Nuclear Energy Policy

Mark Holt
Specialist in Energy Policy

May 10, 2011

Congressional Research Service
7-5700
www.crs.gov
RL33558

CRS Report for Congress
Prepared for Members and Committees of Congress

Summary

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

Significant incentives for new commercial reactors were included in the Energy Policy Act of 2005 (EPACT05, P.L. 109-58). These include production tax credits, loan guarantees, insurance against regulatory delays, and extension of the Price-Anderson Act nuclear liability system. Together with volatile fossil fuel prices and the possibility of greenhouse gas controls, the federal incentives for nuclear power have helped spur renewed interest by utilities and other potential reactor developers. Plans for as many as 31 reactor license applications have been announced, although only a handful of those projects currently appear to be moving toward construction.

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 accident's possible implications for nuclear safety regulation, U.S. nuclear energy expansion, and radioactive waste policy. The tsunami blacked out all electric power at the six-reactor plant, resulting in the overheating of several reactor cores and spent fuel storage pools, major hydrogen explosions, and releases of radioactive material to the environment. Several House and Senate hearings have been held on the accident, and several bills on nuclear safety have been introduced.

In his January 2011 State of the Union Address, President Obama called for nuclear power to be included in a national goal of generating 80% of U.S. electricity "from clean energy sources" by 2035. Financing for new reactors is widely considered to depend on the loan guarantees authorized by EPACT05 Title XVII, administered by the Department of Energy (DOE). The total amount of loan guarantees to be provided to nuclear power projects has been a continuing congressional issue. Nuclear power plants are currently allocated $18.5 billion in loan guarantees, enough for three or four reactors. President Obama's FY2012 budget request would nearly triple the loan guarantee ceiling for nuclear power plants, to $54.5 billion. However, opponents of nuclear power contend that the Administration's proposed increases in nuclear loan guarantees would provide an unjustifiable subsidy to a mature industry and shift investment away from environmentally preferable and more cost-effective energy technologies.

DOE's nuclear energy research and development program includes advanced reactors, fuel cycle technology and facilities, and infrastructure support. The Obama Administration requested $824.1 million in FY2011 and received $732.1 million. The Administration requested $754 million for FY2012.

Disposal of highly radioactive waste has been one of the most controversial aspects of nuclear power. The Nuclear Waste Policy Act of 1982 (P.L. 97-425), as amended in 1987, required DOE to conduct a detailed physical characterization of Yucca Mountain in Nevada as a permanent underground repository for high-level waste. The Obama Administration decided to "terminate the Yucca Mountain program while developing nuclear waste disposal alternatives," according to the DOE FY2010 budget justification. Alternatives to Yucca Mountain are being evaluated by a "blue ribbon" panel of experts convened by the Administration. No funding was provided for the Yucca Mountain project in FY2011, and DOE filed a motion with NRC to withdraw the Yucca Mountain license application on March 3, 2010. However, the motion to withdraw has prompted substantial opposition, including lawsuits in federal court.

Contents

Tables

Contacts

Most Recent Developments

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 accident's possible implications for nuclear safety regulation, U.S. nuclear energy expansion, and radioactive waste policy. The tsunami blacked out all electric power at the six-reactor plant, resulting in the overheating of the reactor cores in three of the units and overheating of several spent fuel storage pools at the site. The overheating caused major hydrogen explosions and releases of radioactive material to the environment. Several House and Senate hearings have been held on the accident, and several bills on nuclear safety have been introduced. Proposed bills would delay all new nuclear licenses and permits until stronger safety standards were in place (H.R. 1242), expand evacuation planning around U.S. nuclear reactors (H.R. 1268), and initiate U.S. efforts to strengthen international nuclear safety agreements (S. 640, H.R. 1326).

The Obama Administration submitted a $754 million FY2012 funding request for Department of Energy (DOE) nuclear energy research and development on February 14, 2011. Including advanced reactors, fuel cycle technology, and infrastructure support, the total nuclear energy request is $21.9 million above the FY2011 funding level approved by Congress on April 14, 2011. The FY2011 level is $37.5 million below the FY2010 appropriation. Those totals exclude funding provided under Other Defense Activities for safeguards and security at DOE's Idaho nuclear facilities, for which $98.5 million is being requested for FY2012.

President Obama's State of the Union Address on January 25, 2011, called for nuclear power to be included in a national goal of generating 80% of U.S. electricity "from clean energy sources" by 2035. Along with nuclear power and renewable energy, "clean energy" would include "efficient" natural gas plants and clean coal technologies, to the extent that they reduced carbon emissions from conventional coal-fired plants. The President's proposed Clean Energy Standard could provide a significant boost to U.S. nuclear power expansion, particularly in areas of the country with relatively limited renewable energy resources.

The Administration's FY2012 budget request would nearly triple the current ceiling on federal loan guarantees for nuclear power plants, to $54.5 billion, as had also been proposed but not approved for FY2011. 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. However, negotiations on a loan guarantee for a new reactor at Maryland's Calvert Cliffs plant came to a halt October 8, 2010, when project sponsor Constellation Energy rejected the federal government's proposed terms. Seventeen applications for combined construction permits and operating licenses (COLs) for 26 new nuclear power units have been submitted to the Nuclear Regulatory Commission (NRC), although work on several applications has been suspended (see **Table 1**).

Congress agreed with the Administration's FY2011 budget proposal to terminate DOE's Office of Civilian Radioactive Waste Management (OCRWM), which was established by the Nuclear Waste Policy Act of 1982 (NWPA, 42 U.S.C. 10101 et seq.) to dispose of highly radioactive waste from nuclear power plants and defense facilities. The FY2011 Continuing Resolution eliminates funding for OCRWM, which had been developing a permanent nuclear waste repository at Yucca Mountain, NV, as specified by an NWPA amendment in 1987. 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. DOE filed a motion with NRC to withdraw the Yucca Mountain license application on March 3, 2010. An NRC licensing panel rejected DOE's withdrawal motion June 29, 2010, and it is now awaiting action before the NRC commissioners. Lawsuits opposing the license withdrawal have also been filed by states that have defense-related waste awaiting permanent disposal. NRC generated further controversy by initiating a shutdown of the Yucca Mountain licensing process on October 4, 2010, without issuing a final decision on the DOE license withdrawal motion. The FY2011 Continuing Resolution approves NRC's request for funding to terminate licensing activities.

Alternatives to Yucca Mountain are being evaluated by the Blue Ribbon Commission on America's Nuclear Future, which was formally established by DOE on March 1, 2010. Congress provided $5 million for the Commission in the FY2010 Energy and Water Development Appropriations Act. The Commission is scheduled to issue a draft report in July 2011.

