercial reactors, evaluation of fuel cycle options, development of improved technologies to prevent diversion of nuclear materials for weapons, and technology to increase nuclear fuel resources, such as uranium extraction from seawater. The Senate Appropriations Committee increased the Administration’s request for the Advanced Fuels subprogram by \$20 million, to \$57.1 million, with an emphasis on developing “meltdown-resistant nuclear fuels” that could be tested and made available within 10 years.

## **Nuclear Waste Management**

One of the most controversial aspects of nuclear power is the disposal of radioactive waste, which can remain hazardous for thousands of years. Each nuclear reactor produces an annual average of about 20 metric tons of highly radioactive spent nuclear fuel, for a nationwide total of about 2,000 metric tons per year. U.S. reactors also generate about 27,000 cubic meters of low-level radioactive waste per year, including contaminated components and materials resulting from reactor decommissioning.

The federal government is responsible for permanent disposal of commercial spent fuel (paid for with a fee on nuclear power production) and federally generated radioactive waste, while states have the authority to develop disposal facilities for most commercial low-level waste. Under the Nuclear Waste Policy Act (NWPA, 42 U.S.C. 10101, et seq.), spent fuel and other highly radioactive waste is to be isolated in a deep underground repository, consisting of a large network

of tunnels carved from a geologic formation that has remained stable for hundreds of thousands of years. As amended in 1987, NWPAs designated Yucca Mountain in Nevada as the only candidate site for the national repository. The act required DOE to begin taking waste from nuclear plant sites by 1998—a deadline that even under the most optimistic scenarios will be missed by more than 20 years. DOE filed a license application with NRC for the proposed Yucca Mountain repository in June 2008.

The Obama Administration “has determined that developing the Yucca Mountain repository is not a workable option and the Nation needs a different solution for nuclear waste disposal,” according to the DOE FY2011 budget justification. To develop alternative waste management strategies, the Administration established the Blue Ribbon Commission on America’s Nuclear Future, which issued its final report to the Secretary of Energy on January 26, 2012.<sup>107</sup> The Blue Ribbon Commission recommended that future efforts to develop nuclear waste facilities follow a “consent based” approach and be carried out by a new organization, rather than DOE. The Commission said the new nuclear waste entity should have “assured access” to the Nuclear Waste Fund, which holds fees collected from nuclear power plant operators to pay for waste disposal. Under NWPAs, those funds cannot be spent without congressional appropriations.

DOE released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* in January 2013 in response to the Blue Ribbon Commission report. The strategy calls for a pilot interim storage facility for spent fuel from closed nuclear reactors to open by 2021 and a larger storage facility, possibly at the same site, to open by 2025. A site for a permanent underground waste repository would be selected by 2026, and the repository would open by 2048. Storage and disposal sites would be selected by a new waste management organization through a consent-based process, as recommended by the Blue Ribbon Commission.<sup>108</sup>

DOE’s Office of Nuclear Energy (NE) currently is responsible for civilian waste management activities. NE’s Fuel Cycle R&D Program (discussed in the “Nuclear Power Research and Development” section above) includes funding under the Used Nuclear Fuel Disposition subprogram to begin implementing the DOE waste management strategy. DOE is seeking \$60.0 million for the Used Fuel subprogram in FY2014, \$2.1 million above the FY2012 funding level, and no funding for Yucca Mountain.

In approving the Energy and Water Development Appropriations bill for FY2014 (H.R. 2609), the House Appropriations Committee excoriated the Obama Administration’s termination of the Yucca Mountain project as “blatant political maneuverings.” The House-passed bill would eliminate DOE’s \$60 million request to implement its new nuclear waste policy and add \$25 million for Yucca Mountain. It would also direct the Nuclear Regulatory Commission to use prior-year funds to continue the Yucca Mountain licensing process.

The Senate Appropriations Committee approved the Administration’s proposed funding level for Used Fuel and did not mention Yucca Mountain. The Committee-passed bill includes a provision

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<sup>107</sup> Blue Ribbon Commission on America’s Nuclear Future, *Report to the Secretary of Energy*, January 2012, [http://brc.gov/sites/default/files/documents/brc\\_finalreport\\_jan2012.pdf](http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf).

<sup>108</sup> DOE, *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, January 2013, <http://energy.gov/sites/prod/files/Strategy%20for%20the%20Management%20and%20Disposal%20of%20Used%20Nuclear%20Fuel%20and%20High%20Level%20Radioactive%20Waste.pdf>.

from the previous year that would authorize DOE to conduct a pilot program to develop one or more high level radioactive waste storage facilities, with the consent of state, local, and tribal governments.

