U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



2009-2010

Information Digest


026



2009–2010

Information Digest

NUREG-1350, Volume 21
Manuscript Completed: August 2009
Date Published: August 2009

U.S. Nuclear Regulatory Commission
Office of Public Affairs
Washington, DC 20555-0001

www.nrc.gov

Protecting People and the Environment

Front Cover: (clockwise from upper left corner)
1. *NRC headquarters in Rockville, MD.*
2. *Limerick Generating Station, located near Philadelphia, PA. (Courtesy of Exelon Generation Co., LLC)*
3. *Control room in a nuclear power plant.*
4. *Gamma Knife® headframe used for treating brain tumors with focused radiation beams. (Photo courtesy of Elekta)*
5. *Background image of entrance to NRC headquarters.*

Inside Cover: (from left to right)
1. *Control room at a nuclear power plant.*
2. *Inside the proposed nuclear waste facility at Yucca Mountain, NV.*
3. *Fire Research Branch Chief Mark Salley (left) and NRC Chairman Gregory B. Jaczko (right) discuss a demonstration of a cable tray fire test at the National Institute of Standards and Technology Fire Research Laboratory.*
4. *Pilgrim nuclear power plant near Plymouth, MA. (Photo courtesy of Entergy Nuclear Operations, Inc.)*

ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) 2009–2010 Information Digest provides a summary of information about the NRC. It describes the agency's regulatory responsibilities and licensing activities and also provides general information on related topics.

To create the Information Digest, the agency compiled and organized NRC- and industry-related data into a quick reference on the agency and the industry it regulates. Data include activities through 2008 or the most current data available at manuscript completion. The NRC Web Link Index provides URL addresses for more information on major topics. Also available in the digest is a tear-out reference sheet with NRC Facts at a Glance. (In this edition, adjustments were made to previous year figures based on preliminary data. All information is final unless otherwise noted.)

The NRC reviewed information from industry sources but did not perform an independent verification.

The agency welcomes comments or suggestions on the Information Digest. Please contact Ivonne Couret by mail at the Office of Public Affairs, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001 or by e-mail at OPA.Resource@nrc.gov.

TABLE OF CONTENTS

FIGURES

SECURITY AND EMERGENCY PREPAREDNESS

TABLES

U.S. AND WORLDWIDE ENERGY

NUCLEAR REACTORS

NUCLEAR MATERIALS

RADIOACTIVE WASTE

NRC headquarters in Rockville, MD.

NRC: AN INDEPENDENT REGULATORY AGENCY

MISSION

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. The mission of the NRC is to license and regulate the Nation's civilian use of byproduct, source, and special nuclear materials in order to protect public health and safety, promote the common defense and security, and protect the environment.

The NRC's regulations are designed to protect both the public and workers against radiation hazards from industries that use radioactive materials.

The NRC's scope of responsibility includes regulation of commercial nuclear power plants; research, test, and training reactors; nuclear fuel cycle facilities; medical, academic, and industrial uses of radioactive materials; and the transport, storage, and disposal of radioactive materials and wastes.

In addition, the NRC licenses the import and export of radioactive materials and works to enhance nuclear safety and security throughout the world.

Values

The NRC adheres to the principles of good regulation—independence, openness, efficiency, clarity, and reliability. The agency puts these principles into practice with effective, realistic, and timely regulatory actions.

Strategic Goals

Safety: Ensure adequate protection of public health and safety and the environment.

Security: Ensure adequate protection in the secure use and management of radioactive materials.

Strategic Outcomes

- Prevent the occurrence of any nuclear reactor accidents.
- Prevent the occurrence of any inadvertent criticality events.
- Prevent the occurrence of any acute radiation exposures resulting in fatalities.
- Prevent the occurrence of any releases of radioactive materials that result in significant radiation exposures.
- Prevent the occurrence of any releases of radioactive materials that cause significant adverse environmental impacts.
- Prevent any instances where licensed radioactive materials are used domestically in a manner hostile to the United States.

Statutory Authority

The NRC was established by the Energy Reorganization Act of 1974 to oversee the commercial nuclear industry. The agency took over regulation formerly carried out by the Atomic Energy Commission and began operations on January 18, 1975. As noted earlier, it is the NRC's job to regulate the civilian commercial, industrial, academic, and medical uses of nuclear materials. Effective regulation enables the Nation to use radioactive materials for beneficial civilian purposes while protecting the American people and their environment.

The NRC's regulations are contained in Title 10 of the *Code of Federal Regulations* (10 CFR). The following principal statutory authorities govern the NRC's work and can be found on the NRC Web site (see Web Link Index):

- Atomic Energy Act of 1954, as Amended (P.L. 83–703)
- Energy Reorganization Act of 1974, as Amended (P.L. 93–438)
- Uranium Mill Tailings Radiation Control Act of 1978, as Amended (P.L. 95–604)
- Nuclear Non-Proliferation Act of 1978 (P.L. 95–242)
- West Valley Demonstration Project Act of 1980 (P.L. 96–368)
- Nuclear Waste Policy Act of 1982, as Amended (P.L. 97–425)
- Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99–240)
- Diplomatic Security and Anti-Terrorism Act of 1986 (P.L. 107–56)
- Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990
- Energy Policy Act of 1992
- Energy Policy Act of 2005

The NRC, licensees (those licensed by the NRC to use radioactive materials), and the Agreement States (states that assume regulatory authority over their own use of certain nuclear materials), share a common responsibility to protect public health and safety and the environment. Federal regulations and the NRC regulatory program are important elements in the protection of the public. However, because licensees are the ones using radioactive material, they bear the primary responsibility for safely handling these materials.

MAJOR ACTIVITIES

The NRC fulfills its responsibilities through the following licensing and regulatory activities:

- Licenses the design, construction, operation, and decommissioning of nuclear plants and other nuclear facilities, such as uranium enrichment facilities and research and test reactors.
- Licenses the possession, use, processing, handling, and importing and exporting of nuclear materials.
- Licenses the siting, design, construction, operation, and closure of low-level radioactive waste disposal sites under NRC jurisdiction and the construction, operation, and closure of a proposed geologic repository for high-level radioactive waste.

- Licenses the operators of civilian nuclear reactors.
- Inspects licensed and certified facilities and activities.
- Certifies privatized uranium enrichment facilities.
- Conducts light-water reactor safety research, using independent research, data, and expertise, to develop regulations and anticipate potential safety problems.
- Collects, analyzes, and disseminates information about the operational safety of commercial nuclear power reactors and certain nonreactor activities.
- Establishes, safety and security policies, goals, rules, regulations, and orders that govern licensed nuclear activities and interacts with other Federal agencies, including the U.S. Department of Homeland Security, on safety and security issues.
- Investigates nuclear incidents and allegations concerning any matter regulated by the NRC.
- Enforces NRC regulations and the conditions of NRC licenses.
- Conducts public hearings on matters of nuclear and radiological safety, environmental concern, and common defense and security.
- Develops effective working relationships with State and Tribal Governments regarding reactor operations and the regulation of nuclear materials.
- Directs the NRC program for response to incidents involving licensees and conducts a program of emergency preparedness and response for licensed nuclear facilities.
- Provides opportunities for public involvement in the regulatory process that include the following: holding open meetings, conferences, and workshops; issuing rules, regulations, petitions, and technical reports for public comment; responding to requests for NRC documents under the Freedom of Information Act; reporting safety concerns; and providing access to thousands of NRC documents through the NRC Web site.

The NRC hosts an annual Regulatory Information Conference (RIC) attended by more than 2,300 people including representatives from more than 25 foreign countries, the nuclear industry, and congressional staff.

Chairman
Gregory B. Jaczko

Commissioner
Dale E. Klein

Commissioner
Kristine L. Svinicki

Commissioner Term Expiration

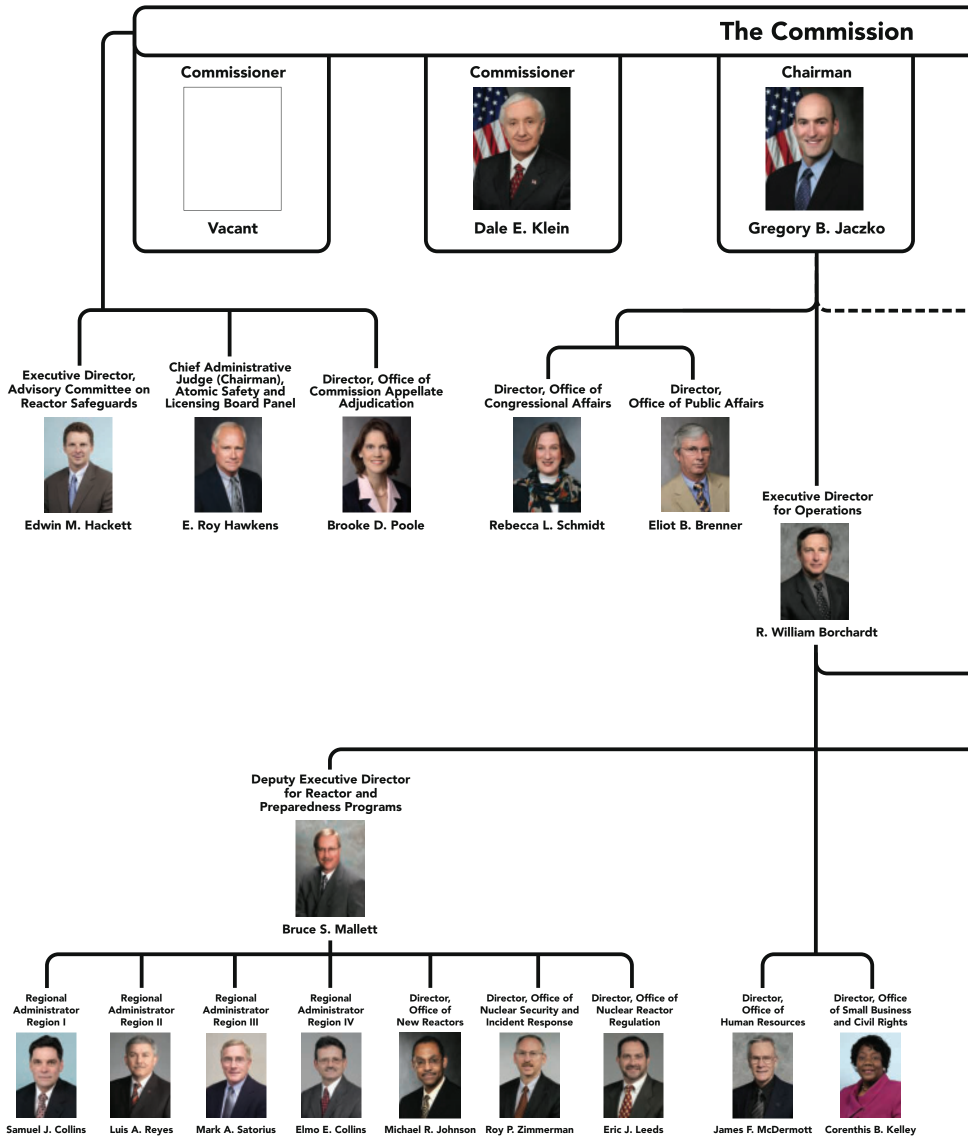
Commissioner	Expiration of Term
Gregory B. Jaczko, Chairman	June 30, 2013
Dale E. Klein	June 30, 2011
Kristine L. Svinicki	June 30, 2012

ORGANIZATIONS AND FUNCTIONS

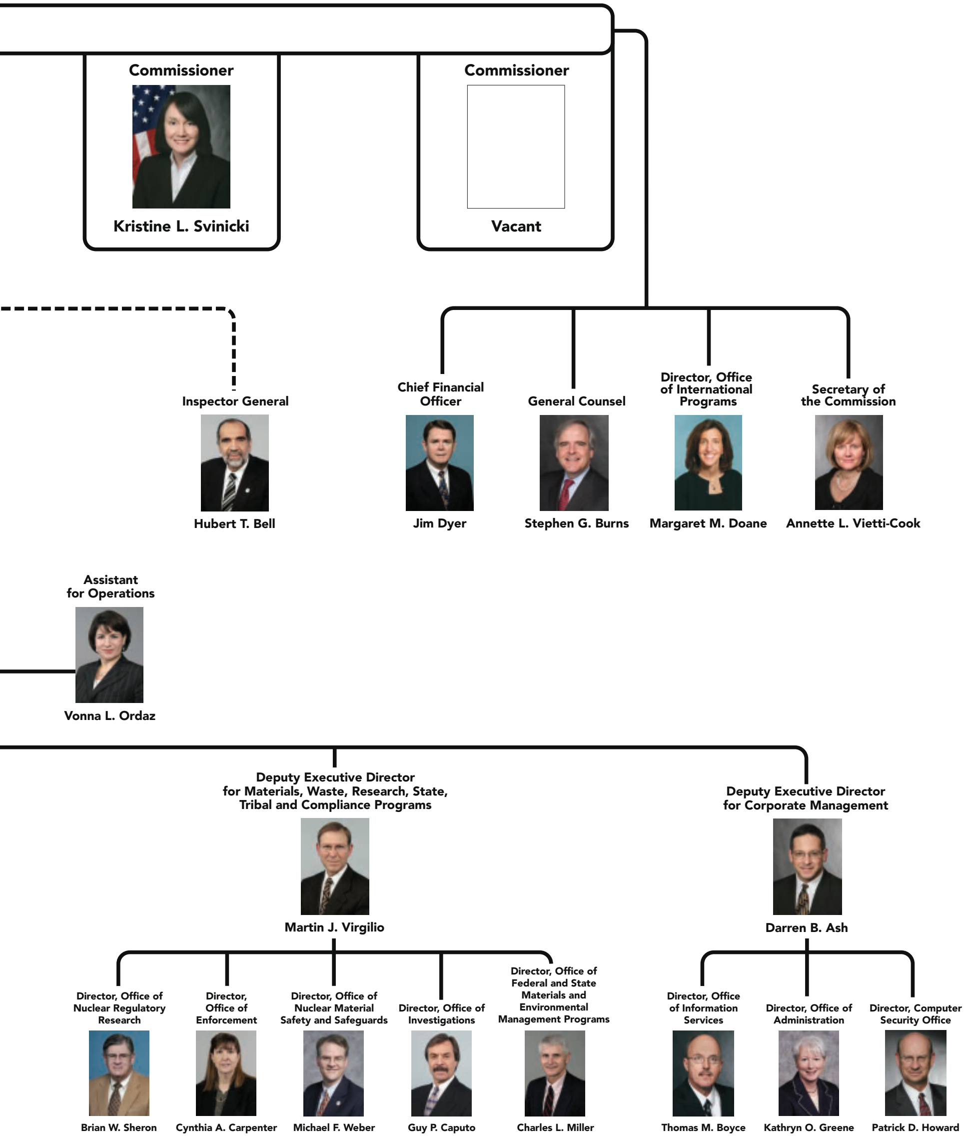
The NRC's Commission is composed of five members nominated by the President and confirmed by the U.S. Senate for a 5-year term. The President designates one member to serve as Chairman, principal executive officer, and spokesperson of the Commission. The members' terms are staggered so that one Commissioner's term expires on June 30 every year. No more than three Commissioners can belong to the same political party. The members of the Commission (as of August 2009) are shown above. There are currently two vacancies.

The Commission as a whole formulates policies and regulations governing nuclear reactor and materials safety, issues orders to licensees, and adjudicates legal matters brought before it. The Executive Director for Operations (EDO) carries out the policies and decisions of the Commission and directs the activities of the program and regional offices (see Figures 1 and 2).

Figure 1. **U.S. Nuclear Regulatory Commission Organization Chart**



Source: U.S. Nuclear Regulatory Commission


Commissioner
Kristine L. Svinicki
Commissioner
Vacant
Inspector General
Hubert T. Bell
Chief Financial Officer
Jim Dyer
General Counsel
Stephen G. Burns
Director, Office of International Programs
Margaret M. Doane
Secretary of the Commission
Annette L. Vietti-Cook
Assistant for Operations
Vonna L. Ordaz
Deputy Executive Director for Materials, Waste, Research, State, Tribal and Compliance Programs
Martin J. Virgilio
Deputy Executive Director for Corporate Management
Darren B. Ash
Director, Office of Nuclear Regulatory Research
Brian W. Sheron
Director, Office of Enforcement
Cynthia A. Carpenter
Director, Office of Nuclear Material Safety and Safeguards
Michael F. Weber
Director, Office of Investigations
Guy P. Caputo
Director, Office of Federal and State Materials and Environmental Management Programs
Charles L. Miller
Director, Office of Information Services
Thomas M. Boyce
Director, Office of Administration
Kathryn O. Greene
Director, Computer Security Office
Patrick D. Howard

Headquarters*:

U.S. Nuclear Regulatory Commission
Rockville, MD
301-415-7000
1-800-368-5642

One White Flint North
11555 Rockville Pike

Two White Flint North
11545 Rockville Pike

Executive Boulevard Building
6003 Executive Boulevard

Gateway Building
7201 Wisconsin Ave

Twinbrook Building
12300 Twinbrook Parkway

Church Street Building
21 Church Street

Operations Center:

Rockville, MD
301-816-5100

The NRC maintains an operations center that coordinates NRC communications with its licensees, State agencies, and other Federal agencies concerning operating events in commercial nuclear facilities. NRC operations officers staff the operations center 24 hours a day.

Regional Offices:

The NRC has four regional offices and one High-Level Waste Management Office.

Region I
King of Prussia, PA
610-337-5000

Region II
Atlanta, GA
404-562-4400

Region III
Lisle, IL
630-829-9500

Region IV
Arlington, TX
817-860-8100

High-Level Waste Management Office
Las Vegas, NV
702-794-5048

Training and Professional Development:

Technical Training Center
Chattanooga, TN
423-855-6500

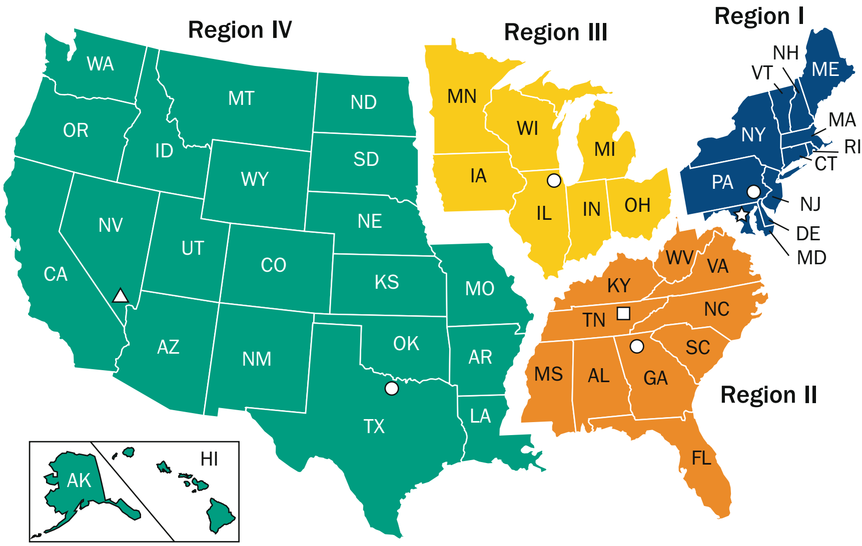
Professional Development Center
Bethesda, MD
301-492-2000

Resident Sites:

At least two NRC resident inspectors who report to the appropriate regional office are located at each nuclear power plant site.

* The six-building headquarters complex houses NRC headquarters staff and the Public Document Room. Five buildings are in Rockville, MD. The Gateway building is in Bethesda. MD.

Figure 2. NRC Regions



☆ Headquarters (1)
○ Regional Office (4)
□ Technical Training Center (1)
△ High-Level Waste Management Office (1)

Nuclear Power Plants

Each region oversees the plants in their region except the Grand Gulf plant in Mississippi which Region IV oversees.

Material Licensees

Region I oversees Region I and Region II licensees.
Region II oversees Region III, Missouri, and all Federal facilities licensees.
Region IV oversees Region IV except Missouri licensees.

Nuclear Fuel Processing Facilities

Region II oversees all the fuel processing facilities in the region and those in Illinois, New Mexico and Washington.

In addition, Region II handles all construction inspectors' activities for new nuclear power plants and fuel cycle facilities in all regions.

Source: U.S. Nuclear Regulatory Commission

Figure 3 provides an overview of the NRC's regulatory process, which has five main components:

(1) Developing regulations and guidance for applicants and licensees

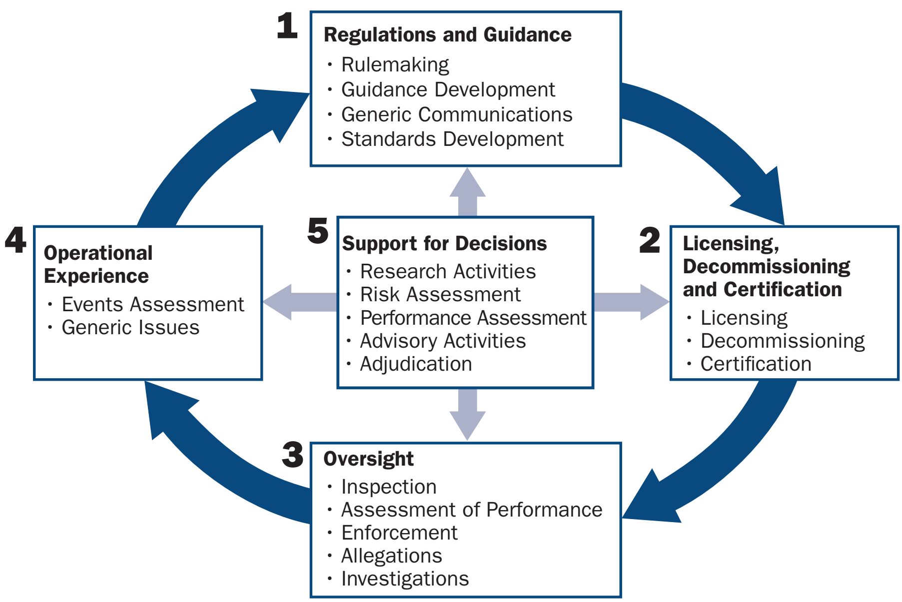
(2) Licensing or certifying applicants to use nuclear materials, operate nuclear facilities, and decommission facilities

(3) Inspecting and assessing licensee operations and facilities to ensure that licensees comply with NRC requirements and taking appropriate followup actions when necessary

(4) Evaluating operational experience of licensed facilities and activities

(5) Conducting research, holding hearings, and obtaining independent reviews to support regulatory decisions

Figure 3. **How We Regulate**



Source: U.S. Nuclear Regulatory Commission

The NRC's major program offices are as follows:

- **Office of Nuclear Reactor Regulation**

  Handles all licensing and inspection activities associated with the operation of both nuclear power reactors and research and test reactors.