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 most of the past two decades.

However, only a handful of proposed U.S. reactor projects currently appear to be making progress toward construction in the near term. High construction cost estimates – a major reason for earlier reactor cancellations – continue to undermine nuclear power economics. An unexpected obstacle to nuclear power growth has been the recent development of vast reserves of domestic natural gas from previously unproducible 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.

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. The Fukushima accident could also lead to new U.S. safety requirements and raise investor concerns about higher costs and liability. However, after the accident the Obama Administration reiterated its support for nuclear power expansion as part of its clean energy policy.[1]

[1] 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.

The recent applications for new power reactors in the United States followed a long period of declining nuclear generation growth rates. No nuclear power plants have been ordered in the United States since 1978, and more than 100 reactors have been canceled, including all ordered after 1973. The most recent U.S. nuclear unit to be completed was 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 28% since the startup of Watts Bar 1.[2]

The U.S. nuclear power industry currently comprises 104 licensed reactors at 65 plant sites in 31 states and generates about 20% of the nation's electricity.[3] TVA's board of directors voted August 1, 2007, to resume construction on Watts Bar 2, which had been suspended in 1985; the project is to cost about $2.5 billion and be completed in 2013. 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.[4] TVA is currently considering completion of Bellefonte unit 1 at a cost of $4.2 billion and signed a $248 million contract for engineering and development work on the project October 5, 2010.[5]

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 accounts for about 45% of U.S. electricity generation.[6] Nuclear plants generate more than half the electricity in six states. The record 807 billion net kilowatt-hours of nuclear electricity generated in the United States during 2010[7] 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.[8]

Reasons for the 30-year halt in U.S. nuclear plant orders include 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 $3,700 per kilowatt of electric generating capacity (in 2007 dollars). 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.[9]

---

[2] Energy Information Administration, *Electric Power Monthly*, Net Generation by Energy Source, April 2011, http://www.eia.gov/cneaf/electricity/epm/epm_sum.html.

[3] 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.

[4] Nuclear Regulatory Commission, "In the Matter of Tennessee Valley Authority (Bellefonte Nuclear Plant Units 1 and 2)," 74 *Federal Register* 10969, March 13, 2009.

[5] Scott DiSavino, "TVA Picks Areva to Help Complete Ala. Bellefonte Reactor," *Reuters*, October 5, 2010, http://www.reuters.com/article/idUSN0515679020101005.

[6] Energy Information Administration, *Electric Power Monthly*, Net Generation by Energy Source, April 2011, http://www.eia.gov/cneaf/electricity/epm/epm_sum.html. Net generation excludes electricity used for power plant operation.

[7] Ibid.

[8] 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.

[9] CRS Report RL34746, *Power Plants: Characteristics and Costs*, by Stan Mark Kaplan.

Average U.S. nuclear plant operating costs, however, dropped substantially since 1990, and costly downtime has been steadily reduced. Licensed U.S. commercial reactors generated electricity at an average of 89% of their total capacity in 2009, according to industry statistics.[10]

Sixty-six commercial reactors have received 20-year license extensions from the Nuclear Regulatory Commission (NRC), giving them up to a total of 60 years of operation. License extensions for 17 additional reactors are currently under review, and more are anticipated, according to NRC.[11] The FY2010 Energy and Water Development Appropriations Act provided $10 million for DOE to study further reactor life extension to 80 years, and DOE requested $21.4 million for that program in FY2012.

Existing nuclear power plants appear to hold a strong position in electricity wholesale markets. In most cases, nuclear utilities have received favorable regulatory treatment of past construction costs, and average existing nuclear plant operating costs are estimated to be competitive with those of fossil fuel technologies.[12] Although eight U.S. nuclear reactors were permanently shut down during the 1990s, none has been closed since 1998.

Possible New Reactors

Electric utilities and other firms have announced plans to apply for combined construction permits and operating licenses (COLs) for about 30 reactors (see **Table 1**).[13]

No firm commitments have been made to build the proposed plants if the COLs are issued, but the sponsors of four nuclear projects have signed preliminary engineering, procurement, and construction (EPC) contracts. At the site of Southern Company's planned Vogtle 3 and 4 reactors in Georgia, about 1,300 workers are currently preparing the foundation and conducting other pre-construction activities, according to the utility.[14] Preliminary work is also taking place at the site of the planned V.C. Summer units 2 and 3 in South Carolina.[15]

However, as **Table 1** indicates, only about 20 of those announced reactors currently appear to be moving forward toward receiving COLs, with the rest suspended, withdrawn, or shifted to site permits only. As noted above, preconstruction work on the planned units 3 and 4 at the South Texas Project was suspended after the Fukushima Daiichi accident, and the project's main partner, NRG Energy, halted further investment April 19, 2011. The joint venture developing the new South Texas Plant reactors, Nuclear Innovation North America (NINA), will focus solely on COLs and DOE loan guarantees.[16] Entergy had previously suspended further license review of its

[10] World Nuclear Performance in 2009 Pushed Down by Lengthy Outages," *Nucleonics Week*, April 1, 2010, p. 1.

[11] Nuclear Regulatory Commission, *Status of License Renewal Applications and Industry Activities*, February 3, 2010, http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html.

[12] Energy Information Administration, *Nuclear Power: 12 percent of America's Generating Capacity, 20 percent of the Electricity*, July 17, 2003, at http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nuclearpower.html.

[13] Nuclear Regulatory Commission, New Reactors, http://www.nrc.gov/reactors/new-reactors.html.

[14]Southern Company, *Construction Video and Photos*, http://www.southerncompany.com/nuclearenergy/photos.aspx.

[15] South Carolina Electric & Gas Company, *V.C. Summer Nuclear Station Units 2 & 3 Quarterly Report to the South Carolina Office of Regulatory Staff*, Quarter Ending September 30, 2010, p. 14, http://dms.psc.sc.gov/pdf/matters/54C244B7-9C28-8971-DB3654C3EE6B1161.pdf.