Senator Wyden, along with Senators Murkowski, Feinstein, and Alexander, introduced legislation June 27, 2013, to redirect the nuclear waste program (S. 1240) along the lines recommended by the Blue Ribbon Commission. The bill would establish an independent Nuclear Waste Administration to develop nuclear waste storage and disposal facilities. Siting of such facilities would require the consent of the affected state, local, and tribal governments. The Nuclear Waste Administration could spend nuclear waste fees collected after the bill's enactment without the need for further appropriation. Fee collection would halt after 2025 if a waste facility had not been opened. The Energy and Natural Resources Committee held a hearing on the bill July 30, 2013.

DOE had filed a license application with NRC for the proposed Yucca Mountain repository in June 2008 but filed a motion to withdraw the application on March 3, 2010. An NRC licensing panel rejected DOE's withdrawal motion June 29, 2010, on the grounds that NWA requires full consideration of the license application by NRC. The full NRC Commission deadlocked on the issue September 9, 2011, leaving the licensing panel's decision in place and prohibiting DOE from withdrawing the Yucca Mountain application. However, the commission ordered at the same time that the licensing process be suspended because of "budgetary limitations."<sup>109</sup> No funding was provided in FY2012 or FY2013 or requested for FY2014 to continue Yucca Mountain licensing activities. However, the U.S. Court of Appeals for the District of Columbia Circuit ruled on August 13, 2013, that NRC must continue work on the Yucca Mountain license application as long as funding is available. The Court determined that NRC has at least \$11.1 million in previously appropriated funds for that purpose.<sup>110</sup>

NWA required DOE to begin taking waste from nuclear plant sites by January 31, 1998. Nuclear utilities, upset over DOE's failure to meet that deadline, have won two federal court decisions upholding the department's obligation to meet the deadline and to compensate utilities for any resulting damages. Utilities have also won several cases in the U.S. Court of Federal Claims. DOE estimates that liability payments would eventually exceed \$20 billion if DOE were to begin removing waste from reactor sites by 2020, the previous target for opening Yucca Mountain.<sup>111</sup> (For more information, see CRS Report R42513, *U.S. Spent Nuclear Fuel Storage*, by James D. Werner; CRS Report RL33461, *Civilian Nuclear Waste Disposal*, by Mark Holt; and CRS Report R40996, *Contract Liability Arising from the Nuclear Waste Policy Act (NWA) of 1982*, by Todd Garvey.)

NRC published a proposed rule September 13, 2013, on continued storage of spent nuclear fuel.<sup>112</sup> The proposed rule responds to a federal circuit court ruling on June 8, 2012, that struck

<sup>109</sup> Nuclear Regulatory Commission, "In the Matter of U.S. Department of Energy (High-Level Waste Repository)," CLI-11-07, September 9, 2011, <http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2011/2011-07cli.pdf>.

<sup>110</sup> 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](http://www.cadc.uscourts.gov/internet/opinions.nsf/BAE0CF34F762EBD985257BC6004DEB18/$file/11-1271-1451347.pdf).

<sup>111</sup> *Ibid.*, p. 80.

<sup>112</sup> NRC, "Waste Confidence—Continued Storage of Spent Nuclear Fuel," proposed rule, 78 *Federal Register* 56776, September 13, 2013.

down NRC's Waste Confidence Decision, which contains the agency's formal findings that waste generated by nuclear power plants will be disposed of safely. The court ruled that the Waste Confidence Decision required an environmental review under the National Environmental Policy Act and that NRC needed to consider the possibility that a permanent waste repository would never be built and to examine potential problems with waste storage pools.

The Waste Confidence Decision, first issued in 1984 and since updated twice, resulted from a 1979 federal circuit court ruling that required NRC to determine whether waste from nuclear facilities would be safely managed after their licenses expired. After the court vacated the Waste Confidence Decision in 2012, NRC stated that it would not issue final licenses for new reactors and waste facilities until a new Waste Confidence Decision was completed.<sup>113</sup>

## **Nuclear Weapons Proliferation**

Renewed interest in nuclear power throughout the world has led to increased concern about nuclear weapons proliferation, because technology for making nuclear fuel can also be used to produce nuclear weapons material. Of particular concern are uranium enrichment, a process to separate and concentrate the fissile isotope uranium-235, and nuclear spent fuel reprocessing, which can produce weapons-useable plutonium.