- **Office of New Reactors**

  Provides safety oversight of the design, siting, licensing, and construction of new commercial nuclear power reactors.

- **Office of Nuclear Material Safety and Safeguards**

  Regulates activities that provide for the safe and secure production of nuclear fuel used in commercial nuclear reactors; the safe storage, transportation, and disposal of high-level radioactive waste and spent nuclear fuel; and the transportation of radioactive materials regulated under the Atomic Energy Act of 1954.

- **Office of Federal and State Materials and Environmental Management Programs**

  Develops and oversees the regulatory framework for the safe and secure use of nuclear materials, industrial, commercial, and medical applications, uranium recovery activities, low-level radioactive waste sites, and the decommissioning of previously operating nuclear facilities and power plants. Works with Federal agencies, States, Tribal and local governments on regulatory matters.

- **Office of Nuclear Regulatory Research**

  Provides independent expertise and information for making timely regulatory judgments, anticipating problems of potential safety significance, and resolving safety issues. Helps develop technical regulations and standards and collects, analyzes and disseminates information about the operational safety of commercial nuclear power plants and certain nuclear materials activities.

- **Office of Nuclear Security and Incident Response**

  Oversees agency security policy for nuclear facilities and for users of radioactive material. Provides a safeguards and security interface with other Federal agencies and maintains the agency emergency preparedness and incident response program.

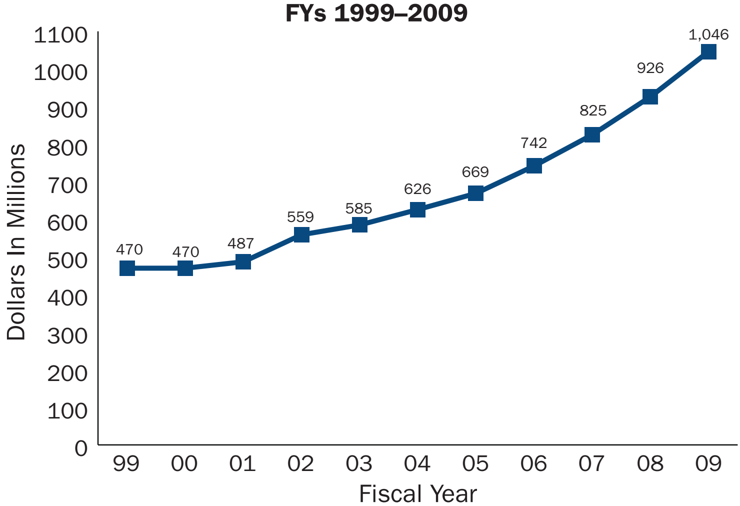
- **Regional Offices**

  Conduct inspection, enforcement, investigation, licensing, and emergency response programs for nuclear reactors, fuel facilities, and materials licensees.

BUDGET

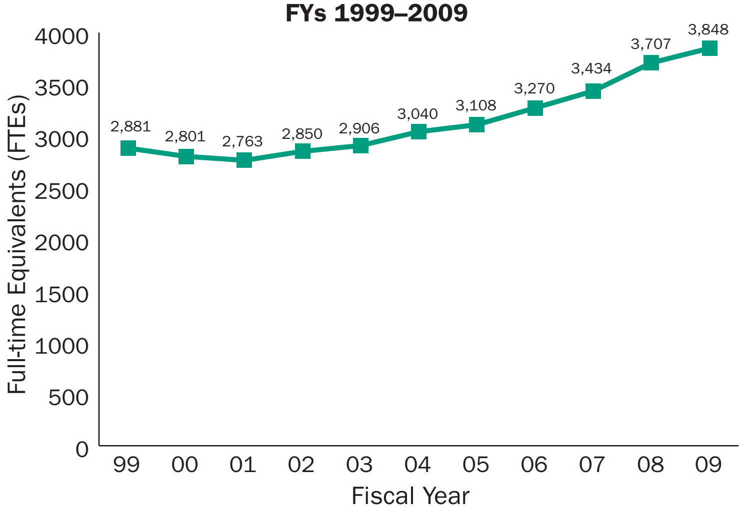
For fiscal year (FY) 2009 (October 1, 2008–September 30, 2009), Congress appropriated $1,046 million to the NRC. The NRC's FY 2009 personnel ceiling is 3,848 full-time equivalent (FTE) staff (see Figures 4 and 5).

Figure 4. **NRC Budget Authority, FYs 1999–2009**



Note: Dollars are rounded to the nearest million.
Source: U.S. Nuclear Regulatory Commission

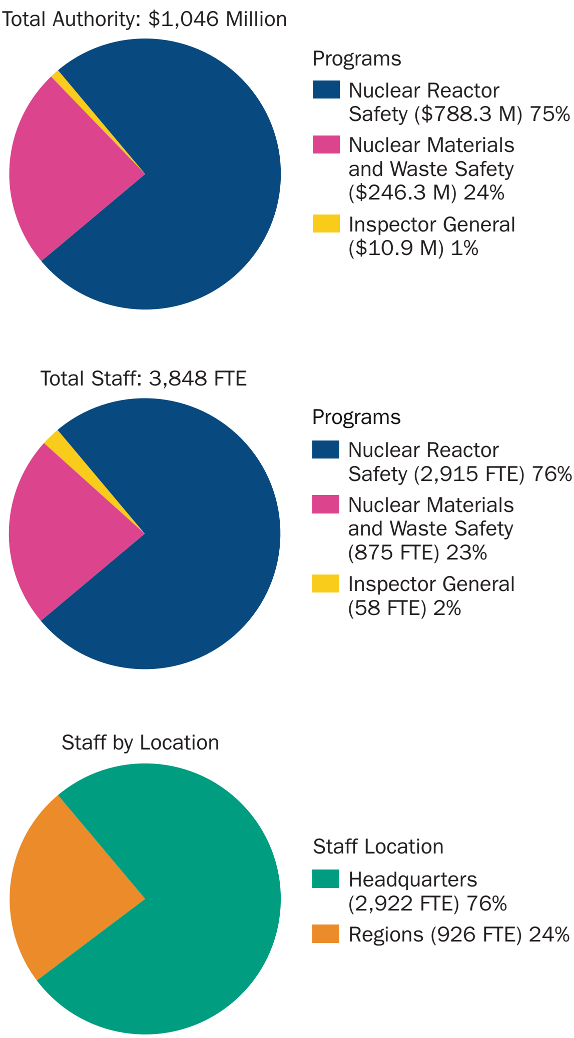
Figure 5. **NRC Personnel Ceiling, FYs 1999–2009**



Source: U.S. Nuclear Regulatory Commission

The Office of the Inspector General (OIG) received its own appropriation of $10.9 million. The amount is included in the total NRC budget. The breakdown of the budget is shown in Figure 6.

Figure 6. Distribution of NRC FY 2009 Budget Authority and Staff (Dollars in Millions)

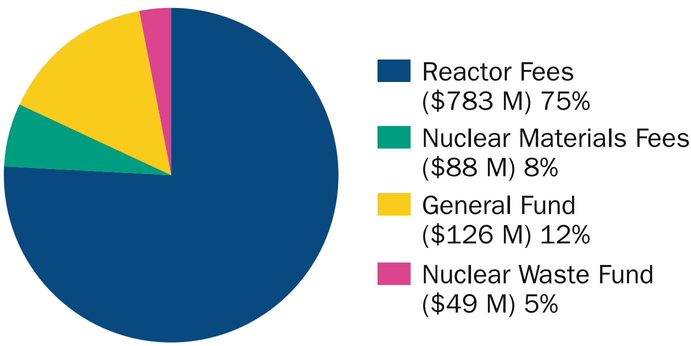


Note: Dollars and percentages are rounded to the nearest whole number.
Source: U.S. Nuclear Regulatory Commission

By law, the NRC must recover, through fees billed to licensees, approximately 90 percent of its budget authority for FY 2009, less the amounts appropriated from the Nuclear Waste Fund for high-level radioactive waste activities and from general funds for waste-incidental-to-reprocessing and generic homeland security activities. Fees are collected by the NRC each year by September 30 and transferred to the U.S. Treasury. The total budget amount to be recovered by NRC in FY 2009 is approximately $870.6 million (see Figure 7).

Figure 7. **Recovery of NRC Budget, FY 2009***

Total Authority: $1,046 Million



Class of Licensee	Annual Fees
Operating Power Reactor	$4,735,000**
Fuel Facility	$770,000 to $4,721,000
Uranium Recovery Facility	$30,600 to $34,700
Materials User	$1,300 to $64,000

* Based on the proposed FY 2009 fee rule and the Omnibus Appropriations Bill.
** Includes spent fuel storage/reactor decommissioning FY 2009 annual fee of $127,000.
Note: Percentages are rounded to the nearest whole number.
Source: U.S. Nuclear Regulatory Commission

The Earth and moon from space.

U.S. AND WORLDWIDE ENERGY

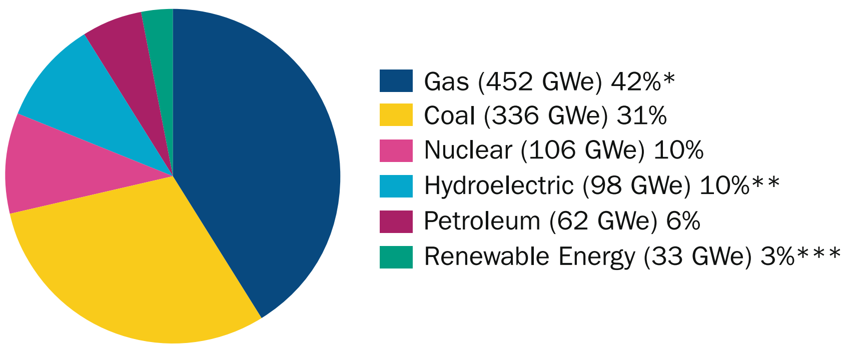
U.S. ELECTRICITY CAPACITY AND GENERATION

U.S. electric generating capacity totaled approximately 1,088 gigawatts in 2007 (see Figure 8), up slightly from 2006 at 986 gigawatts. In 2007, the existing nuclear generating capacity totaled 106 gigawatts, which translates to 10 percent of total electric capacity. Since the 1970s, the Nation's utilities have used power uprates as a way to generate more electricity from existing nuclear plants. By January 2009, the NRC had approved 124 power uprates, resulting in a gain of approximately 5,640 megawatts electric (MWe) at existing plants. Collectively, these uprates have added the equivalent of five new reactors worth of electrical generation at existing plants. The NRC is reviewing or anticipating uprate applications totaling another 2,333 MWe (see Figure 9). In addition, license renewals will also add to projected electric capacity as shown in Figure 10.

As of March 2009, nuclear energy accounted for approximately 19.7 percent of U.S. net electric generation at 806 billion kilowatthours (KWh) (see Figure 11). In

Figure 8. U.S. Electric Existing Capacity by Energy Source, 2007

Total Existing Capacity: 1,088 Gigawatts Electric (GWe)

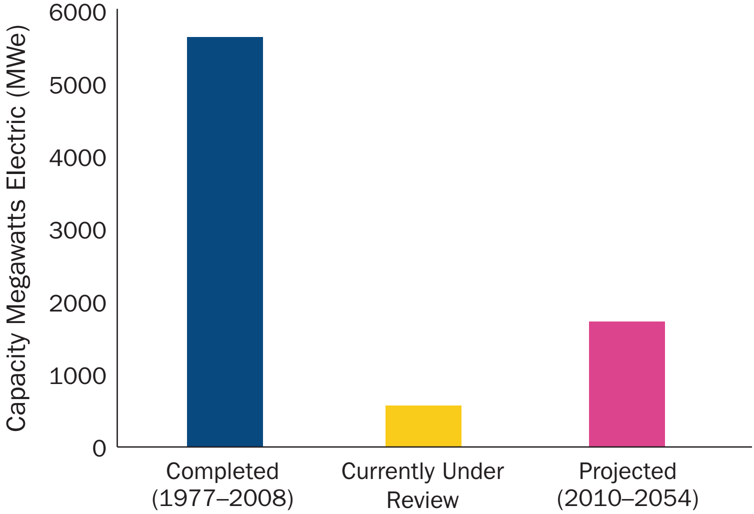


* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.
** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.
*** Renewable energy includes geothermal, wood and nonwood waste, wind, solar energy, and miscellaneous technologies.

Note: Totals may not equal sum of components because of independent rounding. The amounts in parenthesis are measured in gigawatts which is equal to 1,000 million bytes.

Source: DOE/EIA Electric Power Annual 2008, Existing Capacity by Energy Source, Table 2.2, www.eia.doe.gov

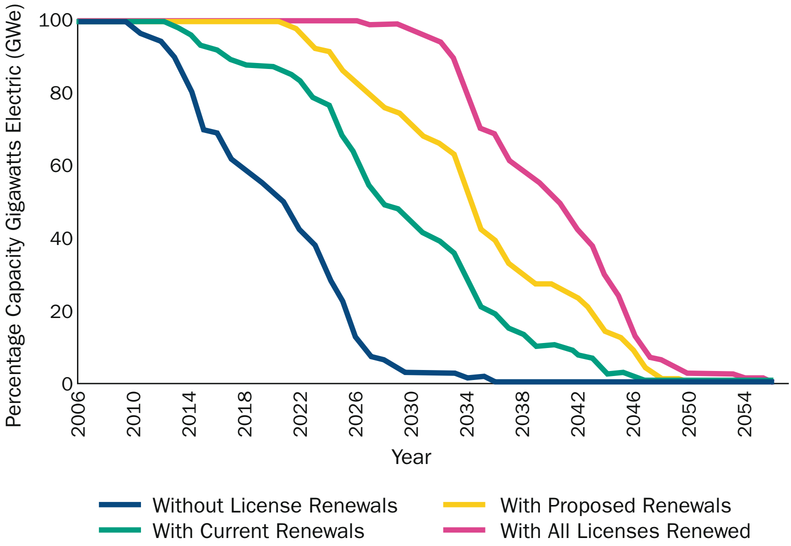
Figure 9. **Power Uprates: Past, Current, and Future**



Note: Power uprates have added the equivalent of five new reactors to the U.S. power grid.

Source: U.S. Nuclear Regulatory Commission

Figure 10. **Projected Electric Capacity Dependent on License Renewals**



Source: U.S. Nuclear Regulatory Commission

2008, 104 nuclear reactors licensed to operate in 31 States generated approximately one-fifth of the Nation's electricity.

As of 2008, three States (New Jersey, South Carolina, and Vermont) relied on nuclear power for more than 50 percent of their electricity. The percentages cited reflect the percentages of the total net generation in these States that were from nuclear sources. An additional 12 States relied on nuclear power for 25 to 50 percent of their electricity (see Figure 12).

Since 1998, net nuclear electric generation has increased by 19.9 percent, and coal-fired electric generation has increased by 6.5 percent (see Figure 13 and Table 1). All other electricity-generating sources have increased by 21 percent.

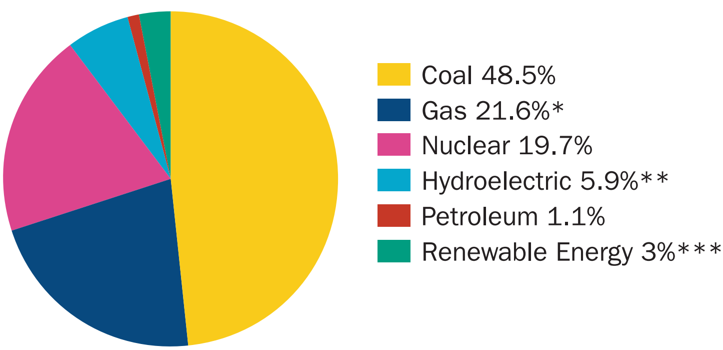
AVERAGE PRODUCTION EXPENSES

The production expense data presented in Table 2 and Figure 14 include all nuclear, fossil, and coal-fired utility-owned steam electric plants.

In 2007, production expenses averaged $20.00 each megawatthour for nuclear power plants and $30.89 each megawatthour for fossil-fuel plants.

Figure 11. U.S. Electric Net Generation by Energy Source, 2008

Total Net Generation: 4,115 billion kilowatthours

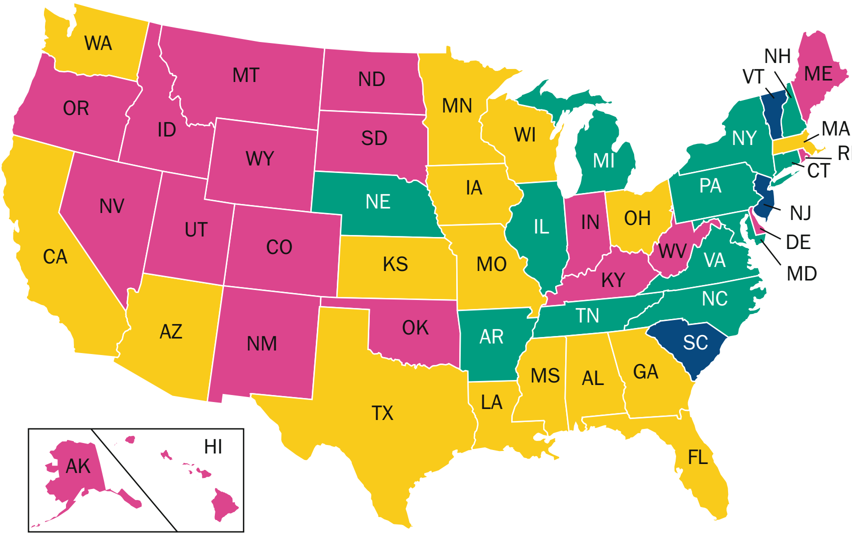


* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.
** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.
*** Renewable energy includes geothermal, wood and nonwood waste, wind, and solar energy.

Note: Percentages are rounded to the nearest whole number. Totals may not equal sum of components because of independent rounding.

Source: DOE/EIA Monthly Energy Review, data from March 2009 www.eia.doe.gov/mer/

Figure 12. Net Electricity Generated in Each State by Nuclear Power, 2008



Percent Net Generation from Nuclear Sources

None (19)

State	Net Capacity	Net Generation
Alaska	0	0
Colorado	0	0
Delaware	0	0
Hawaii	0	0
Idaho	0	0
Indiana	0	0
Kentucky	0	0
Maine	0	0
Montana	0	0
Nevada	0	0
North Dakota	0	0
New Mexico	0	0
Oklahoma	0	0
Oregon	0	0
Rhode Island	0	0
South Dakota	0	0
Utah	0	0
West Virginia	0	0
Wyoming	0	0

1% to 24% (16)

State	Net Capacity	Net Generation
Alabama	16	24
Arizona	15	24
California	7	17
Florida	7	13
Georgia	11	22
Iowa	5	9
Kansas	10	21
Louisiana	8	18
Massachusetts	5	11
Minnesota	13	24
Mississippi	8	19
Missouri	6	10
Ohio	6	10
Texas	5	10
Washington	4	8
Wisconsin	10	20

25% to 50% (12)

State	Net Capacity	Net Generation
Arkansas	12	28
Connecticut	26	49
Illinois	27	48
Maryland	14	29
Michigan	13	26
Nebraska	18	34
New Hampshire	29	46
New York	13	29
North Carolina	18	31
Pennsylvania	21	34
Tennessee	16	30
Virginia	15	35

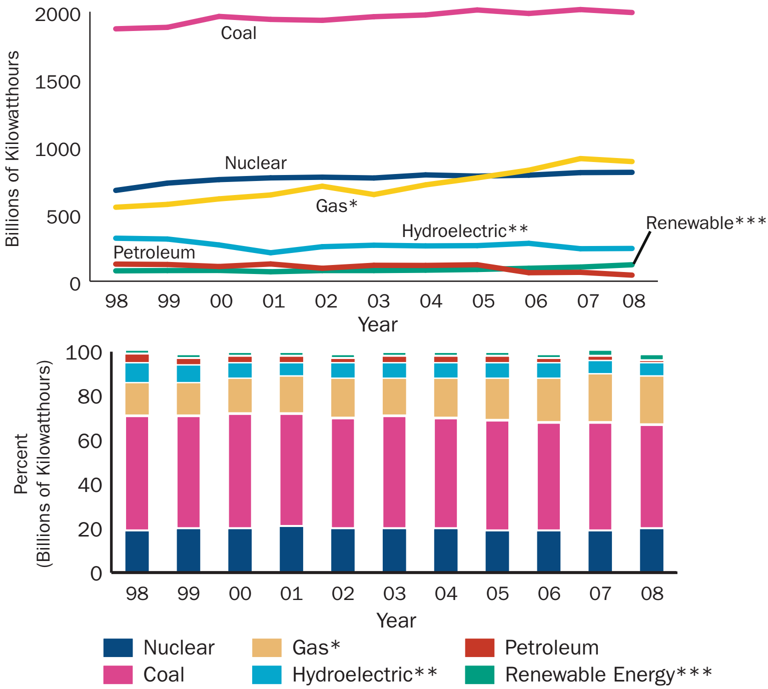
More than 50% (3)

State	Net Capacity	Net Generation
New Jersey	22	51
South Carolina	27	51
Vermont	56	81

Note: Percentages are rounded to the nearest whole number. Units measured are in megawatts.