[16] 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=
(continued...)

planned GE ESBWR reactors at River Bend, LA, and Grand Gulf, MS, and Dominion switched from the ESBWR to the Mitsubishi US-APWR for its planned new reactor at North Anna, VA.[17] AmerenUE suspended review of a COL for its proposed new Callaway unit in Missouri, and Exelon announced June 30, 2009, that it would no longer pursue a COL for a proposed two-unit plant in Victoria County, TX, but would seek an early site permit instead, laying the groundwork for possible future licensing. Several of the other proposed nuclear projects may require additional partners in order to proceed, according to recent company announcements.[18]

Table 1. Announced Nuclear Plant License Applications

(Active applications shown in **bold**)

Announced Applicant	Site	Planned Application	Reactor Type	Units	Status
Alternate Energy	Payett (ID)	2011	Not specified	1	No longer on NRC list of expected applications
Amarillo Power	Amarillo (TX)	Late 2008	Areva EPR	2	No longer on NRC list of expected applications
AmerenUE	Callaway (MO)	Submitted 7/24/08	Areva EPR	1	Construction plans suspended 4/23/09; NRC license review suspended 6/23/09; NRC expects Early Site Permit (ESP) application in 2012
Blue Castle	Utah	ESP application expected by NRC in 2012	Not specified	1	
Dominion	**North Anna (VA)**	Submitted 11/27/07	Mitsubishi US-APWR	**1**	Reactor selection announced 5/7/10; ESP approved 11/20/07
DTE Energy	**Fermi (MI)**	Submitted 9/18/08	GE ESBWR	**1**	
Duke Energy	**William States Lee (SC)**	Submitted 12/13/07	Westing.house AP1000	**2**	
Entergy	River Bend (LA)	Submitted 9/25/08	Not specified	1	Licensing suspended 1/9/09
Exelon	Victoria County (TX)	ESP application submitted 3/25/10	Not specified	2	COL application withdrawn 3/25/10
Luminant Power (formerly TXU)	**Comanche Peak (TX)**	Submitted 9/19/08	Mitsubishi US-APWR	**2**	
FPL	**Turkey Point (FL)**	Submitted 6/30/09	Westinghouse AP1000	**2**	

(...continued)

UGFyZW50SUQ9OTAwMzB8Q2hpbGRJRD0tMXxUeXBlPTM=&t=1.

[17] ESBWR: Economic Simplified Boiling Water Reactor; APWR: Advanced Pressurized Water Reactor.

[18] Jeff Beattie, "Southeast Utilities Seek Partners to Hedge Nuclear Bets," *Energy Daily*, October 5, 2010, p. 1.

Announced Applicant	Site	Planned Application	Reactor Type	Units	Status
Nuclear Innovation North America	**South Texas Project**	Submitted 9/20/07	Toshiba ABWR	**2**	EPC contract signed with Toshiba 2/12/09; NRG Energy halted further investment 4/19/11
NuStart	Grand Gulf (MS), Entergy	Submitted 2/27/08	Not specified	1	Licensing suspended 1/9/09; ESP approved 3/27/07
	Bellefonte (AL), TVA	Submitted 10/30/07	Westinghouse AP1000	2	NuStart shifted lead unit to Vogtle 4/30/09; licensing deferred 9/29/10
PPL	**Bell Bend (PA)**	Submitted 10/10/08	Areva EPR	**1**	
Progress Energy	**Harris (NC)**	Submitted 2/19/08	Westinghouse AP1000	**2**	EPC contract signed 1/5/09
	Levy County (FL)	Submitted 7/30/08	Westinghouse AP1000	**2**	
SCE&G	**Summer (SC)**	Submitted 3/31/08	Westinghouse AP1000	**2**	EPC contract signed 5/27/08
Southern	**Vogtle (GA)**	Submitted 3/31/08	Westinghouse AP1000	**2**	EPC contract signed 4/8/08; ESP and limited construction approved 8/26/09; conditional DOE loan guarantee announced 2/16/10
	Not specified	2011	Not specified	1	No longer on NRC list of expected applications
UniStar (Constellation Energy and EDF)	**Calvert Cliffs (MD)**	Submitted 7/13/07 (Part 1), 3/13/08 (Part 2)	Areva EPR	**1**	Constellation withdrew from project 10/8/10
	Nine Mile Point (NY)	Submitted 9/30/08	Areva EPR	1	Licensing suspended 12/1/09
Total active units for COLs				**20**	

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

TVA issued a final supplemental environmental impact statement (SEIS) on May 12, 2010, for the Bellefonte site. The preferred alternative in the SEIS is to complete the first of two unfinished Babcock & Wilcox reactors already at the site, rather than build two new Westinghouse AP1000 units. TVA had submitted a COL application for the AP1000s in October 2007 as part of the NuStart consortium.[19] TVA asked NRC on September 29, 2010, to defer further review of the

[19] Tennessee Valley Authority, "Single Nuclear Unit at the Bellefonte Plant Site," fact sheet, http://www.tva.gov/ (continued...)

AP1000s until TVA's board of directors chooses which option to pursue at Bellefonte.[20] The Bellefonte decision is to be made after TVA reviews the implications of the Fukushima accident on the project.[21]

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.[22] Constellation sold its share of UniStar to EDF so that EDF can seek another U.S. partner to continue the Calvert Cliffs project.[23] (For more discussion of Constellation's decision, see the "Loan Guarantees" section below.)

NRC's current schedules indicate that the first COLs could be issued by 2011 or 2012, depending on the time required for hearings and other factors.[24] Issuance of a COL allows construction to begin and also is a prerequisite for federal loan guarantees and "regulatory risk insurance" as described below. If full-scale construction were to begin soon after receipt of the COLs, the first new reactors could begin operating before 2020. Southern Company is projecting that its planned two new reactors at the Vogtle site, currently scheduled to get the first COLs, will begin commercial operation by 2016 and 2017,[25] and the new V.C. Summer units are scheduled to start up in 2016 and 2019.[26]

The first group of new reactors, if they move forward to construction, is expected to be crucial for the future of U.S. nuclear power. Successful completion and operation of the first few reactors could encourage a larger wave of further construction, while failures could indicate that past problems with nuclear construction have not been resolved and dry up further investment. Recent projections of U.S. electric generating capacity show a wide variation in the amount of new nuclear generation that could be built by 2030—from none to 100 gigawatts (approximately double current capacity). (See Table 9 of CRS Report R40809, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, by Larry Parker and Brent D. Yacobucci.)

(...continued)

environment/reports/blnp/index.htm.

[20] Platts Nuclear News Flashes, "TVA Asked NRC to Defer Review of a COL Application for Bellefonte-3 and -4," October 6, 2010.

[21] Tennessee Valley Authority, "TVA Board Sets Path for Environmental Future," news release, April 14, 2011, http://www.tva.com/news/releases/aprjun11/board_meeting_0414.htm.

[22] 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.

[23] 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; 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.

[24] http://www.nrc.gov/reactors/new-reactors/col.html.

[25] http://www.southerncompany.com/nuclearenergy/timeline.aspx.

[26] South Carolina Electric & Gas, op. cit., p. 7.