The International Atomic Energy Agency (IAEA) conducts a safeguards program that is intended to prevent civilian nuclear fuel facilities from being used for weapons purposes, but not all potential weapons proliferators belong to the system, and there are ongoing questions about its effectiveness. Several proposals have been developed to guarantee nations without fuel cycle facilities a supply of nuclear fuel in exchange for commitments to forgo enrichment and reprocessing, which was one of the original goals of the Bush Administration's Global Nuclear Energy Partnership, now called the International Framework for Nuclear Energy Cooperation.<sup>114</sup>

Several situations have arisen throughout the world in which ostensibly commercial uranium enrichment and reprocessing technologies have been subverted for military purposes. In 2003 and 2004, it became evident that Pakistani nuclear scientist A.Q. Khan had sold sensitive technology and equipment related to uranium enrichment to states such as Libya, Iran, and North Korea. Although Pakistan's leaders maintain they did not acquiesce in or abet Khan's activities, Pakistan remains outside the Nuclear Nonproliferation Treaty (NPT) and the Nuclear Suppliers Group (NSG). Iran has been a direct recipient of Pakistani enrichment technology.

IAEA's Board of Governors found in 2005 that Iran's breach of its safeguards obligations constituted noncompliance with its safeguards agreement, and referred the case to the U.N. Security Council in February 2006. Despite repeated calls by the U.N. Security Council for Iran to halt enrichment and reprocessing-related activities, and imposition of sanctions, Iran continues to develop enrichment capability at Natanz and at a site near Qom disclosed in September 2009. Iran insists on its inalienable right to develop the peaceful uses of nuclear energy, pursuant to Article IV of the NPT. Interpretations of this right have varied over time. Former IAEA Director General Mohamed ElBaradei did not dispute this inalienable right and, by and large, neither have

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<sup>113</sup> Ibid.

<sup>114</sup> The organization approved a new mission statement with the name change at its June 2010 meeting in Ghana. See <http://www.gneppartnership.org>.

U.S. government officials. However, the case of Iran raises perhaps the most critical question in this decade for strengthening the nuclear nonproliferation regime: How can access to sensitive fuel cycle activities (which could be used to produce fissile material for weapons) be circumscribed without further alienating non-nuclear weapon states in the NPT?

Leaders of the international nuclear nonproliferation regime have suggested ways of reining in the diffusion of such inherently dual-use technology, primarily through the creation of incentives not to enrich uranium or reprocess spent fuel. The international community is in the process of evaluating those proposals and may decide upon a mix of approaches. At the same time, there is debate on how to improve the IAEA safeguards system and its means of detecting diversion of nuclear material to a weapons program in the face of expanded nuclear power facilities worldwide.

(For more information, see CRS Report RL34234, *Managing the Nuclear Fuel Cycle: Policy Implications of Expanding Global Access to Nuclear Power*, coordinated by Mary Beth D. Nikitin; and CRS Report R41216, *2010 Non-Proliferation Treaty (NPT) Review Conference: Key Issues and Implications*, coordinated by Paul K. Kerr and Mary Beth D. Nikitin.)

## Federal Funding for Nuclear Energy Programs

The following tables summarize current funding for DOE nuclear energy programs and NRC. The sources for the funding figures are Administration budget requests and committee reports on the Energy and Water Development Appropriations Acts, which fund DOE and NRC. The House passed its version of the FY2014 Energy and Water bill on July 10, 2013 (H.R. 2609, H.Rept. 113-135). The Senate Appropriations Committee approved its version on June 27, 2013 (S. 1245, S.Rept. 113-47).

**Table 2. Funding for the Nuclear Regulatory Commission**  
(budget authority in millions of current dollars)

	FY2011 Approp.	FY2012 Approp.	FY2013 Approp. <sup>a</sup>	FY2014 Request	FY2014 House	FY2014 Sen. Comm.
Reactor Safety	804.1 <sup>a</sup>	800.1 <sup>a</sup>	— <sup>c</sup>	812.4	812.4	— <sup>c</sup>
Nuclear Materials and Waste	229.4	227.1	—	231.5	231.5	—
Yucca Mountain Licensing	10.0	0	0	0	0	0
Inspector General	10.1	10.9	10.9	11.1	11.1	11.1
<b>Total NRC budget authority</b>	<b>1,052.3</b>	<b>1,038.1</b>	<b>1,036.0</b>	<b>1,055.0</b>	<b>1,055.0</b>	<b>1,055.0</b>
—Offsetting fees	-914.2	-909.5	-909.5	930.7	-930.7	-930.7
<b>Net appropriation</b>	<b>138.1</b>	<b>128.6</b>	<b>126.6</b>	<b>124.3</b>	<b>124.3</b>	<b>124.3</b>

a. FY2013 figures do not reflect March 1, 2013, sequester under P.L. 112-25.

b. Subcategories from NRC budget request.

c. Subcategories not specified.