Source: DOE/EIA State Electricity Profiles, www.eia.doe.gov

Figure 13. U.S. Net Electric Generation by Energy Source, 1998–2008



* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.
** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.
*** Renewable energy includes geothermal, wood and nonwood waste, wind, and solar energy.
Source: DOE/EIA Monthly Energy Review, March 2009, Table 7.2a, www.eia.doe.gov

Table 1. U.S. Net Electric Generation by Energy Source, 1998–2008 (Billion Kilowatthours)

Year	Coal	Petroleum	Gas*	Hydroelectric**	Nuclear	Renewable*** Energy
1998	1,873	128	545	319	674	77
1999	1,881	118	570	313	728	79
2000	1,966	111	614	270	754	81
2001	1,904	125	648	208	769	71
2002	1,933	95	702	256	780	79
2003	1,973	119	665	267	764	79
2004	1,977	120	726	260	788	83
2005	2,013	122	774	264	782	87
2006	1,990	64	829	283	787	96
2007	2,016	66	910	241	806	105
2008†	1,994	45	888	243	808	122

Note: See footnotes for Figure 12. † Based on preliminary data.
Source: DOE/EIA Monthly Energy Review, March 2009, Table 7.2a, www.eia.doe.gov

Table 2. U.S. Average Nuclear Reactor, Coal-Fired, and Fossil-Steam Plant Production Expenses, 1997–2007 (Dollars per Megawatthour)

Year	Operation and Maintenance	Fuel	Total Production Expenses
Nuclear			
1997*	17.92	5.42	23.33
1998	15.77	5.39	21.16
1999	14.06	5.17	19.23
2000	13.34	4.95	18.28
2001	13.31	4.67	17.98
2002	13.58	4.60	18.18
2003	14.09	4.60	18.69
2004	13.68	4.58	18.26
2005	13.62	4.54	18.16
2006	14.61	4.85	19.46
2007	14.99	5.01	20.00

Year	Operation and Maintenance	Fuel	Total Production Expenses
Coal-Fired			
1997*	4.65	16.80	21.45
Fossil-Steam**			
1998	4.58	15.94	20.52
1999	4.59	15.62	20.22
2000	4.76	17.69	22.44
2001	5.01	18.13	23.14
2002	5.22	16.11	21.32
2003	5.23	17.35	22.59
2004	5.64	18.21	23.85
2005	5.93	21.77	27.69
2006	6.42	23.17	29.59
2007	6.88	24.02	30.89

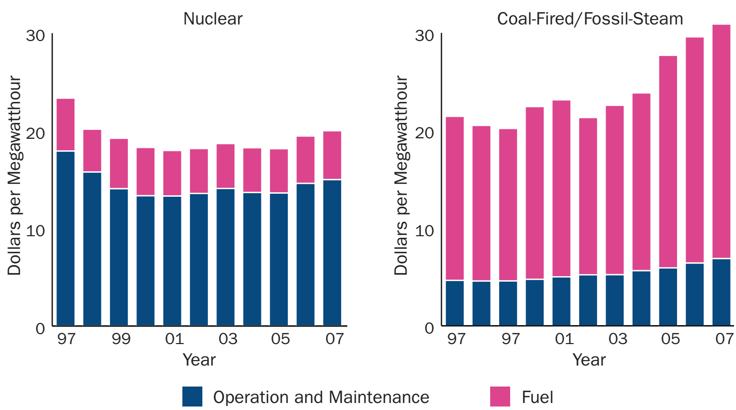
* Data for 1997 and prior years were obtained from Utility Data Institute, Inc.

** Includes coal and fossil fuel. Plant production expenses are no longer available exclusively for coal-fired fuel.

Note: Expenses are average expenses weighted by net generation. Totals may not equal sum of components because of independent rounding.

Source: Federal Energy Regulatory Commission, FERC Form 1, "Annual Report of Major Electric Utilities, Licensees and Others," DOE/EIA Electric Power Annual 2008, www.eia.doe.gov

Figure 14. U.S. Average Nuclear Reactor and Coal-Fired and Fossil-Steam Plant Production Expenses, 1997–2007



Source: Federal Energy Regulatory Commission, FERC Form 1, "Annual Report of Major Electric Utilities, Licensees and Others," DOE/EIA Electric Power Annual 2008, www.eia.doe.gov

U.S. ELECTRICITY GENERATED BY COMMERCIAL NUCLEAR POWER

In 2008, net nuclear-based electric generation in the United States produced a total of 808 billion kilowatthours (see Table 3 and Figure 13). Average U.S. net capacity factor—the ratio of electricity generated to the amount of energy that could have been generated—has increased by approximately 18 percent since 1998. In 2008, the average U.S. net capacity factor was 92 percent.

In 2008, 98 percent of U.S. commercial nuclear reactors operated above average net capacity factor of 70 percent (see Table 4).

Table 3. **U.S. Nuclear Power Reactor Average Net Capacity Factor and Net Generation, 1998–2008**

Year	Number of Operating Reactors	Average Net Capacity Factor (Percent)	Net Generation of Electricity: Billions of Kilowatthours	Net Generation of Electricity: Percent of Total U.S. Capacity
1998	104	78	674	18.6
1999	104	85	728	19.7
2000	104	88	754	19.8
2001	104	89	769	20.6
2002	104	90	780	20.2
2003	104	88	764	19.7
2004	104	90	788	19.9
2005	104	89	782	19.3
2006	104	90	787	19.4
2007	104	92	806	19.4
2008*	104	92	808	19.7

* Based on preliminary data.

Note: Average net capacity factor is based on net maximum dependable capacity. See Glossary for definition.

Source: Based on March 2009 DOE/EIA Monthly Energy Review Table 8.1, www.eia.doe.gov, and licensee data as compiled by the U.S. Nuclear Regulatory Commission

Table 4. **U.S. Commercial Nuclear Power Reactor Average Capacity Factor by Vendor and Reactor Type, 2006–2008**

	Licensed to Operate			Percent of Net Nuclear Generated		
Capacity Factor	**2006**	**2007**	**2008**	**2006**	**2007**	**2008***
Above 70 Percent	101	101	101	99	98	98
50 to 70 Percent	1	2	3	1	1	2
Below 50 Percent	2	1	0	>1	>1	0

	Licensed to Operate			Average Capacity Factor (Percent)		
Reactor Type	**2006**	**2007**	**2008**	**2006**	**2007**	**2008***
Boiling-Water Reactor	35	35	35	90	90	93
Pressurized-Water Reactor	69	69	69	90	93	91
Total	104	104	104	N/A	N/A	N/A

*Based on preliminary data.

Note: Average capacity factor is based on net maximum dependable capacity. See Glossary for definition. Refer to Appendix A for the 2003–2008 average capacity factors for each reactor. Percentages are rounded to the nearest whole number.

Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

WORLDWIDE ELECTRICITY GENERATED BY COMMERCIAL NUCLEAR POWER

As of 2008, there were 436 operating reactors in 30 countries and Taiwan with a total installed capacity of 370,120 gigawatts electric (GWe) (see Figure 15). In addition, five nuclear power plants were in long-term shutdown, and 44 nuclear power plants were under construction.

- Refer to Appendix J for a list of the number of nuclear power reactors by nation and Appendix K for nuclear power units by reactor type, worldwide.

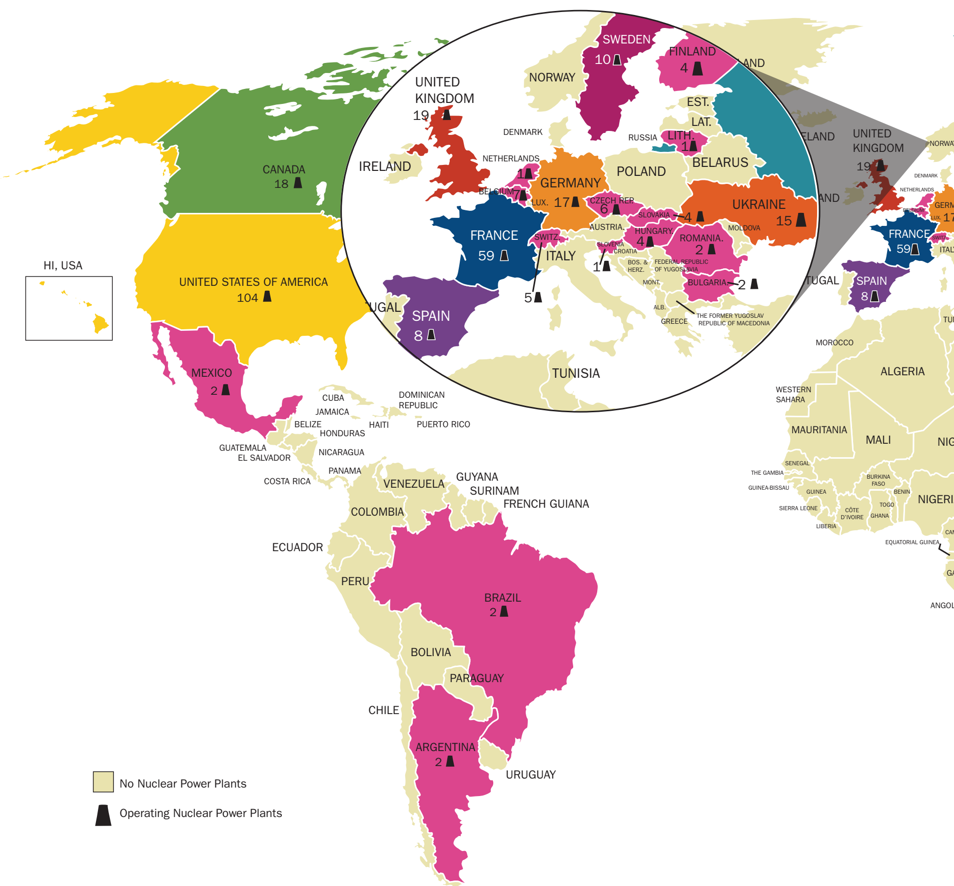
WORLDWIDE NUCLEAR PRODUCTION

The United States produced approximately 31 percent of the world's gross nuclear-generated electricity in 2008 (see Figure 16). France was the next highest producer at 16 percent. Based on preliminary data in 2007, France had the highest nuclear portion (78 percent) of total domestic energy generated.

In the United States, nuclear energy accounted for 19 percent of the domestic energy generated (see Figure 17).

Countries with the highest average gross capacity factor for nuclear reactors in 2008 include South Korea at 93 percent, the United States at 90 percent, Sweden at 78 percent, and Germany at 77 percent (see Table 5).

Figure 15. Operating Nuclear



Note: There are no commercial reactors in Alaska or Hawaii. Refer to Appendix J for a world list of the number of nuclear power reactors.

Source: *Nucleonics Week*© and International Atomic Energy Agency

Reactors in the United States had the greatest gross nuclear generation at 842 billion kilowatthours. France was the next highest producer at 439 billion kilowatthours (see Table 5).

Refer to Appendix L for a list of the top 50 reactors by gross capacity factor worldwide, and refer to Appendix M for a list of the top 50 reactors by gross generation worldwide.

Over the past 10 years, the average annual gross capacity factor has increased 5 percent in the United States and 5 percent in France. In the same period, the average annual gross capacity factor has decreased 20 percent in Japan and 11 percent in Germany (see Table 6).

Power Plants Worldwide, 2008

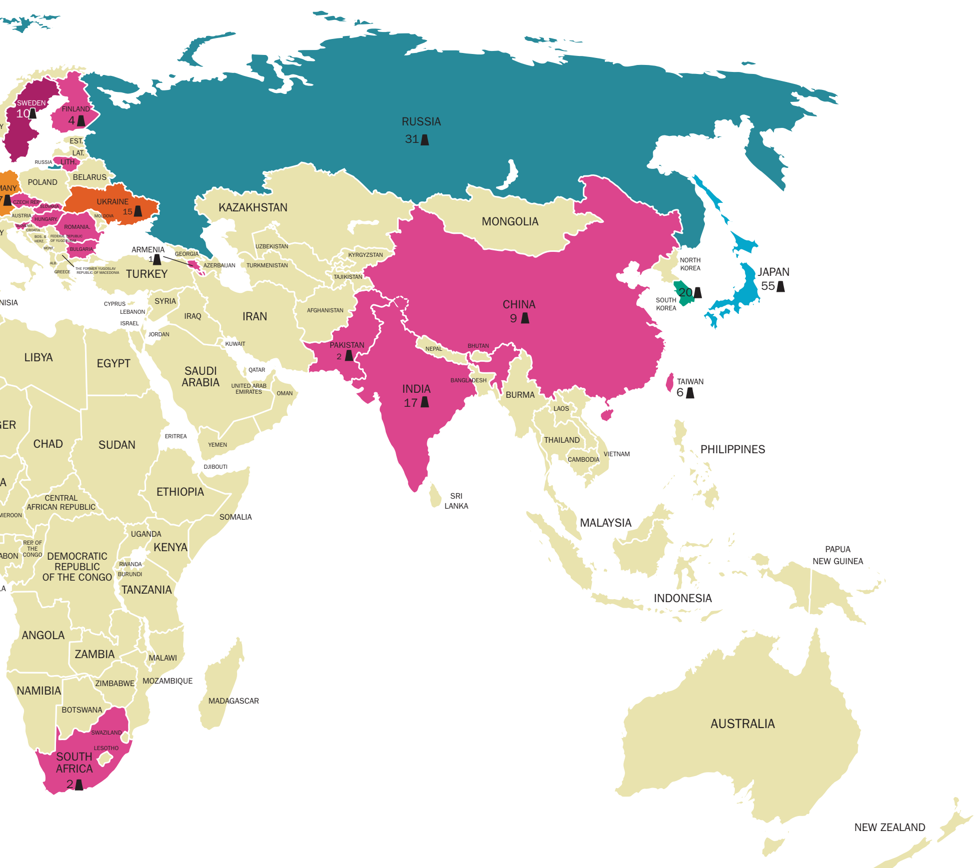
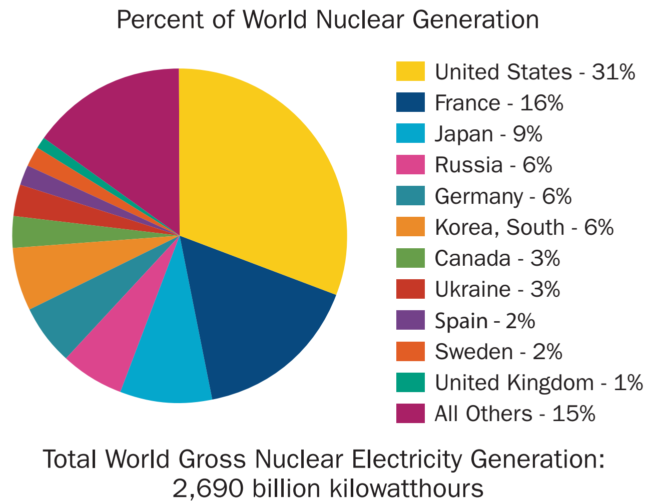
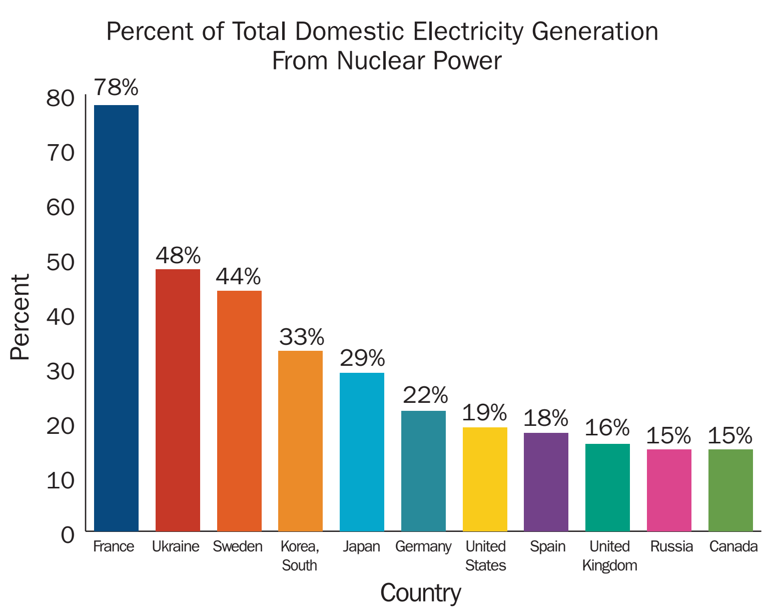


Figure 16. **Gross Nuclear Electric Power as a Percent of World Nuclear Generation, 2008**



Note: Due to independent rounding the figures may not add up total percentage. Country's short-form name used.
Source: *Nucleonics Week*©, March 5, 2009, by McGraw-Hill, Inc. Reproduced by permission.
Further reproduction prohibited.

Figure 17. **Total Domestic Electricity Generation, 2007**



Note: Country's short-form name used.

Source: Energy Information Administration, Office of Energy Markets and End Use, International Energy Statistics Team

Table 5. **Commercial Nuclear Power Reactor Average Gross Capacity Factor and Gross Generation by Selected Country, 2008**

Country	Number of Operating Reactors	Average Gross Capacity Factor (in percent)	Total Gross Nuclear Generation (in billions of kWh)	Number of Operating Reactors in Top 50 by Capacity Factor	Number of Operating Reactors in Top 50 by Generation
Canada	21	67	94	3	0
France	58	76	439	0	11
Germany	17	77	147	2	11
Japan	55	59	252	4	2
Korea, South	20	93	151	5	0
Russia	31	73	162	1	0
Sweden	10	78	64	0	0
Ukraine	15	73	90	0	0
United States	104	90	842	25	23

Note: The United States gross capacity factor and generation includes estimates based on net MWh for 4 of the 104 U.S. units. Country's short-form name used.

Source: Excerpted from *Nucleonics Week*©, March 5, 2009, by McGraw-Hill, Inc. Reproduced by permission. Further reproduction prohibited.

Table 6. **Commercial Nuclear Power Reactor Average Gross Capacity Factor by Selected Country, 1999–2008**

Annual Gross Average Capacity Factor (Percent)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008*
Canada	52	50	53	53	54	64	66	71	67	67
France	71	72	73	75	75	77	78	77	76	76
Germany	88	87	87	83	84	87	86	89	73	77
Japan	79	79	79	77	59	70	69	70	64	59
Korea, South	88	90	93	93	94	92	95	93	88	93
Russia	61	67	67	67	70	68	66	70	71	73
Sweden	78	66	84	75	77	89	87	82	80	78
Ukraine	65	69	74	75	78	76	72	74	75	73
United States	85	87	88	89	87	90	87	88	91	90
	{86	88	90	91	89	91	89	90	92	92 }**

* 2008 based on preliminary data.

** For comparison, the U.S. average net capacity factor is used. The 2008 U.S. average net capacity factor is 92 percent. Brackets { } denote average net capacity factor.

Note: Percentages are rounded to the nearest whole number. Country's short-form name used.

Source: Excerpted from *Nucleonics Week*©, March 5, 2009, by McGraw-Hill, Inc. Reproduced by permission. Further reproduction prohibited. Licensee data as compiled by the U.S. Nuclear Regulatory Commission.

INTERNATIONAL ACTIVITIES

The U.S. Nuclear Regulatory Commission must perform certain legislatively mandated international duties. These include licensing the import and export of nuclear materials and equipment and participating in activities supporting U.S. Government compliance with international treaties and agreement obligations. The NRC has bilateral programs of assistance or cooperation with 40 countries and Taiwan (see Table 7). The NRC has also supported U.S. Government nuclear safety initiatives with countries in the Commonwealth of the Independent States, Africa, Asia and Latin America. In addition, the NRC actively cooperates with multinational organizations, such as the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA), a part of the Organisation for Economic

Table 7. **Bilateral Information Exchange and Cooperation Programs with the United States**

Country	Agreement Renewal Date	Country	Agreement Renewal Date
Argentina	2012	Kazakhstan	2009
Armenia	2012	Korea, South	2010
Australia	2013	Lithuania	2010
Belgium	2010	Mexico	2012
Brazil	2009	Netherlands	2013
Bulgaria	2011	Peru	Open-Ended
Canada	2012	Philippines	Open-Ended
China	2013	Poland	2009
Croatia	2013	Romania	2010
Czech Republic	2010	Russia	2001
Egypt	1991	Slovakia	2010
Finland	2011	Slovenia	2010
France	2013	South Africa	2010
Germany	2012	Spain	2010
Greece	2013	Sweden	2011
Hungary	2012	Switzerland	2012
Indonesia	2013	Ukraine	2011
Israel	2010	United Arab Emirates	2009
Italy	2010	United Kingdom	2013
Japan	2012	Vietnam	2013

Note: The NRC also provides support to the American Institute in Taiwan. Egypt's agreement has been deferred until its regulatory body requests reinstatement. Russia's agreement is still in negotiation. Country's short-form name used.

Source: U.S. Nuclear Regulatory Commission

Commissioner Kristine L. Svinicki, Commissioner (former Chairman) Dale E. Klein, and Executive Director for Operations R. William Borchardt participate in the International Atomic Energy Agency's conference in Vienna, Austria, in September 2008.

Co-operation and Development. The NRC also has a robust international cooperative research program.