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. Based on dose rates reported by Japanese authorities, the Natural Resources Defense Council (NRDC) estimated that the Fukushima accident subjected the population to a total radiation dose of 148,000 person-rem through April 5. In comparison, the total dose from Three Mile Island was estimated at 2,000 person-rem, while Chernobyl was estimated at 25.5 million person-rem.[27] (For more background on the Fukushima accident, see CRS Report R41694, *Fukushima Nuclear Crisis,* by Richard J. Campbell and Mark Holt.)

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 now are required to provide power for 4-8 hours, and additional measures that may be required to assure backup power.

Hydrogen explosions at four of the Fukushima reactors, resulting from a high-temperature reaction between water and nuclear fuel cladding, may be another safety issue for U.S. reactors. Dangerous levels of hydrogen were released not only from reactor cores but also in at least one unit from a pool that was storing irradiated nuclear fuel. As a result, the safety of U.S. spent fuel pools has become a subject of discussion. 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.

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." The short-term review is to be completed in 90 days and determine whether any immediate safety action is required by U.S. nuclear plants. The long-term review is to recommend whether permanent changes are needed in NRC regulations.[28]

[27] Matthew McKinzie and Thomas B. Cochran, Natural Resources Defense Council, "The Collective Effective Dose Resulting from Radiation Emitted During the First Weeks of the Fukushima Daiichi Nuclear Accident," April 10, 2011, http://docs.nrdc.org/nuclear/files/nuc_11041301a.pdf. A person-rem is the equivalent of one person receiving a radiation dose of one rem. For background on radiation doses, see CRS Report R41728, *The Japanese Nuclear Incident: Technical Aspects*, by Jonathan Medalia.

[28] 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.

Legislation introduced after the Fukushima accident includes the Nuclear Power Plant Safety Act of 2011 (H.R. 1242), introduced by Representative Markey on March 29, 2011. It would require NRC to revise its regulation within 18 months to ensure that nuclear plants could handle major disruptive events, a loss of off-site power for 14 days, and the loss of diesel generators for 72 hours. Spent fuel would have to be moved from pool to dry-cask storage within a year after it had cooled sufficiently, and emergency planning would have to include multiple concurrent disasters. NRC could not issue new licenses or permits until the revised regulations were in place.

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.[29] 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.[30]

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.[31] 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.[32] Legislation introduced by Representative Lowey (H.R. 1268) would require evacuation planning within 50 miles of U.S. nuclear power plants.

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

[29] 10 CFR 50.47, Emergency Plans.

[30] Nuclear Regulatory Commission, "Emergency Preparedness & Response," website, http://www.nrc.gov/about-nrc/emerg-preparedness.html.

[31] Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT), "Readings of Integrated Dose at Monitoring Post out of 20 Km Zone of Fukushima Dai-ichi NPP," data series, http://www.mext.go.jp/english/incident/1304275.htm.

[32] 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.

Commissioners for approval on April 8, 2011. 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.[33]

Domestic Reactor Safety

Nuclear power safety has been a long-standing 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 approximately 3,160 reactor-years of operation in the United States,[34] the only incident at a commercial 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.[35] 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."[36]

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

[33] 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.

[34] *Nuclear Engineering International*, "Average 12-Month Load Factor and Average Lifetime Load Factor by Country to the End March 2010," August 2010, p. 32.

[35] 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.

[36] 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.

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.[37]

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.[38]

NRC's safety regulations are designed to keep the probability of accidental core damage (fuel melting) below one in 10,000 per year for each reactor. The regulations also are intended to ensure that reactor containments would be successful at least 90% of the time in preventing major radioactive releases during a core-damage accident. Therefore, the probability of a major release at any given reactor is intended to be below one in 100,000 per year.[39] (For the 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.[40]

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

[37] 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.

[38] 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.

[39] 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," July 1998.

[40] 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.

cesium.[41] 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.[42]

Licensing and Regulation

For many years, a top priority of the 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, 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.[43]

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.

---

[41] The Chernobyl Forum: 2003-2005, *Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts,* International Atomic Energy Agency, April 2006.

[42] Greenpeace. *The Chernobyl Catastrophe: Consequences on Human Health,* April 2006, p. 10.

[43] 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.

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.[44]

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. 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.[45] 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.[46] The rule change was published in the Federal Register June 12, 2009.[47]

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

[44] For more information about the NRC reactor oversight process, see http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/index.html.

[45] NRC Office of Public Affairs, *NRC Approves Final Rule Amending Security Requirements*, News Release No. 07-012, January 29, 2007.

[46] Nuclear Regulatory Commission, *Final Rule—Consideration of Aircraft Impacts for New Nuclear Power Reactors, Commission Voting Record*, SECY-08-0152, February 17, 2009.

[47] 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.

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.[48] The fire mitigation rules were published in the Federal Register March 27, 2009.[49]

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.)

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 special trust 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.[50] Decommissioning of the Connecticut Yankee plant cost $790 million and was approved by NRC on November 26, 2007.[51] NRC approved the cleanup of the decommissioned Rancho Seco reactor site in California on October 7, 2009.[52] The decommissioning of Rancho Seco was estimated to cost $500 million, excluding future demolition of the cooling towers and other remaining plant structures.[53]

[48] 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.

[49] Nuclear Regulatory Commission, "Power Reactor Security Requirements," Final Rule, 74 *Federal Register* 13925, March 27, 2009.

[50] Sharp, David, "NRC Signs Off on Maine Yankee's Decommissioning," *Associated Press*, October 3, 2005.

[51] E-mail communication from Bob Capstick, Connecticut Yankee Atomic Power Company, August 28, 2008.

[52] 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.

[53] "20 Years Later, Rancho Seco Ready for Final Shutdown," *Sacramento County Herald*, June 9, 2009, http://m.news10.net/news.jsp?key=190656.

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. "Until this SNF is removed from these nine sites, the sites cannot be fully decommissioned and made available for other purposes," DOE noted in a 2008 report.[54] 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.

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.[55] Any damages exceeding $375 million are to be assessed equally against all 100-megawatt-and-above power reactors, up to $111.9 million per reactor. Those assessments—called "retrospective premiums"—would be paid at an annual rate of no more than $17.5 million per reactor, to limit the potential financial burden on reactor owners following a major accident. According to NRC, all 104 commercial reactors are currently covered by the Price-Anderson retrospective premium requirement.[56]

For each nuclear incident, the Price-Anderson liability system currently would provide up to $12.6 billion in public compensation. That total includes the $375 million in insurance coverage carried by the reactor that suffered the incident, plus the $111.9 million in retrospective premiums from each of the 104 currently covered reactors, totaling $12.0 billion. On top of those payments, a 5% surcharge may also be imposed, raising the total per-reactor retrospective premium to $117.5 million and the total available compensation to about $12.6 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 an inflation adjustment. Payment of any damages above that liability limit would require congressional approval under special procedures in the act.