**Table 3. DOE Funding for Nuclear Activities (Selected Programs)**

(budget authority in millions of current dollars)

	<b>FY2011 Approp.</b>	<b>FY2012 Approp.</b>	<b>FY2013 Approp.</b>	<b>FY2014 Request</b>	<b>FY2014 House</b>	<b>FY2014 Senate Comm.</b>
Reactor Concepts	168.5	115.5	114.1	72.5	86.5	62.5
Small Modular Reactor Licensing	—	67.0	66.2	70.0	85.0	70.0
Fuel Cycle R&D	187.6	187.4	185.0	165.1	91.1	175.1
Nuclear Energy Enabling Technologies	51.4	74.9	73.9	62.3	66.7	62.3
International Nuclear Energy Cooperation	3.0	3.0	3.0	2.5	2.5	2.5
Radiological Facilities Management	51.7	69.9	68.0	5.0	5.0	20.0
Idaho Facilities Management	183.6	155.0	153.1	181.6	181.6	166.6
Program Direction	86.3	91.0	89.9	87.5	87.5	87.5
Yucca Mountain repository <sup>b</sup>	0	0	0	0	25.0	0
<b>Total, Nuclear Energy<sup>a</sup></b>	<b>732.1</b>	<b>765.4</b>	<b>757.5</b>	<b>735.5</b>	<b>656.4</b>	<b>735.5</b>

a. Excludes funding provided under other accounts.

b. Funded by a 1-mill-per-kilowatt-hour fee on nuclear power.

## Legislation in the 113<sup>th</sup> Congress

### H.R. 259 (Pompeo)

Energy Freedom and Economic Prosperity Act. Terminates nuclear energy production tax credit, among other provisions. Introduced January 15, 2013; referred to Committee on Ways and Means.

### H.R. 1700 (Engel)

Nuclear Disaster Preparedness Act. Requires the President to issue guidance for federal response to nuclear disasters, covering specific topics listed in the bill. Introduced April 24, 2013; referred to Committee on Transportation and Infrastructure.

### H.R. 1023 (Thornberry)

No More Excuses Energy Act of 2013. Includes provisions to prohibit NRC from considering nuclear waste storage when licensing new nuclear facilities, and to establish a tax credit for obtaining nuclear component manufacturing certification. Introduced May 21, 2013; referred to multiple committees.

**H.R. 2609 (Frelinghuysen)/S. 1245 (Feinstein)**

Energy and Water Development and Related Agencies Appropriations Act, 2014. Provides funding for DOE nuclear programs and NRC. House bill introduced July 2, 2013; reported as original measure by Committee on Appropriations July 2, 2013 (H.Rept. 113-135); passed House July 10, 2013, by vote of 227-198. Senate bill introduced June 27, 2013; reported as original measure by Committee on Appropriations June 27, 2013 (S.Rept. 113-47).

**H.R. 2712 (Lowey)**

Nuclear Power Licensing Reform Act of 2013. Requires evacuation planning within 50 miles of U.S. nuclear power plants and that reactor license renewals be subject to the same standards that would apply to new reactors. Introduced July 17, 2013; referred the Committee on Energy and Commerce.

**H.R. 2861 (Lowey)**

Requires NRC to distribute safety-related fines collected from nuclear facilities to the counties in which the facilities are located to maintain radiological emergency preparedness plans. Introduced July 30, 2013; referred to Committee on Energy and Commerce.

**S. 1240 (Wyden)**

Nuclear Waste Administration Act of 2013. Establishes an independent Nuclear Waste Administration to develop nuclear waste storage and disposal facilities. Siting of such facilities would require the consent of the affected state, local, and tribal governments. The Nuclear Waste Administration could spend nuclear waste fees collected after the bill's enactment without the need for further appropriation. Fee collection would halt after 2025 if a waste facility had not been opened. Introduced June 27, 2013; referred to Committee on Energy and Natural Resources. Full committee hearing held July 30, 2013.

**S. 1519 (Vitter)**

Nuclear Regulatory Commission Reorganization Plan Codification and Complements Act. Specifies functions and authorities of the Chairman and Commissioners of NRC. Specifies that any commissioner may request a vote on whether a particular issue should be reserved for the Chairman or handled by the full Commission. Introduced September 18, 2013; referred to Committee on Environment and Public Works.

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