Since its inception, the agency has hosted over 300 foreign nationals in on-the-job training assignments at NRC headquarters and the regional offices. NRC's Foreign Assignee Program helps instill regulatory awareness, capabilities, and commitments in foreign assignees. It also helps to enhance regulatory expertise of both the foreign assignee and NRC staff. Additionally, the program improves international channels of communication by opening interaction with the international nuclear community and developing relationships with key personnel in foreign regulatory agencies.

Through its export/import authority, the NRC upholds the U.S. Government goals of limiting the proliferation of materials that could be used in weapons and enables the safe and secure use of civilian nuclear and radioactive materials. In addition to its direct export/import licensing role, the NRC consults with other U.S. Government agencies on international nuclear commerce activities falling under their authority. The NRC continues to work to strengthen the export/import regulations of nuclear equipment and materials, and to improve communication between domestic and international stakeholders.

The NRC assists in implementing the U.S. Government's international nuclear policies through developing legal instruments that address nuclear nonproliferation, safety, safeguards, physical protection, radiation protection, spent fuel and waste management, and liability. The NRC also participates in the implementation of the U.S. bilateral agreements for peaceful nuclear cooperation under Section 123 of the U.S. Atomic Energy Act of 1954, as amended. In addition, the NRC participates in international conventions on nuclear safety, the safety of spent fuel and radioactive waste management, and the physical protection of nuclear material. The NRC also ensures licensee compliance with the U.S. Voluntary Safeguards Offer agreement with IAEA. This agreement was amended on December 31, 2008, when then President George W. Bush signed the "Protocol Additional to the U.S.-International Atomic Energy

Agency Agreement for the Application of Safeguards in the United States," and entered into force on January 6, 2009, when the IAEA acknowledged receipt of the U.S. ratification.

The NRC also participates in a wide range of mutually beneficial international exchange programs that enhance the safety and security of peaceful nuclear activities worldwide. These low-cost, high-impact programs provide joint cooperative activities and assistance to other countries to develop and improve regulatory organizations. The NRC engages in the following activities:

- Cooperates with countries with mature nuclear programs to ensure the timely exchange of applicable nuclear safety and security information.
- Ensures prompt notification to foreign partners of U.S. safety issues, notifies NRC program offices about foreign safety issues, and shares security information with selected countries.
- Assists other countries to develop and improve regulatory programs through training, workshops, peer review of regulatory documents, working group meetings, technical information, and specialist exchanges.
- Initiates bilateral discussions with countries that have recently built facilities or have vendors of equipment that may be imported to the United States during the anticipated construction of new nuclear power plants.
- Participates in the multinational programs of the IAEA and the NEA concerned with safety research and regulatory matters, radiation protection, risk assessment, emergency preparedness, waste management, transportation, safeguards, physical protection, security, standards development, training, and technical assistance.
- Participates in the Multinational Design Evaluation Program (MDEP), which leverages the resources of interested regulatory authorities to review designs of new power reactors.
- Hosts the International Nuclear Regulators Association (INRA) meetings on a rotating basis with other members. INRA was established to influence and enhance nuclear safety from the regulatory perspective and its members are the most senior officials of well-established independent national nuclear regulatory organizations. Current members are Canada, France, Germany, Japan, South Korea, Spain, Sweden, the United Kingdom, and the United States.
- Meets through NRC's Advisory Committee on Reactor Safeguards with other international advisory committees every 4 years in order to exchange information.
- Participates in joint cooperative research programs through approximately 100 multilateral agreements with 23 countries to leverage access to foreign test facilities not otherwise available to the United States. Access to foreign test facilities expands the NRC's knowledge base and contributes to the efficient and effective use of the NRC's resources in conducting research on high-priority safety issues.

Limerick Generating Station, located near Philadelphia, PA.

Courtesy of Exelon Generation Co. LLC

NUCLEAR REACTORS

U.S. COMMERCIAL NUCLEAR POWER REACTORS

As of August 2009, there were 104 commercial nuclear power reactors licensed to operate in 31 States (see Figure 18 and Appendix A). The reactors are characterized by the following:

- 4 different reactor vendors
- 26 operating companies
- 80 different designs
- 65 sites

Diversity

Although there are many similarities, each reactor design can be considered unique. Figure 19 shows a typical pressurized-water reactor, and Figure 20 shows a typical boiling-water reactor.

Experience

Including 2008, U.S. reactors have accumulated nearly 2,800 years of operational experience (see Figure 21 and Table 8). Permanently shutdown reactors account for an additional 385 years of experience.

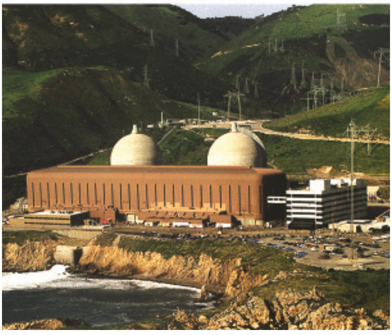
Courtesy: FPL

Turkey Point Nuclear Plant, Homestead, FL

Courtesy: Dominion Generation

North Anna Power Station, Mineral, VA

Courtesy: Pacific Gas & Electric

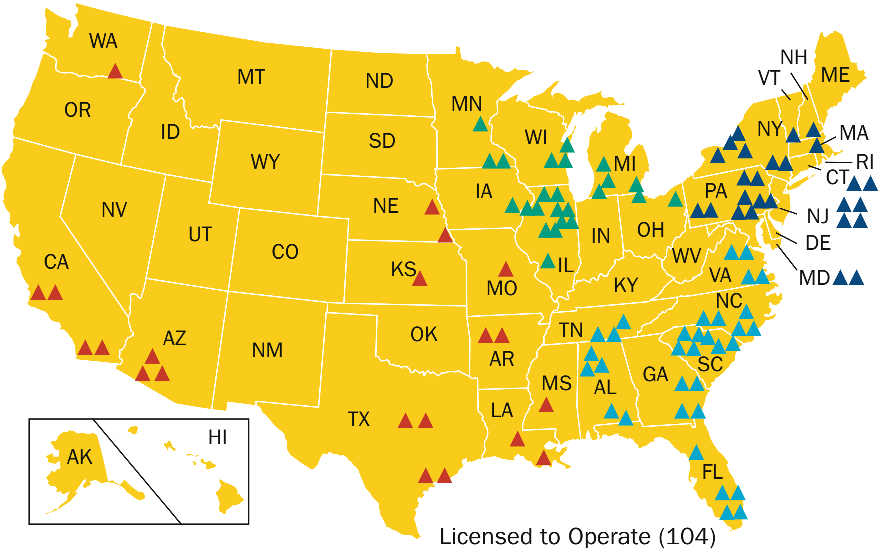


Diablo Canyon Nuclear Power Plant, San Luis Obispo, CA

Courtesy: Dominion Nuclear Conn.

Millstone Power Station, Waterford, CT

Figure 18. U.S. Operating Commercial Nuclear Power Reactors



REGION I

CONNECTICUT
- Millstone 2 and 3

MARYLAND
- Calvert Cliffs 1 and 2

MASSACHUSETTS
- Pilgrim

NEW HAMPSHIRE
- Seabrook

NEW JERSEY
- Hope Creek
- Oyster Creek
- Salem 1 and 2

NEW YORK
- FitzPatrick
- Ginna
- Indian Point 2 and 3
- Nine Mile Point 1 and 2

PENNSYLVANIA
- Beaver Valley 1 and 2
- Limerick 1 and 2
- Peach Bottom 2 and 3
- Susquehanna 1 and 2
- Three Mile Island 1

VERMONT
- Vermont Yankee

REGION II

ALABAMA
- Browns Ferry 1, 2, and 3
- Farley 1 and 2

FLORIDA
- Crystal River 3
- St. Lucie 1 and 2
- Turkey Point 3 and 4

GEORGIA
- Edwin I. Hatch 1 and 2
- Vogtle 1 and 2

NORTH CAROLINA
- Brunswick 1 and 2
- McGuire 1 and 2
- Harris 1

SOUTH CAROLINA
- Catawba 1 and 2
- Oconee 1, 2, and 3
- Robinson 2
- Summer

TENNESSEE
- Sequoyah 1 and 2
- Watts Bar 1

VIRGINIA
- North Anna 1 and 2
- Surry 1 and 2

REGION III

ILLINOIS
- Braidwood 1 and 2
- Byron 1 and 2
- Clinton
- Dresden 2 and 3
- LaSalle 1 and 2
- Quad Cities 1 and 2

IOWA
- Duane Arnold

MICHIGAN
- Cook 1 and 2
- Fermi 2
- Palisades

MINNESOTA
- Monticello
- Prairie Island 1 and 2

OHIO
- Davis-Besse
- Perry

WISCONSIN
- Kewaunee
- Point Beach 1 and 2

REGION IV

ARKANSAS
- Arkansas Nuclear 1 and 2

ARIZONA
- Palo Verde 1, 2, and 3

CALIFORNIA
- Diablo Canyon 1 and 2
- San Onofre 2 and 3

KANSAS
- Wolf Creek 1

LOUISIANA
- River Bend 1
- Waterford 3

MISSISSIPPI
- Grand Gulf

MISSOURI
- Callaway

NEBRASKA
- Cooper
- Fort Calhoun

TEXAS
- Comanche Peak 1 and 2
- South Texas Project 1 and 2

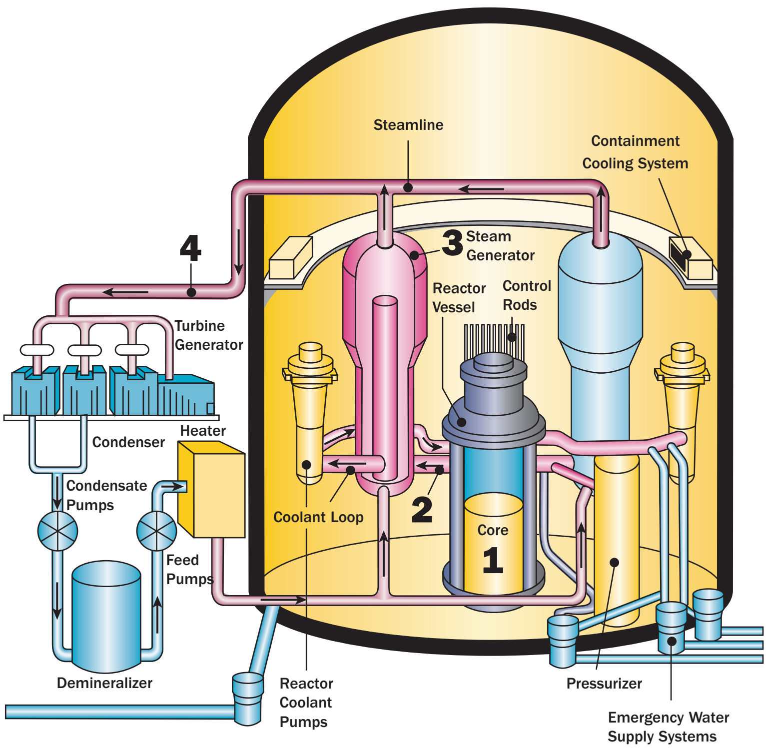
WASHINGTON
- Columbia

Note: NRC-abbreviated reactor names listed
Source: U.S. Nuclear Regulation Commission

Figure 19. **Typical Pressurized-Water Reactor**

How Nuclear Reactors Work

In a typical commercial pressurized light-water reactor, (1) the core inside the reactor vessel creates heat, (2) pressurized water in the primary coolant loop carries the heat to the steam generator, (3) inside the steam generator, heat from the primary coolant loop vaporizes the water in a secondary loop, producing steam, and (4) the steamline directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity. The unused steam is exhausted to the condenser where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated, and pumped back to the steam generator. The reactor's core contains fuel assemblies that are cooled by water circulated using electrically powered pumps. These pumps and other operating systems in the plant receive their power from the electrical grid. If offsite power is lost, emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment cooling system, also need electric power. Pressurized-water reactors contain between 150–200 fuel assemblies.

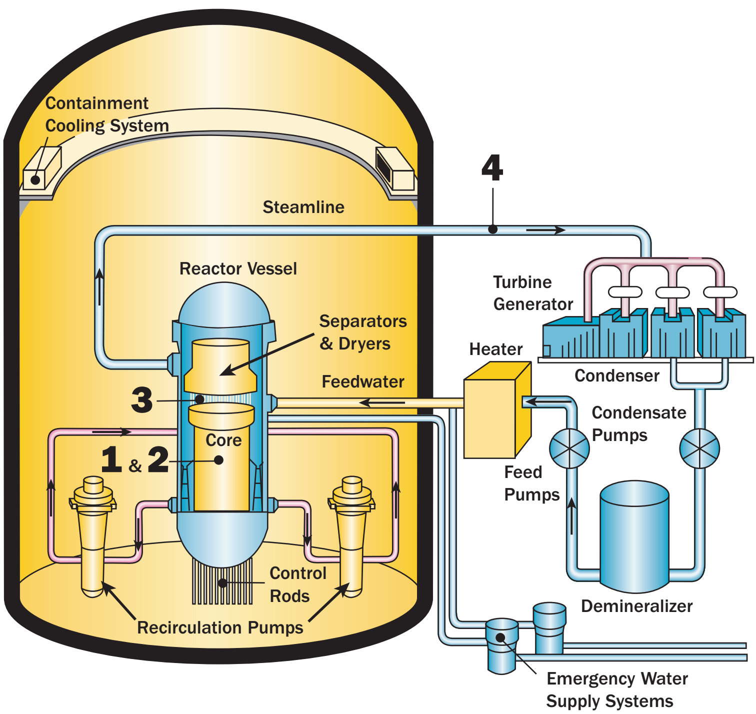


Source: U.S. Nuclear Regulatory Commission

Figure 20. Typical Boiling-Water Reactor

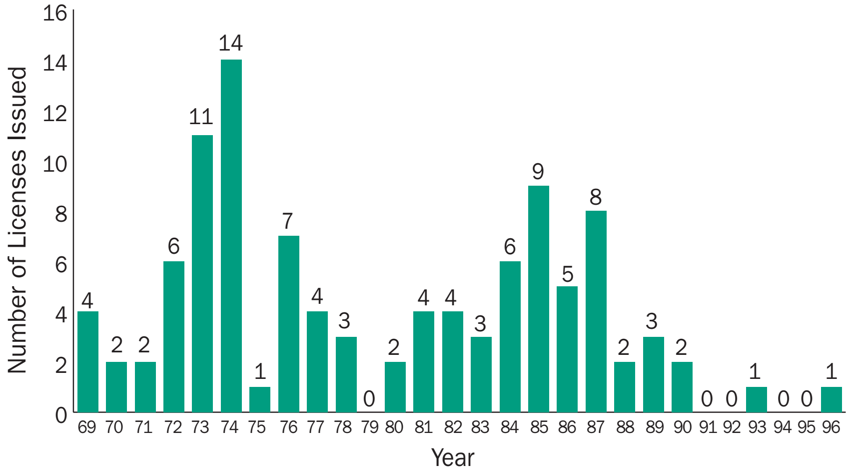
How Nuclear Reactors Work

In a typical commercial boiling-water reactor, (1) the core inside the reactor vessel creates heat, (2) a steam-water mixture is produced when very pure water (reactor coolant) moves upward through the core, absorbing heat, (3) the steam-water mixture leaves the top of the core and enters the two stages of moisture separation where water droplets are removed before the steam is allowed to enter the steamline, and (4) the steamline directs the steam to the main turbine, causing it to turn the turbine generator, which produces electricity. The unused steam is exhausted to the condenser where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated, and pumped back to the reactor vessel. The reactor's core contains fuel assemblies that are cooled by water circulated using electrically powered pumps. These pumps and other operating systems in the plant receive their power from the electrical grid. If offsite power is lost, emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment cooling system, also need electric power. Boiling-water reactors contain between 370–800 fuel assemblies.



Source: U.S. Nuclear Regulatory Commission

Figure 21. U.S. Commercial Nuclear Power Reactor Operating Licenses—Issued by Year



Note: No licenses were issued after 1996.
Source: U.S. Nuclear Regulatory Commission

Table 8. U.S. Commercial Nuclear Power Reactor Operating Licenses—Issued by Year

1969	Dresden 2
	Ginna
	Nine Mile Point 1
	Oyster Creek
1970	Robinson 2
	Point Beach 1
1971	Dresden 3
	Monticello
1972	Palisades
	Pilgrim
	Quad Cities 1
	Quad Cities 2
	Surry 1
	Turkey Point 3
1973	Browns Ferry 1
	Fort Calhoun
	Indian Point 2
	Kewaunee
	Oconee 1
	Oconee 2
	Peach Bottom 2
	Point Beach 2
	Surry 2
	Turkey Point 4
	Vermont Yankee
1974	Arkansas Nuclear 1
	Browns Ferry 2
	Brunswick 2
	Calvert Cliffs 1
	Cooper
	Cook 1
	Duane Arnold
	Hatch 1
	FitzPatrick
	Oconee 3
	Peach Bottom 3
	Prairie Island 1
	Prairie Island 2
	Three Mile Island 1
1975	Millstone 2
1976	Beaver Valley 1
	Browns Ferry 3
	Brunswick 1
	Calvert Cliffs 2
	Indian Point 3
	Salem 1
	St. Lucie 1
1977	Crystal River 3
	Davis-Besse
	D.C. Cook 2
	Joseph M. Farley 1
1978	Arkansas Nuclear 2
	Edwin I. Hatch 2
	North Anna 1
1980	North Anna 2
	Sequoyah 1
1981	Farley 2
	McGuire 1
	Salem 2
	Sequoyah 2
1982	LaSalle 1
	San Onofre 2
	Summer
	Susquehanna 1
1983	McGuire 2
	San Onofre 3
	St. Lucie 2
1984	Callaway
	Diablo Canyon 1
	Grand Gulf 1
	LaSalle 2
	Susquehanna 2
	Columbia
1985	Byron 1
	Catawba 1
	Diablo Canyon 2
	Fermi 2
	Limerick 1
	Palo Verde 1
	River Bend 1
	Waterford 3
	Wolf Creek 1
1986	Catawba 2
	Hope Creek 1
	Millstone 3
	Palo Verde 2
	Perry 1
1987	Beaver Valley 2
	Braidwood 1
	Byron 2
	Clinton
	Nine Mile Point 2
	Palo Verde 3
	Harris 1
	Vogtle 1
1988	Braidwood 2
	South Texas Project 1
1989	Limerick 2
	South Texas Project 2
	Vogtle 2
1990	Comanche Peak 1
	Seabrook 1
1993	Comanche Peak 2
1996	Watts Bar 1

Note: Limited to reactors licensed to operate. Year is based on the date the initial full-power operating license was issued. NRC-abbreviated reactor names listed

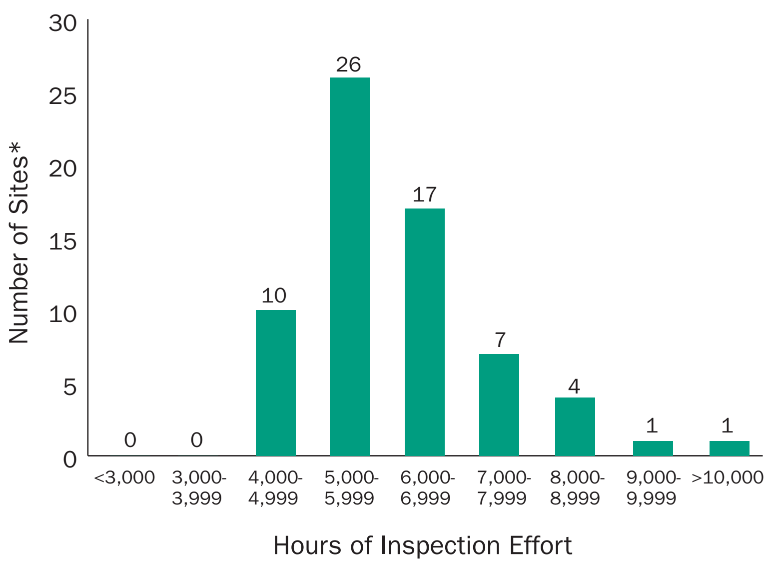
Source: U.S. Nuclear Regulatory Commission

Principal Licensing and Inspection Activities

The NRC conducts a variety of licensing and inspection activities.

- Typically about 10 separate license changes are requested per power reactor each year. The NRC completed more than 1,054 separate reviews in FY 2008.
- The NRC has licensed approximately 4,600 reactor operators. Each operator must requalify every 2 years and apply for license renewal every 6 years.
- On average, the NRC expended approximately 6,055 hours of inspection effort at each operating reactor site during 2008 (see Figure 22).
- The NRC reviews applications for proposed new reactors and is developing an inspection program to oversee construction.
- The NRC reviews approximately 3,000 licensed facility documents concerning events annually.
- The NRC oversees the decommissioning of nuclear power reactors. Refer to Appendix B for permanently shutdown and decommissioning reactors.
- The Advisory Committee on Reactor Safeguards (ACRS), an independent body of nuclear, engineering, and safety experts appointed by the Commission reviewed numerous safety issues for existing or proposed reac-

Figure 22. NRC Inspection Effort at Operating Reactors, 2008



Note: Data include regular and nonregular hours for all activities related to baseline, plant-specific, generic safety issues, and allegation inspections (does not include effort) for performance assessment. Data are presented for calendar year (CY) 2008.

* 66 total sites (Indian Point 2 and 3, Hope Creek, and Salem are treated as separate sites for inspection effort.)

Source: U.S. Nuclear Regulatory Commission

tors and provided independent technical advice to the Commission following 10 full committee meetings held annually.

OVERSIGHT OF U.S. COMMERCIAL NUCLEAR POWER REACTORS

The NRC does not operate nuclear power plants. Rather, it regulates the operation of the Nation's 104 nuclear power plants by establishing regulatory requirements for their design, construction, and operation. To ensure that the plants are operated safely within these requirements, the NRC licenses the plants to operate, licenses the plant operators, and establishes technical specifications for the operation of each plant.