[54] 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.

[55] American Nuclear Insurers, "Need for Nuclear Liability Insurance," January 2010, http://www.nuclearinsurance.com/library/Nuclear%20Liability%20in%20the%20US.pdf.

[56] 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. Both the annual and total limits were most recently adjusted October 29, 2008.[57] 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, a power plant with six 120-megawatt small modular reactors would be liable for retrospective premiums of up to $111.9 million, rather than $671.4 million (excluding the 5% surcharge).

The Price-Anderson Act also covers contractors who operate hazardous 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.[58] 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. Previously, Atomic Energy Act §234A specifically exempted seven nonprofit DOE contractors and their subcontractors from civil penalties and authorized DOE to automatically remit any civil penalties imposed on nonprofit educational institutions serving as DOE contractors. EPACT05 eliminated the civil penalty exemption for future contracts by the seven listed nonprofit contractors and DOE's authority to automatically remit penalties on nonprofit educational institutions.

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. The possibility that damages to the public from the Fukushima accident could greatly exceed the Price-Anderson liability limits has prompted new calls for reexamination of the law.[59]

The United States 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

[57] Nuclear Regulatory Commission, "Inflation Adjustment to the Price-Anderson Act Financial Protection Regulations," 73 *Federal Register* 56451, September 29, 2008.

[58] Department of Energy, "Adjusted Indemnification Amount," 74 *Federal Register* 52793, October 14, 2009.

[59] 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.

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.

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. reactor 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."[60] 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 above in the "Nuclear Accident Liability" section of this report). 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 112th 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.[61]

[60] 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/.

[61] 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.

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 Treasury Department published interim guidance for the nuclear production tax credit on May 1, 2006.[62] 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 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,[63] so if all those reactors were built before 2021 they would receive less than 20% of the maximum tax credit. More recent utility target dates for opening new reactors indicate that no more than 17,000 megawatts of new nuclear capacity is likely before 2021.[64] The credit is not adjusted for inflation.

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.[65]

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.[66] According to a DOE description of the final rule,

---

[62] 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.

[63] Energy Information Administration, *Status of Potential New Commercial Nuclear Reactors in the United States*, February 19, 2009.

[64] William Freebairn and Housley Carr, "New U.S. Nuclear Construction Slowed by Economic, Market Issues," *Nucleonics Week*, September 23, 2010, p. 1.

[65] 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.

[66] Department of Energy, "Standby Support for Certain Nuclear Plant Delays," *Federal Register*, August 11, 2006, (continued...)

> Events that would be covered by the risk insurance include delays associated with the Nuclear Regulatory Commission's reviews of inspections, tests, analyses and acceptance criteria or other licensing schedule delays as well as certain delays associated with litigation in federal, state or tribal courts. Insurance coverage is not available for normal business risks such as employment strikes and weather delays. Covered losses would include principal and interest on debt and losses resulting from the purchase of replacement power to satisfy contractual obligations.[67]

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. No conditional agreements have yet been reached, according to DOE, primarily because the subsidy cost estimates have not been approved by the Office of Management and Budget (OMB).[68]

The Nuclear Energy Institute has called for expanding the Standby Support program to $500 million for all six covered reactors, rather than just the first two. In addition, NEI proposed that if a reactor successfully begins operating without any delay payments, that plant's Standby Support coverage, instead of expiring unused, be allowed to "roll over" to the next plant with a conditional agreement.[69]

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.[70]

The total amount of Title XVII loan guarantees to be made available for nuclear power has been the subject of considerable congressional debate. President Obama's FY2011 budget request would have nearly tripled the current ceiling on federal loan guarantees for nuclear power plants, from $18.5 billion to $54.5 billion. A $36 billion increase would increase the number of reactors that could receive loan guarantees from about three or four to about a dozen, depending on their size. The Department of Defense and Full-Year Continuing Appropriations Act for FY2011 (P.L.

(...continued)

p. 46306.

[67] DOE press release, August 4, 2006 http://nuclear.gov/home/08-04-06.html.

[68] Meeting with Rebecca F. Smith-Kevern, Director, DOE Office of Light Water Reactor Deployment, October 7, 2009.

[69] Nuclear Energy Institute, op. cit.

[70] 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.

112-10) did not provide the requested increase, leaving the nuclear power loan guarantee ceiling at $18.5 billion, but the Administration again requested the $36 billion increase for FY2012.

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. Other finalists for the first round of nuclear reactor loan guarantees are Calvert Cliffs 3 in Maryland, South Texas Plant 3 and 4, and Summer 2 and 3.[71] However, as noted earlier, the future of the proposed units at Calvert Cliffs and the South Texas Plant is currently uncertain, leaving only Summer 2 and 3 as clearly viable candidates.

DOE issued final rules for the program October 4, 2007,[72] and finalized the first loan guarantee on September 4, 2009, totaling $535 million for a plant to produce photovoltaic panels.[73] DOE's proposed loan guarantee rules, published May 16, 2007, had been sharply criticized by the nuclear industry for limiting the guarantees to 90% of a project's debt. The industry contended that EPACT05 allows all of a project's debt to be covered, as long as debt does not exceed 80% of total construction costs. In its explanation of the proposed rules, DOE expressed concern that guaranteeing 100% of a project's debt could reduce lenders' incentive to perform adequate due diligence and therefore increase default risks. In the final rule, however, DOE agreed to guarantee up to 100% of debt, but only for loans issued by the Federal Financing Bank.

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. 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.[74] For example, appropriations bills that provide loan guarantee authorizations include an adjustment totaling 1% of the loan guarantee ceiling.

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 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.

[71] Letter from Office of Management and Budget Director Peter R. Orszag to House and Senate leaders, May 21, 2010, http://www.whitehouse.gov/omb/assets/legislative_letters/Pelosi_05212010.pdf.

[72] Published October 23, 2007 (72 *Federal Register* 60116).

[73] Department of Energy, "Vice President Biden Announces Finalized $535 Million Loan Guarantee," press release, September 4, 2009, http://www.lgprogram.energy.gov/press/090409.pdf.

[74] 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. Energy Secretary Steven Chu stated in March 2010 that the subsidy cost would probably be about 1%.[75] The nuclear industry, contending that historical experience indicates defaults are likely to be minimal, agrees with Chu's assessment that nuclear plant subsidy costs should be low.[76] 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."[77]

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.[78] 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 drop too low or if its costs are higher than anticipated.

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 110th 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 subsidy costs were paid by project sponsors, but it was dropped from the final legislation (P.L. 110-140). Similar language has been included in subsequent legislative proposals, such as energy legislation reported by the Senate Committee on Energy and Natural Resources July 16, 2009 (S. 1462).