Reactor Oversight Process

The NRC provides continuous oversight of plants through its Reactor Oversight Process (ROP) to verify that they are being operated in accordance with NRC rules, regulations, and license requirements. The NRC has full authority to take action to protect public health and safety. It may demand immediate licensee action, up to and including a plant shutdown.

The ROP is described on the NRC's Web site and in NUREG-1649, Revision 4, "Reactor Oversight Process," December 2006. In general terms, the ROP uses both NRC inspection findings and performance indicators (PIs) from licensees to assess the safety performance of each plant. The ROP recognizes that issues of very low safety significance inevitably occur, and plants are expected to address these issues effectively. The NRC performs an intensive baseline level of inspection at each plant. The NRC may perform supplemental inspections and take additional actions to ensure that significant performance issues are addressed. The latest plant-specific inspection findings and PI information can be found on the NRC's Web site (see Web Link Index).

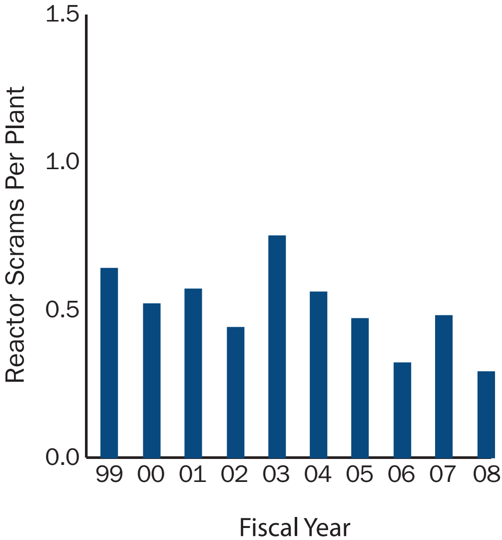
The ROP takes into account improvements in the performance of the nuclear industry over the past 25 years and improved approaches to inspecting and evaluating the safety performance of NRC-licensed plants. The improvements in plant performance can be attributed both to efforts within the nuclear industry and to successful regulatory oversight.

Industry Performance Indicators

In addition to evaluating the performance of each individual plant, the NRC compiles data on overall reactor industry performance using various industry-level performance indicators (see Figure 23 and Appendix G). The industry PIs provide additional data for assessing trends in overall industry performance.

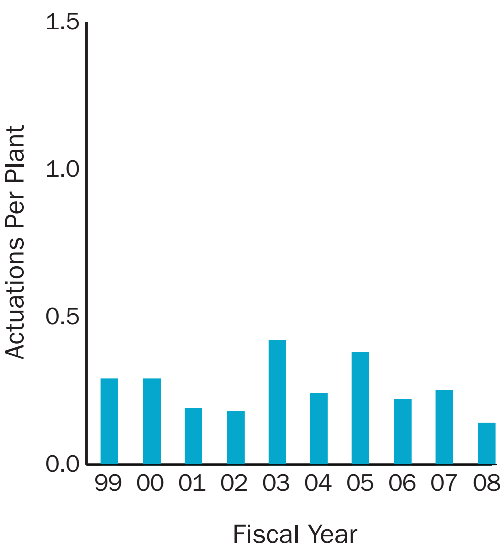
Figure 23. Industry Performance Indicators: Annual Industry Averages (for 104 plants), FYs 1999–2008

Automatic Scrams While Critical



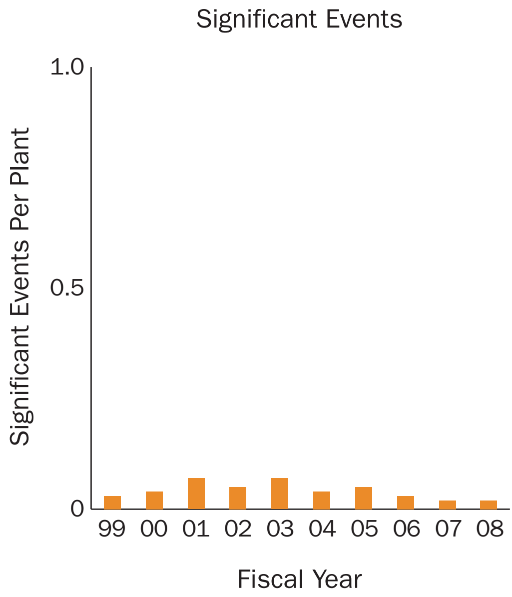
A reactor is said to be "critical" when it achieves a self-sustaining nuclear chain reaction, as when the reactor is operating. The sudden shutting down of a nuclear reactor by rapid insertion of control rods, either automatically or manually by the reactor operator, is referred to as a "scram." This indicator measures the number of unplanned automatic scrams that occurred while the reactor was critical.

Safety System Actuations

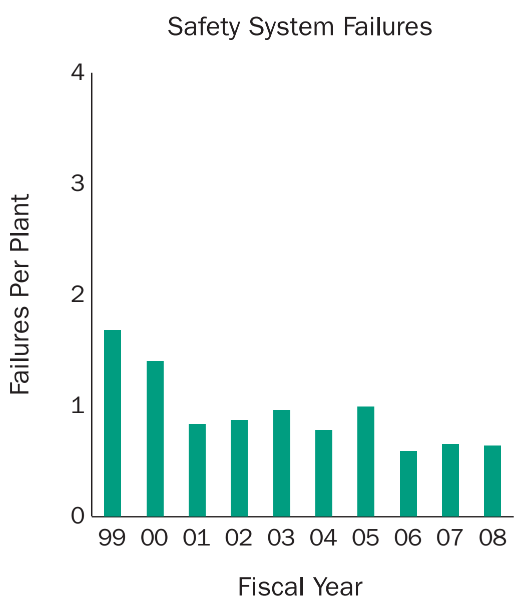


Safety system actuations are certain manual or automatic engagements of the logic or equipment of the emergency core cooling systems or emergency power systems. These systems are specifically designed to either remove heat from the reactor fuel rods if the normal core cooling system fails or provide emergency electrical power if the normal electrical systems fail.

Figure 23. Industry Performance Indicators: Annual Industry Averages (for 104 plants), FYs 1999–2008 (Continued)

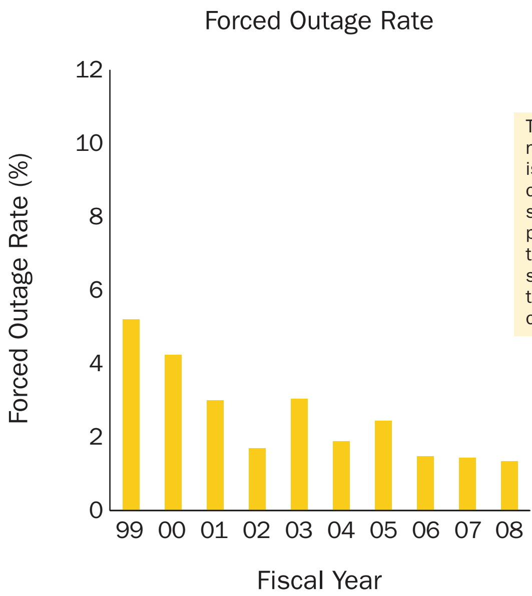


Significant events are events that meet specific NRC criteria, including degradation of safety equipment, a reactor scram with complications, an unexpected response to a transient, or degradation of a fuel or pressure boundary. The NRC staff identifies significant events through detailed screening and evaluation of operating experience.

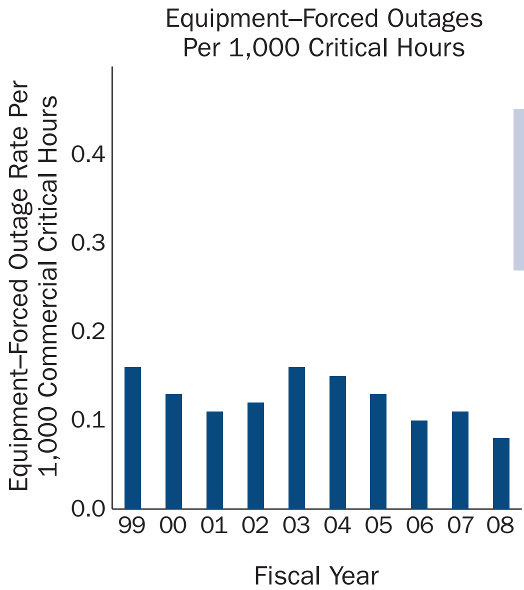


Safety system failures are any actual failures, events, or conditions that could prevent a system from performing its required safety function.

Figure 23. Industry Performance Indicators: Annual Industry Averages (for 104 plants), FYs 1999–2008 (Continued)

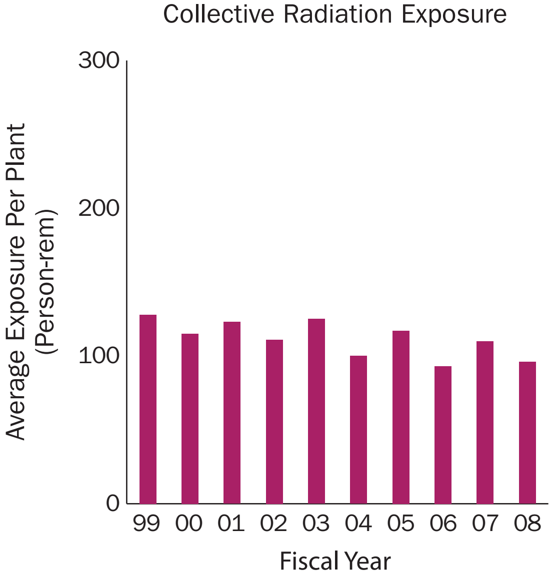


The forced outage rate is the number of hours that the plant is unable to operate (forced outage hours) divided by the sum of the hours that the plant is generating and transmitting electricity (unit service hours) and the hours that the plant is unable to operate (forced outage hours).



This indicator is the number of times the plant is forced to shut down because of equipment failures for every 1,000 hours that the plant is in operation and transmitting electricity.

Figure 23. Industry Performance Indicators: Annual Industry Averages (for 104 plants), FYs 1999–2008 (Continued)



This indicator monitors the total radiation dose accumulated by plant personnel.

Explanation:
In 2008, those workers receiving a measurable dose of radiation received about 0.1 rem. For comparison purposes, the average U.S. citizen receives 0.3 rem of radiation each year from natural sources (i.e., the everyday environment).

Note: Data represent annual industry averages, with plants in extended shutdown excluded. Data are rounded for display purposes. These data may differ slightly from previously published data as a result of refinements in data quality.
Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

Resident Inspectors

There are at least two full-time NRC inspectors at each nuclear power plant site to ensure facilities are meeting NRC regulations.

NEW COMMERCIAL NUCLEAR POWER REACTOR LICENSING

The NRC continues to interact with vendors and utilities regarding new reactor and licensing activities. The new licensing process is a substantial improvement over the system used through the 1990s. The NRC will review combined construction and operating license (called a combined license or COL) applications for reactors over the next several years and has in place the infrastructure and staff to support the necessary technical work. The NRC expects up to 23 COL applications for a total of 34 new nuclear units over the next few years (see Figure 24, Table 9, and the Web Link Index).

Construction and Operating Applications

As of June 30, 2009, the NRC had received 18 COL applications:

- Calvert Cliffs (MD)
- South Texas Project (TX)
- Bellefonte (AL)
- North Anna (VA)
- William States Lee III (SC)
- Shearon Harris (NC)
- Grand Gulf (MS)
- Vogtle (GA)
- V.C. Summer (SC)
- Callaway (MO)
- Levy County (FL)
- Victoria County (TX)
- Fermi (MI)
- Comanche Peak (TX)
- River Bend (LA)
- Nine Mile Point (NY)
- Bell Bend (PA)
- Turkey Point (FL)

The staff expects to receive an additional five COL applications by the end of 2011. For a current schedule of received and expected new reactor licensing applications, see Figure 24 and the Web Link Index. Figure 25 is a location map of expected new reactors.

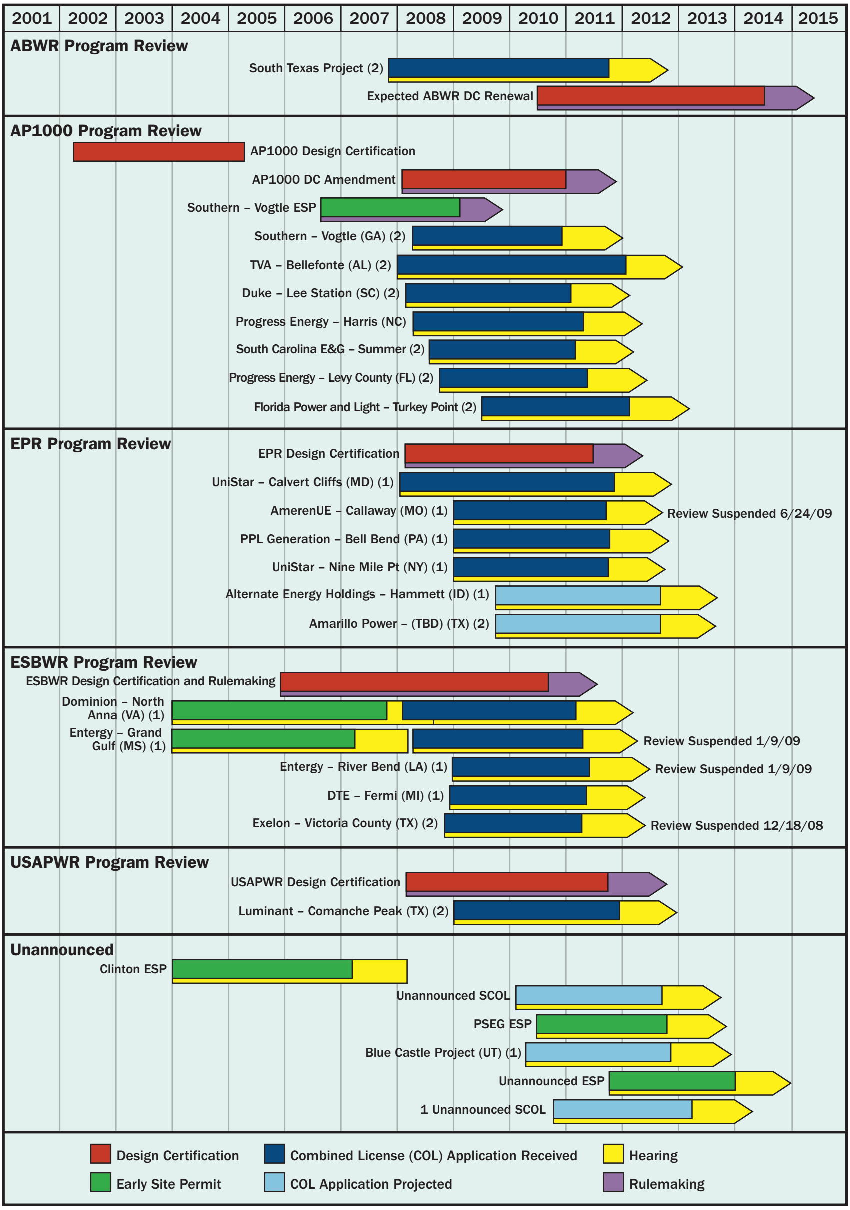
The NRC's new reactor licensing process offers many opportunities for public participation. Before the it receives an application, the agency talks to residents in the community near the location where a proposed new reactor may be built to explain how we review an application and how the public may participate in the process. We listen to comments on what factors should be considered in the agency's environmental review of the application. The public may then comment on the NRC's draft environmental evaluation that is posted to the agency's Web site. In addition, the public is afforded the opportunity to legally challenge a license application through Atomic Safety and Licensing Board hearings that are announced in press releases and posted to the NRC Web site.

The NRC has tailored its new reactor licensing activities to review new applications effectively and efficiently. These activities include the following:

- Revised regulations governing COL applications in NRC regulations that cover early site permits, standard design approvals, standard design certifications, COLs, and manufacturing licenses.

Figure 24. **New Reactor Licensing Schedule of Applications by Design**

Estimated Schedules by Calendar Year (as of June 30, 2009)



Note: Projected applications are based on potential applicants' information and are subject to change. Schedules depicted for future activities represent nominal assumed review durations based on submittal timeframes in letters of intent from prospective applicants. Numbers in ( ) next to the COL name indicate number of units/site. The acceptance review is included at the beginning of the COL review. Hearings on COLs are governed by the rules in Title 10 of the *Code of Federal Regulations* Part 2, "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders."

Source: U.S. Nuclear Regulatory Commission

Table 9. Expected New Nuclear Power Plant Applications (as of June 30, 2009)

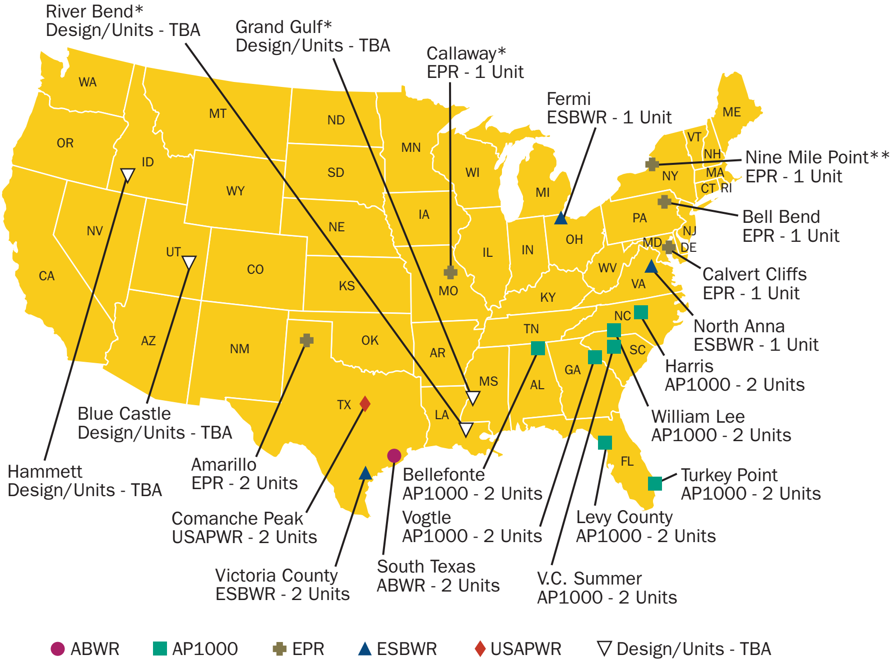
Company (Project/Docket#)	Date of Application	Design	Date Accepted	Site Under Consideration	State	Existing Op. Plant
CY 2007 Applications						
☑ NRG Energy (52-012/013)	9/20/07	ABWR	11/29/07	South Texas Project (2 units)	TX	Y
☑ NuStart Energy (52-014/015)	10/30/07	AP1000	1/18/08	Bellefonte (2 units)	AL	N
☑ UNISTAR (52-016)	7/13/07 (Env.), 3/13/08 (Safety)	EPR	1/25/08 6/03/08	Calvert Cliffs (1 unit)	MD	Y
☑ Dominion (52-017)	11/27/07	ESBWR	1/28/08	North Anna (1 unit)	VA	Y
☑ Duke (52-018/019)	12/13/07	AP1000	2/25/08	William Lee Nuclear Station (2 units)	SC	N
2007 TOTAL NUMBER OF APPLICATIONS = 5				TOTAL NUMBER OF UNITS = 8		
CY 2008 Applications						
☑ Progress Energy (52-022/023)	2/19/08	AP1000	4/17/08	Harris (2 units)	NC	Y
☑ NuStart Energy (52-024)	2/27/08	ESBWR	4/17/08	Grand Gulf (1 unit)	MS	Y
☑ Southern Nuclear Operating Co. (52-025/026)	3/31/08	AP1000	5/30/08	Vogtle (2 units)	GA	Y
☑ South Carolina Electric & Gas (52-027/028)	3/31/08	AP1000	7/31/08	Summer (2 units)	SC	Y
☑ Progress Energy (52-029/030)	7/30/08	AP1000	10/6/08	Levy County (2 units)	FL	N
☑ Exelon (52-031/032)	9/3/08	ESBWR	10/30/08	Victoria County (2 units)	TX	N
☑ Detroit Edison (52-033)	9/18/08	ESBWR	11/25/08	Fermi (1 unit)	MI	Y
☑ Luminant Power (52-034/035)	9/19/08	USAPWR	12/2/08	Comanche Peak (2 units)	TX	Y
☑ Entergy (52-036)	9/25/08	ESBWR	12/4/08	River Bend (1 unit)	LA	Y
☑ AmerenUE (52-037)	7/24/08	EPR	12/12/08	Callaway (1 unit)	MO	Y
☑ UNISTAR (52-038)	9/30/08	EPR	12/12/08	Nine Mile Point (1 unit)	NY	Y
☑ PPL Generation (52-039)	10/10/08	EPR	12/19/08	Bell Bend (1 unit)	PA	Y
2008 TOTAL NUMBER OF APPLICATIONS = 12				TOTAL NUMBER OF UNITS = 18		
CY 2009 Applications						
☐ Florida Power and Light (763)	6/30/09	AP1000		Turkey Point (2 units)	FL	Y
Amarillo Power (752)		EPR		Vicinity of Amarillo (2 units)	TX	N
Alternate Energy Holdings (765)		EPR		Hammett (1 unit)	ID	N
2009 TOTAL NUMBER OF APPLICATIONS = 3				TOTAL NUMBER OF UNITS = 5		
CY 2010 Applications						
Blue Castle Project		TBD		Utah	UT	N
Unannounced		TBD		TBD	TBD	UNK
Unannounced		TBD		TBD (1 Unit)	TBD	UNK
2010 TOTAL NUMBER OF APPLICATIONS = 3				TOTAL NUMBER OF UNITS = 3		
2007 – 2011 TOTAL NUMBER OF APPLICATIONS = 23				TOTAL NUMBER OF UNITS = 34		

☐ – Acceptance Review Ongoing   ☑ – Accepted/Docketed   UNK – Unknown

Source: U.S. Nuclear Regulatory Commission

NUCLEAR REACTORS

Figure 25. **Location of Projected New Nuclear Power Reactors**



*Review Suspended
**Review Partially Suspended

Note: Data as of June 30, 2009
Source: U.S. Nuclear Regulatory Commission

- Adopted an optimized approach for reviewing applications through a design-centered licensing review.
- Revised limited work authority regulations to allow some preconstruction activities without NRC approval, such as site clearing, road building, and transmission line routing.
- Developed Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."
- Gained insights from the Multinational Design Evaluation Programme (MDEP), in which the NRC participates with the regulators of nine other countries that are undertaking or considering new reactors. Members of the program benefit from enhanced cooperation and shared experience and research as they strive for convergence on acceptance of technical requirement, reciprocity on oversight and other activities.

Early Site Permits

The NRC has issued three early site permits (ESPs) to the following applicants:

- System Energy Resources, Inc. (Entergy), for the Grand Gulf site in Mississippi
- Exelon Generation Company, LLC, for the Clinton site in Illinois
- Dominion Nuclear North Anna, LLC, for the North Anna site in Virginia

The agency is currently reviewing an ESP application submitted by Southern Nuclear Operating Company for the Vogtle site in Georgia. The staff expects to receive two additional ESP applications by the end of 2011. An ESP provides for early resolution of site safety, environmental protection, and emergency preparedness issues independent of a specific nuclear plant review. The Advisory Committee for Reactor Safeguards reviews those portions of the ESP application that concern safety. Mandatory adjudicatory hearings associated with the ESPs are conducted after the completion of the NRC staff's technical review.

Design Certifications

The NRC has issued design certifications (DCs) for four reactor designs that can be referenced in an application for a nuclear power plant. These designs are:

- General Electric-Hitachi Nuclear Energy's (GEH's) Advanced Boiling-Water Reactor (ABWR)
- Westinghouse's System 80+
- Westinghouse's AP600
- Westinghouse's AP1000

The NRC is currently reviewing the following DC applications:

- GEH's Economic Simplified Boiling-Water Reactor (ESBWR)
- Westinghouse's AP1000 DC Amendment
- AREVA's Evolutionary Power Reactor (EPR)
- Mitsubishi Heavy Industries's U.S. Advanced Pressurized-Water Reactor (US-APWR)

Advanced Reactor Designs

In addition, a range of advanced reactor designs and technologies have emerged that may be submitted to the NRC within the next several years. These technologies include small- and medium-sized light-water reactors, liquid-metal reactors, and high-temperature gas-cooled reactors.

New Reactor Construction Inspections

The NRC's future activities will include inspecting licensee construction to ensure that the as-built facility conforms to its COL conditions and that the construction meets the regulations for quality control and assurance. The agency also inspects vendor facilities to ensure that products and services furnished to new U.S. reactors meet quality and other regulatory requirements. To meet that demand, the NRC established a special construction inspection organization in Region II in Atlanta, GA.

The NRC staff will examine a licensee's operational programs, such as security, radiation protection, and operator training and qualification, to ensure that the licensee is ready to operate the plant once it is built. The agency's construction site inspectors will devote significant resources to verifying a licensee's completion of inspections, tests, analyses, and acceptance criteria. The NRC will use these direct inspections and other methods to confirm the licensee has completed these actions and has met the acceptance criteria included in a COL before allowing startup of the plant.

The NRC also will dispatch several full-time inspectors to a site during the construction phase to oversee day-to-day activities of the licensee and its contractors.

More information on the NRC's new reactor licensing activities is available on the NRC Web site (see Web Link Index).

REACTOR LICENSE RENEWAL

Based on the Atomic Energy Act of 1954, as amended, the NRC issues licenses for commercial power reactors to operate for 40 years. Under current regulations, licensees may renew their licenses for up to 20 years.

Economic and antitrust considerations, not limitations of nuclear technology, determined the original 40-year term for reactor licenses. However, due to this selected time period, some systems, structures, and components may have been engineered on the basis of an expected 40-year service life.

As of May 2009, approximately half of the licensed reactor units have either received or are under review for license renewal. Of these, 52 units (at 30 sites) have received renewed licenses. Figure 26 illustrates the years of commercial operation of operating power reactors. Figure 27 and Table 10 show the expiration dates of operating commercial nuclear licenses.

The decision to seek license renewal rests entirely with nuclear power plant owners and typically is based on the plant's economic situation and on whether it can meet NRC requirements.

The NRC will only renew a license if it determines that a currently operating plant will continue to maintain the required level of safety.

Over the plant's life, this level of safety has been enhanced through maintenance of the licensing basis, with appropriate adjustments to address new information from industry operating experience. In addition, the NRC's regulatory activities have provided ongoing

Figure 26. U.S. Commercial Nuclear Power Reactors— Years of Operation by the End of 2009

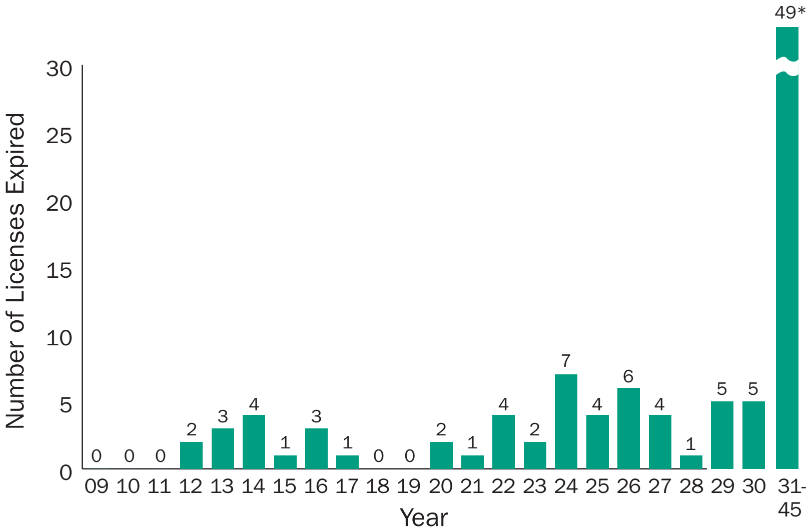
Years of Commercial Operation	Number of Reactors
△ 0-9	0
▲ 10-19	6
▲ 20-29	48
▲ 30-39	48
▲ 40 plus	2

Note: Ages have been rounded up to the end of the year.
Source: U.S. Nuclear Regulatory Commission

assurance that the current licensing basis will provide an acceptable level of safety. The agency developed the license renewal review process to provide continued assurance that the licensee will maintain this level of safety for the period of extended operation.

The NRC has issued regulations establishing clear requirements for license renewal to ensure safe plant operation for extended plant life codified in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." Environmental protection requirements for license renewal are contained in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The review of a renewal application proceeds along two paths–one for the review of safety issues and the other for environmental issues (see Figure 28). An applicant must provide the NRC with an evaluation that addresses the technical aspects of plant aging and describes the ways those effects will be managed. The applicant must also prepare an evaluation of the potential impact on the environment if the plant operates for up to an additional 20 years. The NRC reviews the application and verifies the safety evaluation through inspections.

Figure 27. **U.S. Commercial Nuclear Power Reactor Operating Licenses—Expiring by Year**



*Data exceed graph parameters.
Source: U.S. Nuclear Regulatory Commission

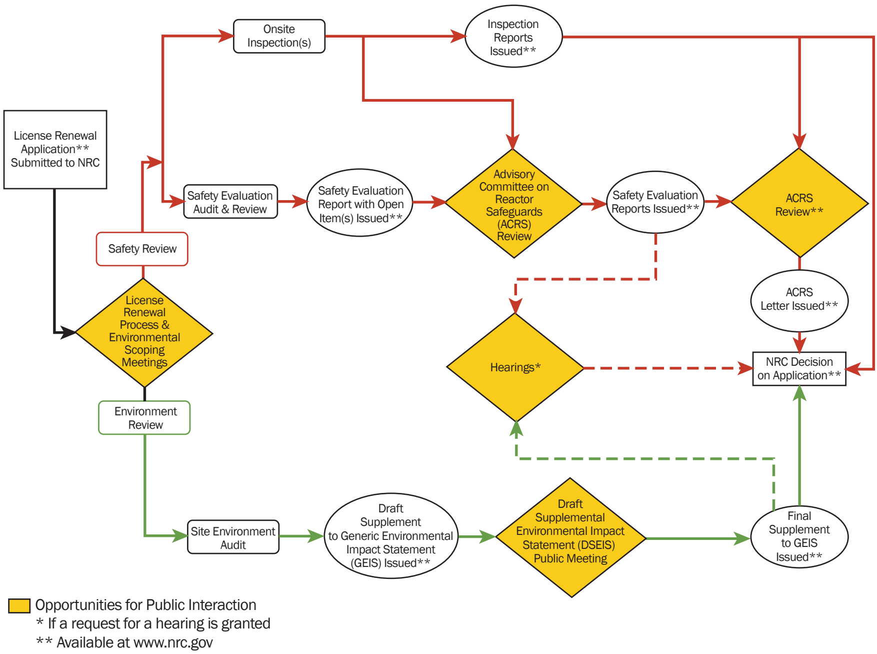
Table 10. **U.S. Commercial Nuclear Power Reactor Operating Licenses—Expiration by Year, 2009–2049**

2012	Pilgrim
	Vermont Yankee
2013	Indian Point 2
	Kewaunee
	Prairie Island 1
2014	Cooper
	Duane Arnold
	Prairie Island 2
	Three Mile Island 1
2015	Indian Point 3
2016	Beaver Valley 1
	Crystal River 3
	Salem 1
2017	Davis-Besse
2020	Salem 2
	Sequoyah 1
2021	Sequoyah 2
2022	LaSalle 1
	San Onofre 2
	San Onofre 3
	Susquehanna 1
2023	Columbia
	LaSalle 2
2024	Byron 1
	Callaway
	Diablo Canyon 1
	Grand Gulf 1
	Limerick 1
	Susquehanna 2
	Waterford 3
2025	Diablo Canyon 2
	Fermi 2
	Palo Verde 1
	River Bend 1
2026	Braidwood 1
	Byron 2
	Clinton
	Palo Verde 2
	Hope Creek
	Perry
2027	Beaver Valley 2
	Braidwood 2
	Palo Verde 3
	South Texas Project 1
2028	South Texas Project 2
2029	Dresden 2
	Ginna
	Limerick 2
	Nine Mile Point 1
	Oyster Creek
2030	Comanche Peak 1
	Monticello
	Point Beach 1
	Robinson 2
	Seabrook
2031	Dresden 3
	Palisades
2032	Quad Cities 1
	Quad Cities 2
	Surry 1
	Turkey Point 3
2033	Browns Ferry 1
	Comanche Peak 2
	Fort Calhoun
	Oconee 1
	Oconee 2
	Peach Bottom 2
	Point Beach 2
	Surry 2
	Turkey Point 4
2034	Arkansas Nuclear 1
	Browns Ferry 2
	Brunswick 2
	Calvert Cliffs 1
	Cook 1
	Hatch 1
	FitzPatrick
	Oconee 3
	Peach Bottom 3
2035	Millstone 2
	Watts Bar 1
2036	Browns Ferry 3
	Brunswick 1
	Calvert Cliffs 2
	St. Lucie 1
2037	Cook 2
	Farley 1
2038	Arkansas Nuclear 2
	Hatch 2
	North Anna 1
2040	North Anna 2
2041	Farley 2
	McGuire 1
2042	Summer
2043	Catawba 1
	Catawba 2
	McGuire 2
	St. Lucie 2
2045	Millstone 3
	Wolf Creek 1
2046	Nine Mile Point 2
	Harris 1
2047	Vogtle 1
2049	Vogtle 2

Note: Limited to reactors licensed to operate. NRC-abbreviated reactor names listed.

Source: Data as of June 2009 complied by the U.S. Nuclear Regulatory Commission

Figure 28. **License Renewal Process**



Source: U.S. Nuclear Regulatory Commission

Public Involvement

Public participation is an important part of the license renewal process. There are several opportunities for members of the public to question how aging will be managed during the period of extended operation. Information provided by the applicant is made available to the public. The NRC holds a number of public meetings. The agency fully documents all of its technical and environmental review results and makes them publicly available. In addition, the Advisory Committee on Reactor Safeguards holds public meetings to discuss technical or safety issues about plant designs or a particular plant or site. Stakeholder concerns may be litigated in an adjudicatory hearing if any party that would be affected requests a hearing and submits an admissible contention.

The NRC provides information on the license renewal process, plants that have received renewed licenses, and plants under review. For more information, visit the NRC Web site (see Web Link Index).

NUCLEAR RESEARCH AND TEST REACTORS

Nuclear research and test reactors are designed and used for research, testing, and education in physics, chemistry, biology, anthropology, medicine, materials sciences, and related fields. These reactors help prepare people for nuclear-related careers in the fields of electric power, national defense, health services, research, and education.

There are 43 licensed research and test reactors:

- 32 research and test reactors operating in 22 States (see Figure 29)
- 11 reactors shut down and in various stages of decommissioning

Refer to Appendix E for a list of the 32 operating research and test reactors regulated by the NRC.

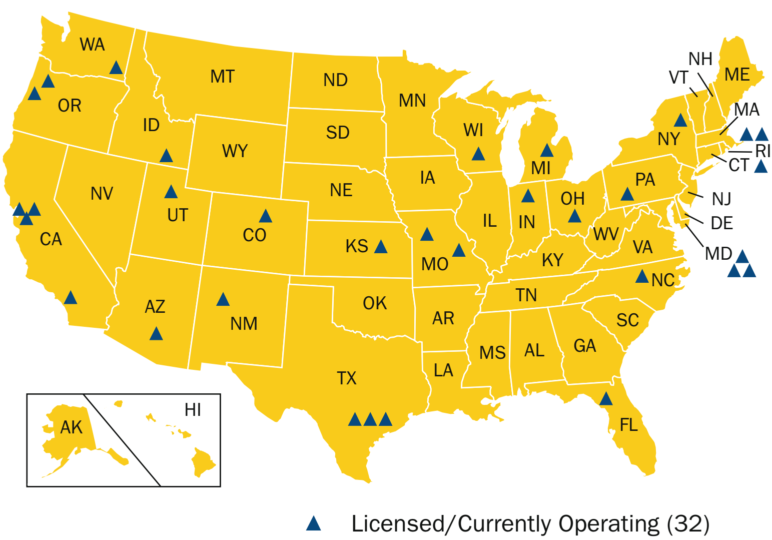
Since 1958, 82 licensed research and test reactors have been decommissioned.

Refer to Appendix F for a list of the 11 research and test reactors regulated by the NRC that are in the process of decommissioning.

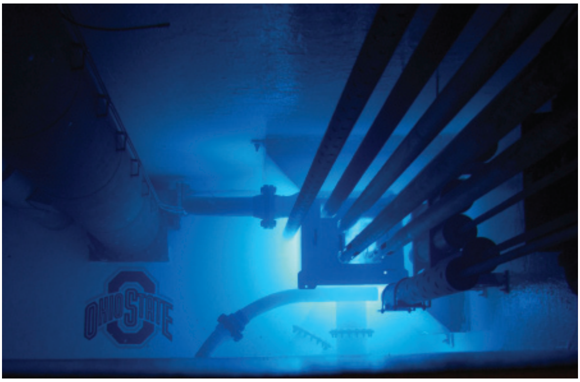
Principal licensing and inspection activities include the following:

- Licensing approximately 92 research and test reactor operators.
- Requalifying each operator before renewal of his or her 6-year license.
- Conducting approximately 36 research and test reactor inspections each year.

Figure 29. U.S. Nuclear Research and Test Reactors



Source: U.S. Nuclear Regulatory Commission



A blue glow of radiation, known as the "Cerenkov effect," from nuclear fuel in the Ohio State Research/Test Reactor

NUCLEAR REGULATORY RESEARCH

The NRC's research program supports the agency's regulatory mission by providing technical advice, tools, and information to identify and resolve safety issues, make regulatory decisions, and promulgate regulations and guidance. This includes conducting confirmatory experiments and analyses; developing technical bases that support the NRC's safety decisions; and preparing the agency for the future by evaluating the safety aspects of new technologies and designs for nuclear reactors, materials, waste, and security. The NRC faces challenges as the industry matures, including potential new safety issues, the availability of new technologies, technical issues associated with the deployment of new reactor designs, and knowledge management.

The NRC focuses its research primarily on near-term needs related to oversight of operating light-water reactors, the technology currently used in the United States. However, recent applications for advanced light-water reactors and preapplication activity regarding nonlight-water reactor vendors have prompted the agency to consider longer-term research needs.

The NRC ensures protection of public health, safety, and the environment through research programs that do the following:

- Examine technical issues such as:
  - material degradation issues (e.g., stress-corrosion cracking and boric acid corrosion)
  - new and evolving technologies (e.g., new reactor technology, mixed oxide fuel performance)
  - experience gained from operating reactors
  - probabilistic risk assessment (PRA) methods

- Examine human factor issues including safety culture and human interaction with computers, such as simulator training.
- Develop and improve computer codes as computational abilities expand and additional experimental and operational data allow for more realistic simulation. These computer codes analyze a wide spectrum of technical areas, including the following:
  - severe accidents
  - radionuclide transport through the environment
  - health effects of radioactive releases
  - nuclear criticality
  - fire conditions in nuclear facilities
  - thermal-hydraulic performance of reactors
  - reactor fuel performance
  - PRA of each nuclear power reactor
- Ensure the secure use and management of nuclear facilities and radioactive materials by investigating potential security vulnerabilities and possible compensatory actions.

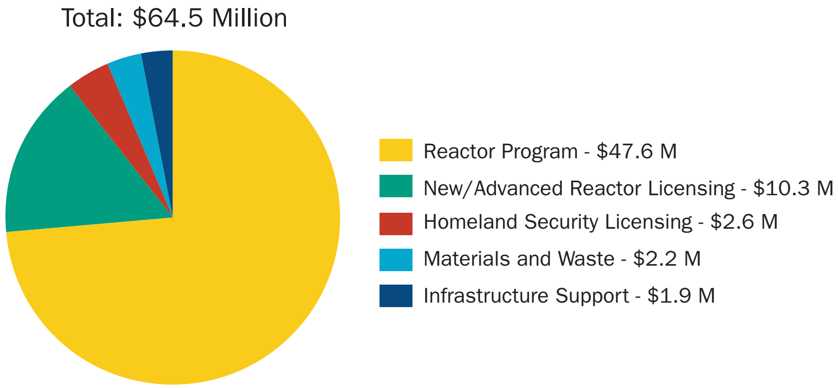
The NRC dedicates about 7 percent of its personnel and about 14 percent of its contracting funds to research. This research enables the NRC's highly skilled, experienced experts to formulate sound technical solutions and to support timely and realistic regulatory decisions.

The NRC research budget for FY 2009 is nearly $65 million. This includes contracts with national laboratories, universities, and other research organizations for greater expertise and access to research facilities. The primary areas of research are illustrated in Figure 30.

The NRC directs about three-fourths of the research program toward maintaining the safety of existing operating reactors. As licensees continue submitting new reactor applications, the agency is directing more research towards new and advanced reactors.

NRC Manager Lawrence Kokajko speaks about NRC's safety and security mission to students enrolled in the new nuclear engineering curriculum at the University of Puerto Rico-Mayaguez. The agency sponsored the development of the university's nuclear engineering curriculum through its Nuclear Education Grant Program.

Figure 30. NRC Research Funding, FY 2009



Note: Totals may not equal sum of components because of independent rounding.
Source: U.S. Nuclear Regulatory Commission

Radioactive waste programs and security are additional focus areas for research. Infrastructure support includes information technology and human resources.

The NRC also has cooperative agreements with universities and nonprofit organizations to research specific areas of interest to the agency.

These cooperative agreements and grants include the following organizations:

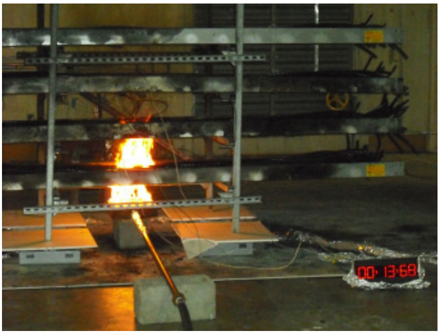
- Electric Power Research Institute for work on fire risk and advancing probabilistic risk assessments
- Pennsylvania State University for research on spacer grid thermal hydraulics and nuclear fuel cladding behavior
- University of Tennessee for work on sparse radiation survey data
- Ohio State University for research on the risk importance of digital systems
- Massachusetts Institute of Technology for work on advanced nuclear technologies
- University of Maryland for work on fire risk and uncertainties
- National Institute for Standards and Technology (NIST) for work on mathematical fire modeling

The NRC collaborates with the international research community on nonlight-water reactor technologies. This collaboration helps the agency initiate activities focused on new technologies using minimal resources. Collaboration is aided by the agency's leadership role in the standing committees and senior advisory groups of international organizations, such as the International Atomic Energy Agency and the Nuclear Energy Agency.