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-

[75] William Freebairn, "U.S. Industry, Interest Groups Differ on Credit Fees," *Nucleonics Week*, March 18, 2010, p. 1.

[76] 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.

[77] 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.

[78] 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.

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.[79]

The FY2009 omnibus funding act increased DOE's total loan guarantee authority to $47 billion, in addition to the $4 billion authorized 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. The loan guarantee ceilings remained the same for FY2010 but were sharply reduced for non-nuclear technologies by the FY2011 Continuing Appropriations Act. The nuclear power loan guarantee ceiling remains at $18.5 billion.

DOE issued a solicitation for up to $20.5 billion in nuclear power and uranium enrichment plant loan guarantees on June 30, 2008.[80] 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.[81] 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 are not expected until late 2011 at the earliest.

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.[82] 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.[83] DOE offered a $2 billion conditional loan guarantee to Areva on May 20, 2010.[84]

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

[79] *Congressional Record*, December 17, 2007, p. H15585.

[80] http://www.lgprogram.energy.gov/keydocs.html.

[81] 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.

[82] Department of Energy, "800 to 1000 New Jobs Coming to Piketon," press release, July 28, 2009, http://www.lgprogram.energy.gov/press/072809.pdf.

[83] Maureen Conley, "DOE Finds $2 Billion More for SWU Plant Loan Guarantees," *NuclearFuel*, April 5, 2010, p. 3.

[84] 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.

from these emissions is the principal justification for government support of the nuclear energy option."[85] As discussed above, the Obama Administration is also including nuclear power as part of its clean energy strategy.

However, 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.[86] They also contend that energy efficiency and renewable energy would be far more productive investments for reducing greenhouse gas emissions.[87]

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. Utilities that have applied for nuclear power plant licenses have often cited the possibility of federal greenhouse gas controls as one of the reasons for pursuing new reactors. (For more on federal incentives and the economics of nuclear power and other electricity generation technologies, see CRS Report RL34746, *Power Plants: Characteristics and Costs*, by Stan Mark Kaplan.)

Nuclear Power Research and Development

The Obama Administration's FY2012 funding request for nuclear energy research and development totals $754 million. Including advanced reactors, fuel cycle technology, and infrastructure support, the total nuclear energy request is about $22 million above the FY2011 funding level approved by Congress on April 14, 2011. The FY2011 level is about $37 million below the FY2010 appropriation. Those totals exclude funding provided under Other Defense Activities for safeguards and security at DOE's Idaho nuclear facilities, for which $98.5 million is being requested for FY2012.

Using reorganized budget categories established for FY2011, the Administration's FY2012 nuclear R&D budget request is consistent with DOE's *Nuclear Energy Research and Development Roadmap* issued in April 2010.[88] 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;

[85] Interdisciplinary MIT Study, *The Future of Nuclear Power*, Massachusetts Institute of Technology, 2003, p. 79.

[86] Gronlund, Lisbeth, David Lochbaum, and Edwin Lyman, *Nuclear Power in a Warming World*, Union of Concerned Scientists, December 2007.

[87] 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.

[88] Department of Energy, *Nuclear Energy Research and Development Roadmap*, Report to Congress, Washington, DC, April 2010, http://nuclear.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf.

- Develop sustainable nuclear fuel cycles; and
- Understand and minimize the risks of nuclear proliferation and terrorism.

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). Funding would also be provided for developing small modular reactors and to enhance the "sustainability" of existing commercial nuclear plants. The total FY2012 funding request for this program is $125 million.

NGNP is a high-temperature gas-cooled reactor demonstration project authorized by the Energy Policy Act of 2005 (EPACT05). 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 requesting $49.6 million for the NGNP project for FY2012, down from $103 million requested in FY2011. Under EPACT05, the Secretary of Energy is to decide by the end of FY2011 whether to proceed toward construction of a demonstration plant. Potential obstacles facing NGNP include low prices for natural gas, the major competing fuel, and private-sector willingness to share the project's costs as required by EPACT05.[89]

The FY2012 funding request for the Advanced Reactor Concepts program is $21.9 million, the same as the FY2011 request. The program was described by the FY2011 budget justification as "an expanded version" of the previous Generation IV Nuclear Energy Systems program. "The program will focus on reactors that could dramatically improve performance in sustainability, safety, economics, security, and proliferation resistance," according to the FY2011 and FY2012 justifications. 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).

DOE's Light Water Reactor Sustainability Program is to receive $21.4 million, about $4.4 million below the FY2011 request. 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 fuel leakage and increasing safety and performance, according to the budget justification.

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 350 megawatts of electrical capacity, such reactors would be only a

[89] Yanmei Xie, "Cheap Natural Gas, Cost-Share Disagreement Jeopardize NGNP," *Nucleonics Week,* April 28, 2011, p. 1.

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 high-temperature gas technology in the NGNP program and the light water (LWR) technology used by today's commercial reactors.

DOE is requesting $67 million for FY2012 to provide technical support for licensing small modular LWRs, a substantial boost from the FY2011 request of $38.9 million. DOE plans to hold a competitive solicitation to award cost-shared financial assistance to as many as two SMR LWR designs, according to the FY2012 budget justification. The program would be similar to DOE's support for larger commercial reactor designs under the Nuclear Power 2010 Program, which ended in FY2010. DOE would provide support for design certification, standards, and licensing. As with the Nuclear Power 2010 Program, at least half the costs of the SMR program are to be covered by industry partners, according to DOE.

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, 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 large conventional reactors, their ability to be constructed in smaller increments could reduce the financial commitment and risk to electric utilities.

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 FY2012 funding request for this program is $155 million, about $46 million below the FY2011 request.

Under the George W. Bush Administration, when it was called the Advanced Fuel Cycle Initiative (AFCI), the program had focused on near-term development and deployment of a specific type of spent fuel reprocessing technology, UREX, which was intended to recycle plutonium, uranium, and other long-lived radioactive materials into new nuclear fuel. AFCI had constituted the domestic portion of the Bush Administration's Global Nuclear Energy Partnership (GNEP) initiative, which had been intended to provide secure nuclear fuel services to discourage the international spread of nuclear fuel cycle technology.

Under the Obama Administration, the program has been redirected toward development of technology options for a wider range of nuclear fuel cycle approaches, including direct disposal of spent fuel (the "once through" cycle) and partial and full recycling, according to the justification. "Specifically, the 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 justification says.

Much of the planned research on spent fuel management options has supported the Blue Ribbon Commission on America's Nuclear Future, which is to develop alternatives to the planned Yucca Mountain, NV, spent fuel repository, which President Obama wants to terminate. Other major research areas in the Fuel Cycle R&D Program include the development of advanced fuels for

existing commercial reactors and advanced reactors, improvements in nuclear waste characteristics, modeling and simulation of fuel cycle options, and technology to increase nuclear fuel resources, such as uranium extraction from seawater.

Nuclear Energy Enabling Technologies

Research under the Nuclear Energy Enabling Technologies (NEET) program is intended to "contribute to a wide variety of existing and developing reactor and fuel cycle technologies," according to the FY2012 DOE budget justification. The funding request for the program is $97.4 million, about $2 million below the FY2011 request.

Under the category of Crosscutting Technology Development, which would receive $41.2 million, research is to be conducted on new types of reactor materials, the weapons proliferation risks of fuel cycle options, advanced nuclear plant manufacturing methods, and advanced sensors and instrumentation. The Energy Innovation Hub for Modeling and Simulation, created in FY2010, has a request of $24.3 million, the same as in FY2011. The Modeling and Simulation Hub is creating a computer model of an operating reactor to allow a better understanding of nuclear technology, with the benefits of such modeling extending to other energy technologies in the future, according to the justification.

Transformative Nuclear Concepts Research, with a request of $14.6 million, is to provide competitive support to "investigator-initiated transformative projects that are high-risk, high-reward concepts with the potential for making significant leaps forward in advanced nuclear technology development," according to the FY2012 justification. Awards are to be available to national laboratories, universities, research institutions, and industry. DOE is also requesting $14.6 million to support up to five university partnerships to conduct experiments "at facilities not normally accessible."

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 40,000 cubic meters of low-level radioactive waste per year, including contaminated components and materials resulting from reactor decommissioning.[90]

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 (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 rock that has remained geologically undisturbed for hundreds of thousands of years. As amended in 1987, NWPA designated Yucca Mountain in Nevada as the only candidate site for

[90] DOE, Manifest Information Management System http://mims.apps.em.doe.gov. Average annual utility disposal from 2002 through 2007.

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. As a result, no funding for Yucca Mountain or DOE's Office of Civilian Radioactive Waste Management (OCRWM), which had run the program, was requested for FY2011. The Continuing Appropriations Act for FY2011 (P.L. 112-10) approved the funding termination.

DOE filed a motion with NRC to withdraw the Yucca Mountain license application on March 3, 2010. An NRC licensing panel denied DOE's withdrawal motion June 29, 2010,[91] and the matter is now before the full Commission. The license withdrawal is also being opposed in federal court by states that have defense-related waste awaiting permanent disposal. NRC began closing down its review of the Yucca Mountain license application on October 1, 2010, the start of the new fiscal year, a move that has also sparked controversy.[92] NRC had requested $10 million in FY2011 for "orderly closure" of the Yucca Mountain licensing review process, a request that was approved by P.L. 112-10.

Alternatives to Yucca Mountain are being evaluated by the Blue Ribbon Commission on America's Nuclear Future, which was formally established by DOE on March 1, 2010. The Commission is expected to issue a draft report in the summer of 2011 and a final report six months later.

Funding for the nuclear waste program in the past has been provided under two appropriations accounts. The Administration's FY2010 request was divided evenly between an appropriation from the Nuclear Waste Fund, which holds fees paid by nuclear utilities, and the Defense Nuclear Waste Disposal account, which pays for disposal of high-level waste from the nuclear weapons program. The Senate Appropriations Committee report for that year called for the Secretary of Energy to suspend fee collections, "given the Administration's decision to terminate the Yucca Mountain repository program while developing disposal alternatives," but the language was dropped in conference. Energy Secretary Steven Chu in October 2009 rejected requests from the nuclear industry and state utility regulators to suspend the fee, saying the revenues were still necessary, and nuclear utilities and regulators filed lawsuits to stop the fee in April 2010.[93]

The Yucca Mountain project faced regulatory uncertainty even before the Obama Administration's move to shut it down. A ruling on July 9, 2004, by the U.S. Court of Appeals for the District of Columbia Circuit overturned a key aspect of the Environmental Protection

[91] U.S. Nuclear Regulatory Commission, Atomic Safety and Licensing Board, Docket No. 63-001-HLW, Memorandum and Order, June 29, 2010.

[92] Elaine Hiruo, "Lack of Commission Quorum Lets Termination of Yucca Work Stand," *NuclearFuel*, October 18, 2010, p. 1.

[93] National Association of Regulatory Utility Commissioners, "State Regulators Go to Court with DOE over Nuclear Waste Fees," news release, April 2, 2010, http://www.naruc.org/News/default.cfm?pr=193; Nuclear Energy Institute, "NEI, Electric Utilities File Suit to Suspend Collection of Fees for Reactor Fuel Management," news release, April 5, 2010, http://www.nei.org/newsandevents/newsreleases/nei-electric-utilities-file-suit-to-suspend-collection-of-fee-for-reactor-fuel-management.

Agency's (EPA's) regulations for the planned repository.[94] The three-judge panel ruled that EPA's 10,000-year compliance period was too short, but it rejected several other challenges to the rules. EPA published new standards on October 15, 2008, that would allow radiation exposure from the repository to increase after 10,000 years.[95] The State of Nevada has filed a federal Appeals Court challenge to the EPA standards. (For more information on the EPA standards, see CRS Report RL34698, *EPA's Final Health and Safety Standard for Yucca Mountain*, by Bonnie C. Gitlin.)

NWPA 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 total $11 billion if DOE were to begin removing waste from reactor sites by 2020, the previous target for opening Yucca Mountain.[96] (For more information, see CRS Report R40996, *Contract Liability Arising from the Nuclear Waste Policy Act (NWPA) of 1982*, by Todd Garvey CRS Report R40202, *Nuclear Waste Disposal: Alternatives to Yucca Mountain*, by Mark Holt, and CRS Report RL33461, *Civilian Nuclear Waste Disposal*, by Mark Holt.)

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.[97]

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

[94] *Nuclear Energy Institute v. Environmental Protection Agency*, U.S. Court of Appeals for the District of Columbia Circuit, no. 01-1258, July 9, 2004.

[95] Environmental Protection Agency, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada," 73 *Federal Register* 61256, October 15, 2008.

[96] Statement of Edward F. Sproat III, Director of the Office of Civilian Radioactive Waste Management, Before the House Budget Committee, October 4, 2007.

[97] The organization approved a new mission statement with the name change at its June 2010 meeting in Ghana. See http://www.gneppartnership.org.