The NRC also has research agreements with foreign governments for international cooperative research that include the following projects:

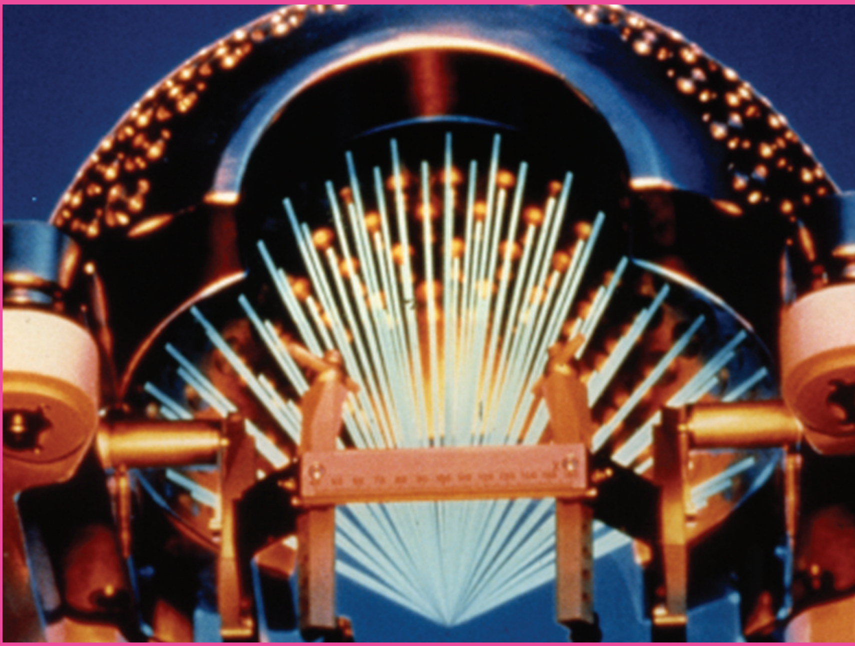
- Halden Reactor Project in Norway for research and development of fuel, reactor internals, plant control and monitoring, and human factors
- Phebus International Source Term Program (Phebus-ISTP)
- Studsvik Cladding Integrity Project in Sweden for nuclear fuels research
- Integral high-burnup fuel loss-of-coolant accident tests at Studsvik in Sweden

Demonstration of Cable Tray Fire Test in May 2009



NRC Chairman Gregory B. Jaczko visited the National Institute of Standards and Technology Fire Research Laboratory to witness the cable tray tests sponsored by the Office of Nuclear Regulatory Research. The purpose of this test series is to quantify the energy released from burning electrical cables. Nuclear power plants typically contain hundreds of miles of electrical cables. The data gathered from this test program will be used to develop more realistic models of cable fires for use in fire probabilistic risk assessment analyses.

A Leskel Gamma Knife® headframe uses radiation beams to treat people with brain cancer.



Courtesy of Elekta

NUCLEAR MATERIALS

The NRC regulates nuclear materials for use in medical, industrial, and commercial applications. It also regulates the phases of the nuclear fuel cycle (see Figure 31) which begins with the uranium recovery and enrichment facilities that produce nuclear fuel for power plants.

MATERIALS LICENSES

The NRC and Agreement States have issued approximately 22,500 licenses for medical, academic, industrial, and general uses of nuclear materials (see Figure 32 and Table 11).

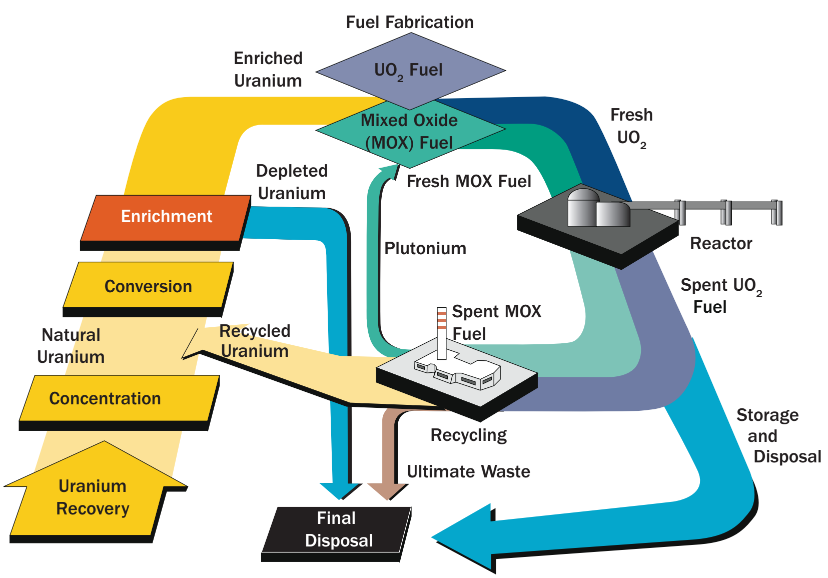
- NRC administers approximately 3,400 licenses
- 36 Agreement States administer approximately 19,100 licenses

Reactor- and accelerator-produced radionuclides are used extensively throughout the United States for civilian and military industrial applications; basic and applied research; manufacture of consumer products; academic studies; and medical diagnosis, treatment, and research. The NRC and Agreement State regulatory programs are designed to ensure that licensees safely use these materials and do not endanger public health and safety or cause damage to the environment.

MEDICAL AND ACADEMIC

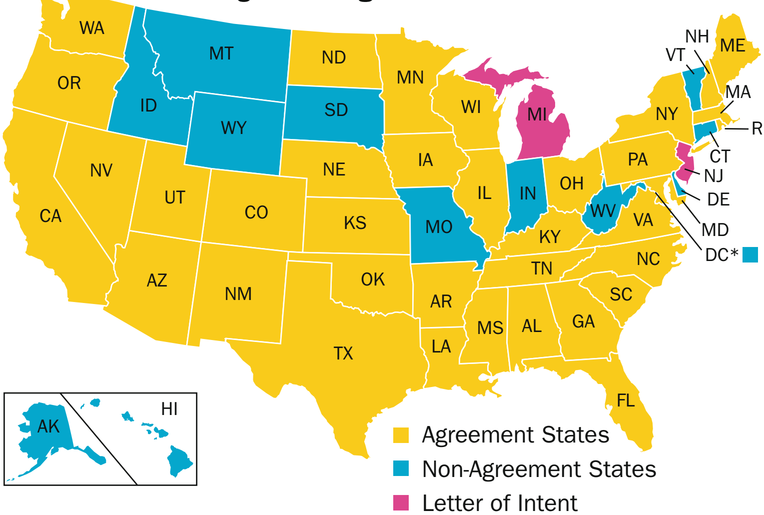
In both medical and academic settings, the NRC reviews the facilities, personnel, program controls, and equipment to ensure the safety of the public, patients, and workers who might be exposed to radiation.

Figure 31. The Nuclear Fuel Cycle



Source: U.S. Nuclear Regulatory Commission

Figure 32. Agreement States



Through agreements with the NRC, many States have assumed regulatory authority over radioactive materials, with the exception of nuclear reactors, fuel facilities and certain quantities of special nuclear material. These States are called Agreement States, as shown in gold.

* Other Non-Agreement States include major U.S. territories, such as Puerto Rico, Virgin Islands, and Guam.

Source: U.S. Nuclear Regulatory Commission

Medical

The NRC and Agreement States issue licenses to hospitals and physicians for the use of radioactive materials in medical treatments. In addition, the NRC develops guidance and regulations for use by licensees and maintains a committee of medical experts to obtain advice about the use of byproduct materials in medicine. The Advisory Committee on the Medical Uses of Isotopes is comprised of physicians, scientists, and other health care professionals who provide advice to the NRC staff on initiatives in the medical uses of radioactive materials.

About one-third of all patients admitted to hospitals are diagnosed or treated using radioactive materials. This branch of medicine is known as nuclear medicine, and the radioactive materials for treatment are called radiopharmaceuticals. Doctors of nuclear medicine use radiopharmaceuticals to diagnose patients using in vivo tests (direct administration of radiopharmaceuticals to patients) or in vitro tests (the addition of radioactive materials to lab samples taken from patients). Doctors also use radiopharmaceuticals and radiation-producing devices to treat conditions such as hyperthyroidism and certain forms of cancer and to ease bone pain caused by cancer.

Diagnostic Procedures

For most diagnostic procedures in nuclear medicine, a small

Table 11. U.S. Materials Licenses by State

State	Number of Licenses: NRC	Number of Licenses: Agreement States
Alabama	17	458
Alaska	56	0
Arizona	10	372
Arkansas	6	228
California	47	2,007
Colorado	20	354
Connecticut	192	0
Delaware	61	0
District of Columbia	42	0
Florida	14	1,720
Georgia	16	521
Hawaii	37	0
Idaho	81	0
Illinois	37	742
Indiana	289	0
Iowa	4	193
Kansas	11	300
Kentucky	10	449
Louisiana	13	550
Maine	2	125
Maryland	74	638
Massachusetts	26	500
Michigan	533	0
Minnesota	13	187
Mississippi	6	333
Missouri	294	0
Montana	84	0

State	Number of Licenses: NRC	Number of Licenses: Agreement States
Nebraska	6	153
Nevada	5	270
New Hampshire	5	78
New Jersey	480	0
New Mexico	15	186
New York	32	1,461
North Carolina	18	680
North Dakota	9	66
Ohio	46	748
Oklahoma	21	297
Oregon	4	435
Pennsylvania	66	926
Rhode Island	1	56
South Carolina	11	417
South Dakota	44	0
Tennessee	19	608
Texas	47	1,670
Utah	10	188
Vermont	37	0
Virginia	71	431
Washington	19	437
West Virginia	179	0
Wisconsin	22	336
Wyoming	84	0
Others*	158	0
Total	3,429	19,100

(Yellow shading) Agreement State

* Others include major U.S. territories.

Note: Agreement States data are the latest available as of October 2008; the NRC data are the latest available as of April 2009.

Source: U.S. Nuclear Regulatory Commission

amount of radioactive material is administered, either by injection, inhalation, or oral administration. The radiopharmaceutical collects in the organ or area being evaluated, where it emits photons. These photons can be detected by a device known as a gamma camera, which produces images that provide information about the organ function and composition.

Radiation Therapy

The primary objective of radiation therapy is to deliver an accurately prescribed dose of radiation to the target site while minimizing the radiation dose to surrounding healthy tissue. Radiation therapy can be used to treat cancer or to relieve symptoms associated with certain diseases. Treatments often involve multiple exposures spaced over a period of time for maximum therapeutic effect. When used to treat malignant diseases, radiation therapy is often delivered in combination with surgery or chemotherapy.

There are three main categories of radiation therapy:

- External beam therapy (also called teletherapy) is a beam of radiation directed to the target tissue. There are several different categories of external beam therapy units. The type of treatment machine that is regulated by the NRC contains a high-activity radioactive source (usually cobalt-60) that emits photons to treat the target site.
- In brachytherapy treatments, sealed radioactive sources are permanently or temporarily placed near or on a body surface, in a body cavity, directly to a surface within a cavity, or directly on the cancerous tissue. The radiation dose is delivered at a distance of up to an inch (a few centimeters) from the target area.
- Therapeutic radiopharmaceuticals are large amounts of unsealed radioactive materials that localize in a specific region or organ system to deliver a large radiation dose.

Academic

The NRC issues licenses to academic institutions for educational and research purposes. For example, qualified instructors use radioactive materials in classroom demonstrations. Scientists in a wide variety of disciplines use radioactive materials for laboratory research.

INDUSTRIAL

The NRC and Agreement States license users of radioactive material for the specific type, quantity, and location of material that may be used. Radionuclides are used in a number of industrial and commercial applications, including industrial radiography, gauges, well-logging, and manufacturing. For example, radiography uses radiation sources to find structural defects in metallic materials and welds. Gauges use radiation sources to determine the thickness of paper products, fluid levels in oil and chemical tanks, and the moisture and density of soils and material at construction sites. Gas chromatography uses low-energy radiation sources for identifying the chemical elements in an unknown substance. Gas chromatography can determine the components of complex mixtures, such as petroleum products, smog, and cigarette smoke, and can be used in biological and medical research to identify the components of complex proteins and enzymes. Well-logging devices use a radioactive source and detection equipment to make a record of geological formations down a bore hole. This process is used extensively for oil, gas, coal, and mineral exploration.

Nuclear Gauges

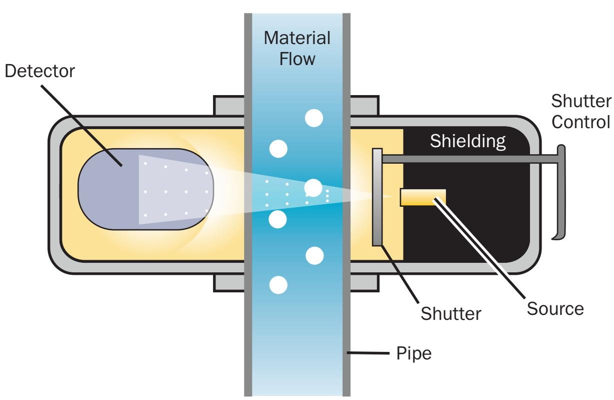
Nuclear gauges are used as non-destructive devices to measure the physical properties of products and industrial processes as a part of quality control. There are fixed and portable gauges.

A fixed gauge consists of a radioactive source that is contained in a source holder. When the user opens the container's shutter, a controlled beam of radiation hits the material or product being processed or controlled. A detector mounted opposite the source measures the radiation passing through the product. The gauge readout or computer monitor shows the measurement. The selection of the type, energy, and strength of radiation is dictated by the material and process being monitored.

The diagram on this page shows a fixed fluid gauge installed on a pipe (see Figure 33). The beverage, food, plastics, and chemical industries use such devices to measure the densities, flow rates, levels, thicknesses, and weights of a wide variety of materials and surfaces.

A portable gauge is a radioactive source and detector mounted together in a portable shielded

Figure 33. **Cross-Section of Fixed Fluid Gauge**



Source: U.S. Nuclear Regulatory Commission

device. The device is placed on the object to be measured, and the source is either inserted into the object or the gauge relies on a reflection of radiation from the source to bounce back to the bottom of the gauge. The detector in the gauge measures the radiation, either directly from the inserted source or from the reflected radiation.

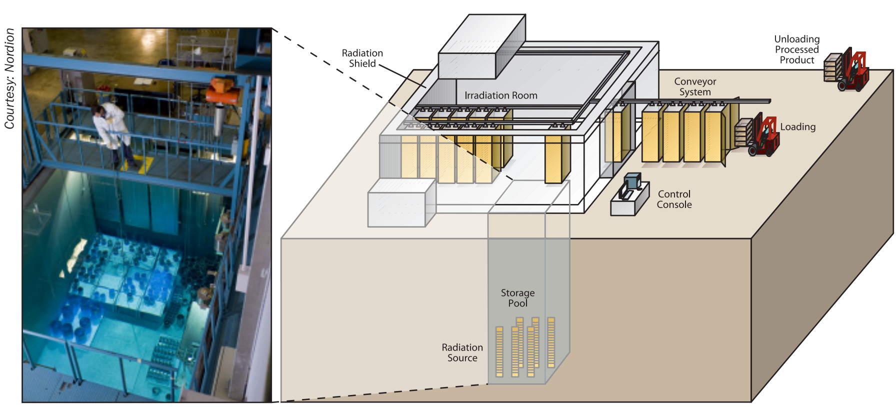
The radiation measurement indicates the thickness, density, moisture content, or some other property that is displayed on a gauge readout or on a computer monitor. The top of the gauge has sufficient shielding to protect the operator while the source is exposed. When the measuring process is completed, the source is retracted or a shutter closes, minimizing exposure from the source.

Commercial Irradiators

Commercial irradiators expose products such as food, food containers, spices, medical supplies, and wood flooring to radiation to eliminate harmful bacteria, germs, and insects, or for hardening or other purposes (see Figure 34). The gamma radiation does not leave any radioactive residue or cause any of the treated products to become radioactive themselves. The source of that radiation can be radioactive materials (e.g., cobalt-60), an X-ray tube, or an electron beam.

There are approximately 50 commercial irradiators nationwide that are licensed by the NRC and Agreement States. For the past 40 years, the U.S. Food and Drug Administration and other agencies have approved the irradiation of meat and poultry, as well as other foods, including fresh fruits and

Figure 34. Commercial Irradiator



Source: U.S. Nuclear Regulatory Commission

vegetables. The amount of radioactive material in the devices can range from 1 to 10 million curies.

There are generally two types of irradiators in operation in the United States: underwater and wet-source-storage panoramic models.

- In the case of underwater irradiators, the sealed sources (radioactive material encased inside a capsule) that provide the radiation remain in the water at all times, providing shielding for workers and the public. The product to be irradiated is placed in a watertight container, lowered into the pool, irradiated, and then removed.
- With wet-source-storage panoramic irradiators, the radioactive sealed sources are also stored in the water, but they are raised into the air to irradiate products that are automatically moved into the room on a conveyor system. Sources are then lowered back to the bottom of the pool. For this type of irradiator, thick concrete walls or steel provide protection for workers and the public when the sources are lifted from the pool.

MATERIAL SECURITY

In January 2009, the NRC deployed its National Source Tracking System (NSTS), by which the agency and its Agreement States are tracking the manufacture, distribution, and ownership of the most high-risk sources. Licensees use the NSTS, a secure Web-based system, to enter up-to-date information on the receipt or transfer of tracked radioactive materials (see Figure 35).

Over the past several years, the NRC and the Agreement States have increased the controls they have imposed on the most sensitive radioactive materials, including physical security requirements and limited personnel access to the materials. Working with other Federal agencies, such as the U.S. Department of Homeland Security, the NRC has also implemented a voluntary program of additional security improvements. Together, these activities will make potentially dangerous radioactive sources even more secure and less vulnerable to terrorists.

Principal Licensing and Inspection Activities

Each year, the NRC issues approximately 2,700 new licenses, license renewals, and amendments for existing licenses.

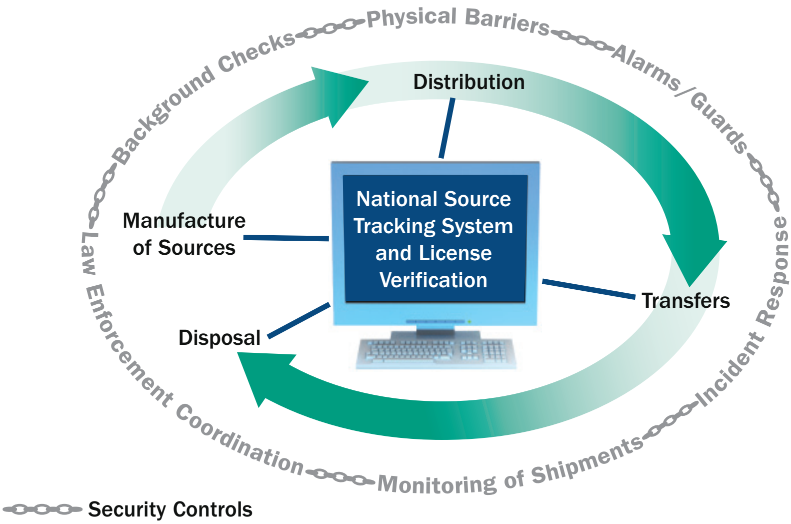
The NRC conducts approximately 1,250 health and safety and security inspections of its nuclear materials licensees each year.

URANIUM RECOVERY

To make fuel for reactors, uranium is recovered or extracted from the ore, converted, and enriched into fuel pellets.

A conventional uranium recovery facility is a chemical plant that

Figure 35. **Life Cycle Approach to Source Security**



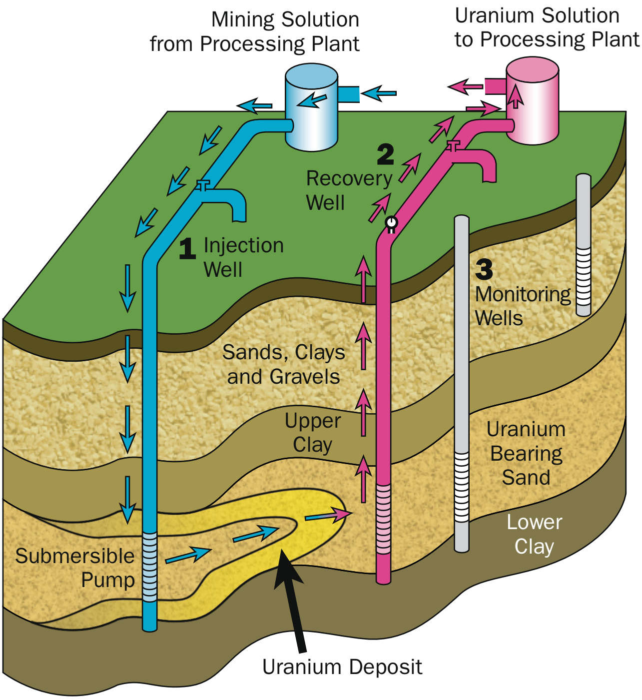
Source: U.S. Nuclear Regulatory Commission

extracts uranium from mined ore. The mined ore is transported to the uranium recovery facility, where it is crushed. Sulfuric acid then dissolves the soluble components, including 90 to 95 percent of the uranium, from the ore. The uranium is then separated from the solution. Conventional mills are typically located in areas of low population density, and they process ores from mines within about 50 kilometers (30 miles) of the facility. Remaining conventional uranium recovery facilities in the United States are on standby, with the potential to restart in the future.

In situ recovery (ISR) is another means of extracting uranium from underground ore. ISR facilities recover uranium from ores that may not be economically viable to recover by other methods. In this process, a solution of native groundwater typically mixed with oxygen or hydrogen peroxide and sodium bicarbonate, is injected through wells into the ore to dissolve the uranium. The resulting solution is pumped from the rock formation, and the uranium is then separated from the solution (see Figure 36). About 12 such ISR facilities exist in the United States. Of these, four are licensed by the NRC, and the rest are licensed by Agreement States (see Figure 37).

The NRC does not regulate traditional mining, but it does regulate the processing of uranium ore. It has jurisdiction over uranium recovery and in situ recovery facilities. In both processes, the final product of uranium recovering is "yellowcake," so named because of its yellowish color. The yellowcake is sent to a conversion facility for processing in the next step in the manufacture of nuclear fuel.