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 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 Nikitin; and CRS Report R41216, *2010 Non-Proliferation Treaty (NPT) Review Conference: Key Issues and Implications*, coordinated by Paul K. Kerr and Mary Beth 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. FY2009 funding for energy and water programs was included in the Omnibus Appropriations Act for FY2009 (P.L. 111-8), signed March 11, 2009. Detailed funding tables for the act are provided by the Committee Print of the House Committee on Appropriations on H.R. 1105. FY2010 funding is included in the Energy and Water Development and Related Agencies Appropriations Act, 2010 (P.L. 111-85, H.Rept. 111-278), signed October 28, 2009. The FY2011 DOE funding request for nuclear energy was significantly reorganized, as discussed in the earlier section on Nuclear Energy Research and Development. FY2011 funding is provided under the Department of Defense and Full-Year Continuing Appropriations Act (P.L. 112-10), which did not specify funding levels for sub-accounts, as noted in the tables.

Table 2. Funding for the Nuclear Regulatory Commission

(budget authority in millions of current dollars)

	FY2009 Approp.	FY2010 Approp.	FY2011 Approp.	FY2012 Request
Nuclear Regulatory Commission				
Reactor Safety	788.3	806.8	804.1[a]	800.8
Nuclear Materials and Waste	197.3	220.2	229.4	226.5
Yucca Mountain Licensing	49.0	29.0	10.0	0
Inspector General	10.9	10.9	10.1	10.9
Total NRC budget authority	1,045.5	1,066.9	1,052.3	1,038.1
—Offsetting fees	-870.6	-912.2	-914.2	909.5
Net appropriation	**174.9**	**154.7**	**138.1**	**128.6**

a. Subcategories from NRC budget request.

b. Not specified.

Table 3. DOE Funding for Nuclear Activities

(budget authority in millions of current dollars)

	FY2009 Approp.	FY2010 Approp.	FY2011 Approp.	FY2012 Request
University programs	5.0	5.0	—[a]	0
Nuclear Power 2010	177.5	105.0	—	0
Generation IV Nuclear Systems	178.6	220.1	—	0
Reactor Concepts			—	125.0
Nuclear Hydrogen Initiative	7.4	0	—	0
Fuel Cycle R&D	142.6	136.0	—	155.0
Nuclear Energy Enabling Technologies			—	97.4
International Nuclear Energy Coop.			—	3.0
Radiological Facilities Management	66.1	72.0	—	150.0
Idaho Facilities Management	140.0	173.0	—	98.5
Program Direction	73.0	73.0	—	93.1
Total, Nuclear Energy[b]	791.4	786.6	732.1	754.0
Civilian Nuclear Waste Disposal[c]	288.4	196.8	0	0

a. Not available.

b. Excludes funding provided under other accounts.

c. Funded by a 1-mill-per-kilowatt-hour fee on nuclear power, plus appropriations for defense waste disposal and homeland security.

Legislation in the 112th Congress

H.R. 301 (Forbes)

New Manhattan Project for Energy Independence. Establishes program to develop new energy-related technologies, including treatment of nuclear waste. Introduced January 18, 2011; referred to Committee on Science and Technology.

H.R. 617 (Matheson)

Radioactive Import Deterrence Act. Restricts imports of radioactive waste. Introduced February 10, 2011; referred to Committee on Energy and Commerce.

H.R. 909 (Nunes)

Roadmap for America's Energy Future. Includes provisions to triple the number of U.S. nuclear power plants, encourage recycling of spent nuclear fuel, develop nuclear waste disposal capacity, remove statutory limits on waste disposal at the proposed Yucca Mountain repository, establish a nuclear fuel supply reserve, and require NRC to establish expedited procedures for issuing new reactor combined construction and operating licenses. Introduced March 3, 2011; referred to multiple committees.

H.R. 1023 (Thornberry)

No More Excuses Energy Act of 2011. 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 March 10, 2011; referred to multiple committees.

H.R. 1242 (Markey)

Nuclear Power Plant Safety Act of 2011. Requires NRC to revise its regulation within 18 months to ensure that nuclear plants could handle major disruptive events, a loss of off-site power for 14 days, and the loss of diesel generators for 72 hours. Spent fuel would have to be moved from pool to dry-cask storage within a year after it had cooled sufficiently, and emergency planning would have to include multiple concurrent disasters. NRC could not issue new licenses or permits until the revised regulations were in place. Introduced March 29, 2011; referred to Committee on Energy and Commerce.

H.R. 1268 (Lowey)

Nuclear Power Licensing Reform Act of 2011. 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 April 7, 2011; referred the Committee on Energy and Commerce.

H.R. 1280 (Ros-Lehtinen)/S. 109 (Ensign)

Requires congressional approval of agreements for peaceful nuclear cooperation with foreign countries. House bill introduced March 31, 2011; referred to Committee on Foreign Affairs. Senate bill introduced January 25, 2011; referred to Committee on Foreign Relations.

H.R. 1320 (Berman)

Nuclear Nonproliferation and Cooperation Act of 2011. Requires additional nonproliferation conditions for new peaceful nuclear cooperation agreements. Introduced April 1, 2011; referred to Committee on Foreign Affairs.

H.R. 1326 (Fortenberry)/S. 640 (Akaka)

Furthering International Nuclear Safety Act of 2011. Requires U.S. delegation to the Convention on Nuclear Safety to encourage member countries to use metrics in assessing safety improvements and publicly post national safety reports, and that U.S. agencies submit a strategic plan for international nuclear safety cooperation. Senate bill introduced March 17, 2011; referred to Committee on Foreign Relations. House bill introduced April 1, 2011; referred to Committee on Foreign Affairs.

H.R. 1436 (Christopher H. Smith)

Requires nuclear power facilities to notify NRC and state and local governments within 24 hours of an unplanned release of radionuclides above allowable limits. Introduced April 7, 2011; referred to Committee on Energy and Commerce.

H.R. 1694 (Engle)

Nuclear Disaster Preparedness Act. Requires the President to issue guidance for federal response to nuclear disasters, covering specific topics listed in the bill. Introduced May 3, 2011; referred to Committee on Transportation and Infrastructure.

H.R. 1710 (Burgess)

Nuclear Used Fuel Prize Act of 2011. Authorizes the Secretary of Energy to establish monetary prizes for advancements in used nuclear fuel management technology. Introduced May 4, 2011; referred to Committees on Science, Space, and Technology and Ways and Means.

S. 512 (Bingaman)

Nuclear Power 2021 Act. Establishes a cost-shared program between DOE and the nuclear industry to develop and license standard designs by 2021 for two reactors below 300 megawatts of electric generating capacity, including at least one no larger than 50 megawatts. Introduced March 8, 2011; referred to Committee on Energy and Natural Resources.

Author Contact Information

Mark Holt
Specialist in Energy Policy
mholt@crs.loc.gov, 7-1704