Figure 36. The In Situ Uranium Recovery Process

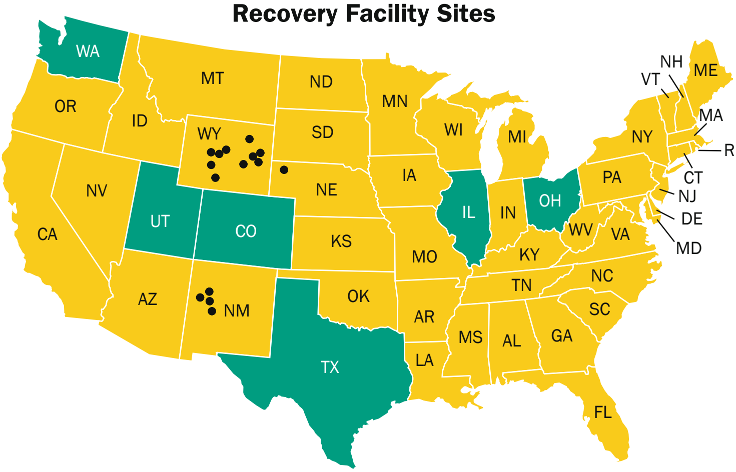


Injection wells (1) pump a chemical solution—typically sodium bicarbonate and oxygen—into the layer of earth containing uranium ore. The solution dissolves the uranium from the deposit in the ground and is then pumped back to the surface through **recovery wells** (2) and sent to the processing plant to be converted into uranium yellowcake. **Monitoring wells** (3) are checked regularly to ensure that uranium and chemicals are not escaping from the drilling area.

Source: U.S. Nuclear Regulatory Commission

Because of the resurgence of interest in the construction of new nuclear power plants, the agency anticipates as many as 24 applications for new uranium recovery facilities and several applications to expand or restart existing uranium recovery facilities in the next few years. As of April 2009, the agency had received five applications for new facilities and three applications to expand or restart an existing facility. The current status of applications can be found on the NRC's Web site (see Web Link Index). Existing facilities and new potential sites are located in Wyoming, New Mexico, Nebraska, South Dakota, and Arizona, and in the Agreement States of Texas, Colorado, and Utah (see Figure 37 and Table 12). The NRC works closely with stakeholders, including Native American Tribal Governments, to address concerns with the licensing of new uranium recovery facilities.

Figure 37. Locations of NRC-Licensed Uranium Recovery Facility Sites



● NRC-licensed uranium recovery facility sites

■ States with authority to license uranium recovery facility sites

■ States where the NRC has retained authority to license uranium recovery facilities

Source: U.S. Nuclear Regulatory Commission

Table 12. Locations of NRC-Licensed Uranium Recovery Facilities

LICENSEE	SITE NAME, LOCATION
In Situ Recovery Facilities	
Cogema Mining, Inc.°	Irigaray/Christensen Ranch, WY
Crow Butte Resources, Inc.	Crow Butte, NE
Hydro Resources, Inc.	Crownpoint, NM
Power Resources, Inc.	Smith Ranch and Highlands, WY*
Conventional Uranium Recovery Facilities	
American Nuclear Corp. †	Gas Hills, WY
Bear Creek Uranium Co. †	Bear Creek, WY
Exxon Mobil Corp. †	Highlands, WY
Homestake Mining Co. †	Homestake, NM
Kennecott Uranium Corp.	Sweetwater, WY
Pathfinder Mines Corp. †	Lucky Mc, WY
Pathfinder Mines Corp. †	Shirley Basin, WY
Rio Algom Mining, LLC †	Ambrosia Lake, NM
Umetco Minerals Corp.†	Gas Hills, WY
United Nuclear Corp. †	Church Rock, NM
Western Nuclear, Inc. †	Split Rock, WY

Note: The facilities listed are under the authority of the NRC.

* There are satellite facilities located within the State.

° Sites not currently operating

† Sites undergoing decommissioning

Source: U.S. Nuclear Regulatory Commission

The NRC has a well-established regulatory framework for ensuring that uranium recovery facilities are appropriately licensed, operated, decommissioned, and monitored to protect public health and safety. Through the regulatory framework, the NRC is responsible for the following:

- Inspecting and overseeing both active and inactive uranium recovery facilities
- Ensuring that siting and design features of tailings (waste) impoundments minimize disturbance by natural forces and minimize the release of radon (see Glossary)
- Developing comprehensive reclamation and decommissioning requirements to ensure adequate cleanup of active and formerly active uranium recovery facilities
- Formulating stringent financial requirements to ensure funds are available for decommissioning
- Monitoring adherence to requirements for below-grade disposal of mill tailings and liners for tailings impoundments (see Glossary)
- Ground water monitoring to prevent ground water contamination
- Long-term monitoring and oversight of decommissioned facilities

FUEL CYCLE FACILITIES

Anticipated growth in the nuclear industry has created renewed interest in the fuel cycle–the process of turning uranium into fuel for nuclear reactors. This process includes conversion of the uranium "yellowcake" into uranium hexafluoride (UF_6), enrichment of the uranium in the isotope U-235, and fabrication of the fuel. The NRC licenses and inspects all commercial nuclear fuel facilities involved in conversion, enrichment, and fuel fabrication (see Figures 38-40 and Table 13).

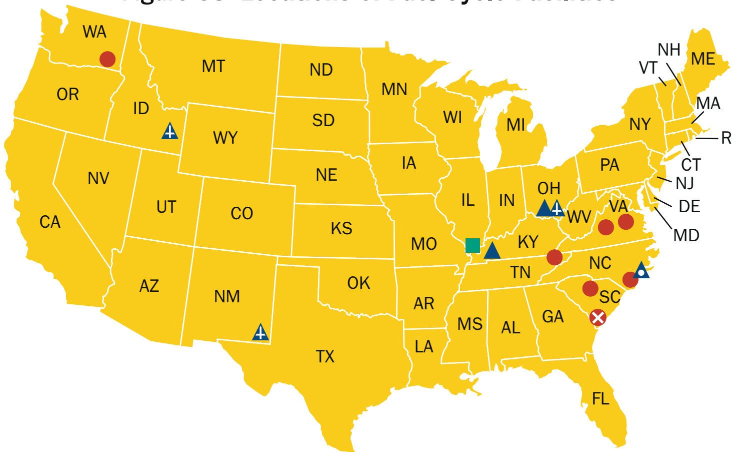
The NRC regulates one conversion facility, six enrichment facilities (two of which are under review), six fuel fabrication facilities, and one mixed oxide fuel fabrication facility.

Once nuclear fuel is fabricated and then used to generate nuclear energy, it becomes spent nuclear fuel. In the United States, spent nuclear fuel is stored securely either at a nuclear power plant or at a special storage facility away from a plant. Some countries reprocess their spent nuclear fuel to recover fissile material and use it to generate more energy. The NRC has completed an initial analysis of the existing regulatory framework to identify any gaps and possibly develop new regulations for reprocessing.

Domestic Safeguards Program

The NRC's domestic safeguards program for fuel cycle facilities and transportation is aimed at ensuring that special nuclear material (such

Figure 38. Locations of Fuel Cycle Facilities



- ■ Uranium Hexafluoride Conversion Facility (1)
- ● Uranium Fuel Fabrication Facility (6)
- ⊗ Mixed Oxide Fuel Fabrication Facility (1)
- ▲ Gaseous Diffusion Enrichment Facility (2)
- ▲ Gas Centrifuge Enrichment Facility (3)
- ▲ Laser Enrichment Facility (1)

Note: There are no fuel cycle facilities in Alaska or Hawaii.
Source: U.S. Nuclear Regulatory Commission

Table 13. Major U.S. Fuel Cycle Facility Sites

Licensee	Location	Status
Uranium Hexafluoride Conversion Facility		
Honeywell International, Inc.	Metropolis, IL	active
Uranium Fuel Fabrication Facilities		
Global Nuclear Fuels-Americas, LLC	Wilmington, NC	active
Westinghouse Electric Company, LLC Columbia Fuel Fabrication Facility	Columbia, SC	active
Nuclear Fuel Services, Inc.	Erwin, TN	active
AREVA NP, Inc. Mt. Athos Road Facility	Lynchburg, VA	active
B&W Nuclear Operations Group	Lynchburg, VA	active
AREVA NP, Inc.	Richland, WA	active
Mixed Oxide Fuel Fabrication Facilities		
Shaw AREVA MOX Services, LLC	Aiken, SC	in construction, operating license under review
Gaseous Diffusion Uranium Enrichment Facilities		
USEC Inc.	Paducah, KY	active
USEC Inc.	Piketon, OH*	in cold standby
Gas Centrifuge Uranium Enrichment Facilities		
USEC Inc.	Piketon, OH	in construction
Louisiana Energy Services	Eunice, NM	in construction
Areva Enrichment Services	Idaho Falls, ID	under review
Laser Enrichment Facility		
GE-Hitachi	Wilmington, NC	under review

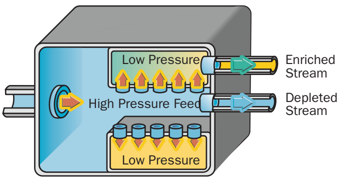
Note: The NRC regulates nine other facilities that possess significant quantities of special nuclear material (other than reactors) or process source material (other than uranium recovery facilities).

* Currently in cold shutdown and not used for enrichment.

Source: U.S. Nuclear Regulatory Commission

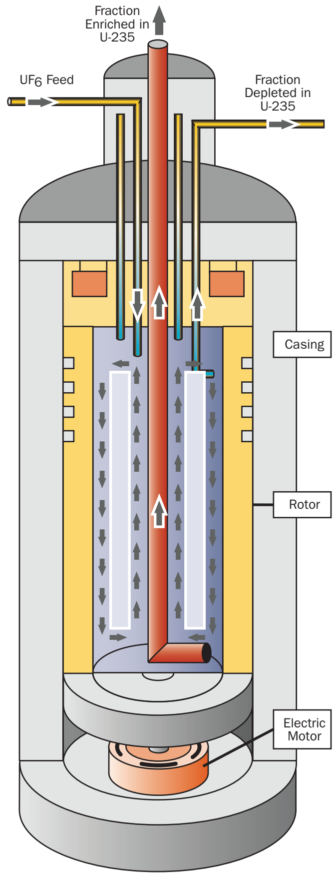
Figure 39. **Enrichment Processes**

A. Gaseous Diffusion Process



The gaseous diffusion process uses molecular diffusion to separate a gas from a two-gas mixture. The isotopic separation is accomplished by diffusing uranium, which has been combined with fluorine to form uranium hexafluoride (UF_6) gas, through a porous membrane (barrier) and using the different molecular velocities of the two isotopes to achieve separation.

B. Gas Centrifuge Process



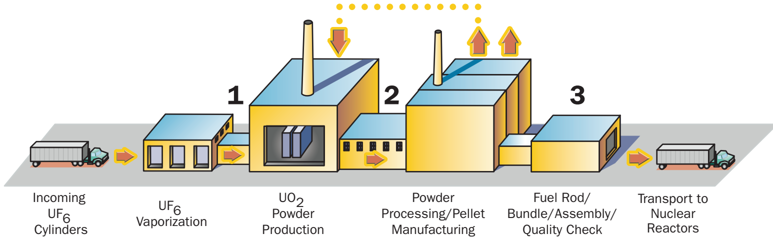
The gas centrifuge process uses a large number of rotating cylinders in series and parallel configurations. Gas is introduced and rotated at high speed, concentrating the component of higher molecular weight towards the outer wall of the cylinder and the lower molecular weight component toward the center. The enriched and the depleted gases are removed by scoops.

Source: U.S. Nuclear Regulatory Commission

as plutonium or enriched uranium) is not stolen for possible use in an improvised weapon. It also works to ensure that such material does not pose an unreasonable risk to the public from radiological sabotage.

The NRC verifies through licensing and inspection activities that licensees apply safeguards to protect special nuclear material. Additionally, the NRC and DOE developed the Nuclear Materials Management and Safeguards System (NMMSS) to track transfers and inventories of special nuclear material, source material from abroad, and other material.

Figure 40. **Simplified Fuel Fabrication Process**



Fabrication is the final step in the process used to produce uranium fuel. Fuel fabrication facilities mechanically and chemically process the enriched uranium into nuclear reactor fuel.

Fabrication begins with the conversion of enriched UF_6 gas to a uranium dioxide (UO_2) solid. Nuclear fuel must maintain both its chemical and physical properties under the extreme conditions of heat and radiation present inside an operating reactor vessel. Fabrication of commercial light-water reactor fuel consists of the following three basic steps:

(1) the chemical conversion of UF_6 to UO_2 powder

(2) a ceramic process that converts UO_2 powder to small ceramic pellets

(3) a mechanical process that loads the fuel pellets into rods and constructs finished fuel assemblies

After the UF_6 is chemically converted to UO_2, the powder is blended, milled, and pressed into ceramic fuel pellets about the size of a fingertip. The pellets are stacked into long tubes made of material called "cladding" (such as zirconium alloys). After careful inspection, the resulting fuel rods are bundled into fuel assemblies for use in reactors. The cladding material provides one of several barriers to contain the radioactive fission products produced during the nuclear chain reaction.

Following final assembly operations, the completed fuel assembly, about 3.7 meters (12 feet) long, is washed, inspected, and finally stored in a special rack until it is ready for shipment to a nuclear power plant site.

Source: U.S. Nuclear Regulatory Commission

The NRC has issued licenses to approximately 180 facilities authorizing them to possess special nuclear material in quantities ranging from a single kilogram to multiple tons. These licensees verify and document their inventories in the NMMSS database. There are several hundred additional sites licensed by the NRC or State governments that possess special nuclear material in smaller quantities (typically ranging from one gram to tens of grams).

Licensees who possess small amounts of special nuclear material are now required to confirm their inventory annually in the NMMSS database. Previously, those licensees reported transfers of material but not annual inventories.

Principal Licensing and Inspection Activities

On average, the NRC completes approximately 80 new licenses, license renewals, license amendments, and safety and safeguards reviews for fuel cycle facilities annually.

The NRC routinely conducts safety, safeguards, and environmental protection inspections at all fuel cycle facilities.

Empty storage/transport container for radioactive waste delivered at a reactor site.

RADIOACTIVE WASTE

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

Low-level radioactive waste (LLW) includes items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. This waste typically consists of contaminated protective shoe covers and clothing, wiping rags, mops, filters, reactor water treatment residues, equipment and tools, medical tubes, swabs, injection needles, syringes, and laboratory animal carcasses and tissue.

The radioactivity can range from just-above-background levels found in nature to very high levels from the parts inside the reactor vessel in a nuclear power plant. Lower-level radioactive waste is stored onsite by licensees until it has decayed away. Then it can be disposed of as ordinary trash. Waste that does not decay is stored until amounts are large enough for shipment to a low-level radioactive waste disposal site in containers approved by the U.S. Department of Transportation or the U.S. Nuclear Regulatory Commission (NRC).

Commercial LLW is disposed of in facilities licensed by either the NRC or Agreement States in accordance with health and safety requirements. The facilities are designed, constructed, and operated to meet safety standards. The operator of the facility also extensively characterizes the site on which the facility is located and analyzes how the facility will perform in the future.

Current LLW disposal uses shallow land disposal sites with or without concrete vaults. The low-level radioactive waste will sit there safely for thousands of years.

The NRC has developed a classification system for low-level radioactive waste based on its potential hazards. It has specified disposal and waste requirements for each of the three classes of waste–Class A, B, and C–that are acceptable for disposal in near-surface facilities. These classes have progressively higher levels of concentrations of radioactive material, with A having the lowest and C having the highest level. Class A waste accounts for approximately 96 percent of the total volume of low-level radioactive waste. Determination of the classification of waste is a complex process. A fourth class of LLW, greater than Class C, is not generally acceptable for near-surface shallow depth disposal.

The volume and radioactivity of waste vary from year to year based on the types and quantities of waste shipped each year. Waste volumes currently include several million cubic feet each year from reactor facilities undergoing decommissioning and cleanup of contaminated sites.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 gave the States responsibility for the disposal of LLW. It authorized States to do the following:

- Form 10 regional compacts with each compact to establish an LLW disposal site (see Table 14).
- Exclude waste generated outside a compact.

Active licensed LLW disposal facilities include the following:

- **Barnwell,** located in Barnwell, SC–Previously, Barnwell accepted waste from all U.S. generators. As of July 2008, Barnwell only accepts waste from the Atlantic Compact States (Connecticut, New Jersey, and South Carolina). The State of South Carolina licenses Barnwell to receive all classes of LLW.
- **EnergySolutions,** located in Clive, UT–EnergySolutions accepts waste from all regions of the United States. The State of Utah licenses EnergySolutions for Class A waste only.
- **Hanford,** located in Hanford, WA–Hanford accepts waste

Table 14. U.S. Low-Level Radioactive Waste Compacts

Compact	States
Appalachian	Delaware Maryland Pennsylvania West Virginia
Atlantic	Connecticut New Jersey South Carolina*
Central	Arkansas Kansas Louisiana Oklahoma
Central Midwest	Illinois Kentucky
Midwest	Indiana Iowa Minnesota Missouri Ohio Wisconsin
Northwest	Alaska Hawaii Idaho Montana Oregon Utah* Washington* Wyoming
Rocky Mountain (Northwest accepts Rocky Mountain waste as agreed between Compacts)	Colorado Nevada New Mexico
Southeast	Alabama Florida Georgia Mississippi Tennessee Virginia
Southwestern	Arizona California North Dakota South Dakota
Texas	Texas Vermont
Unaffiliated	District of Columbia Maine Massachusetts Michigan Nebraska New Hampshire New York North Carolina Puerto Rico Rhode Island

Note: Data as of April 2009

*Site of an active LLW disposal facility.

Source: U.S. Nuclear Regulatory Commission

from the Northwest and Rocky Mountain compacts. The State of Washington licenses Hanford to receive all classes of LLW.

Closed LLW disposal facilities:

- Beatty, NV, closed 1993
- Sheffield, IL, closed 1978
- Maxey Flats, KY, closed 1977
- West Valley, NY, closed 1975

HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT

Spent Nuclear Fuel Storage

A survey conducted by the U.S. Energy Information Administration in 2002 found that U.S. commercial nuclear power plants were storing approximately 46,000 metric tons of spent nuclear fuel onsite. By early 2009, the amount of commercial spent fuel in storage at commercial nuclear power plants had grown to an estimated 60,000 metric tons. The amount of spent fuel in storage at individual commercial nuclear power plants is increasing at a rate of approximately 2,000 metric tons per year. As with all civilian uses of nuclear materials, the NRC licenses and regulates the storage of spent fuel, both at commercial nuclear power plants and at storage facilities located away from reactors.

Commercial spent nuclear fuel is currently being stored in 35 States (see Figure 41 and Table 15). This includes 31 States with operating nuclear power reactors, where spent fuel is being stored onsite in spent fuel pools and in dry casks. The remaining four States–Colorado, Idaho, Maine, and Oregon–do not have operating power reactors but are also storing spent fuel at storage facilities.

Congress established the Nuclear Waste Fund to pay for the disposal of spent nuclear fuel. Nuclear power utilities pay 1/10th of a cent per kilowatthour of nuclear-generated electricity into the fund. (A kilowatthour is the amount of electricity needed to run 10 100-watt light bulbs for an hour.) This cost is typically passed on to the consumer. Each year, Congress appropriates money from the Nuclear Waste Fund for the repository program. As of December 31, 2008, payments and interest credited to the fund totaled $16 billion.

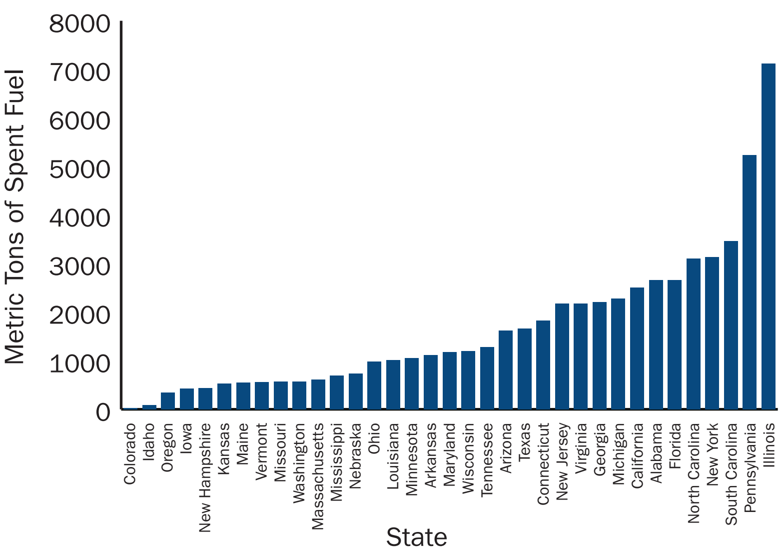
Most reactor facilities were not designed to store the full amount of spent fuel that the reactor would generate during its operational life. Facilities originally planned to store spent fuel temporarily in deep pools of continuously circulating water that cool the spent fuel assemblies and provide shielding from radiation. After a few years, the facilities expected to send the spent fuel to a recycling plant. However, the Federal Government declared a moratorium on recycling spent fuel in 1977. Although the ban was later lifted, recycling was not pursued. To cope with the spent fuel they were generating, facilities expanded their storage capacity by using high-density storage racks in their spent fuel pools (see Figure 42). However, spent fuel pools are not a permanent storage solution.

To supplement storage of spent fuel, some licensees have decided to store some portion of their spent fuel inventories in dry casks onsite. These facilities are called independent spent fuel storage installations (ISFSI) and are licensed by the NRC. These large casks are typically made of leak-tight, welded, and bolted steel and concrete surrounded by another layer of steel or concrete. The spent fuel bundle sits in the center of the nested canisters in an inert gas. Dry cask storage shields people and the environment from radiation and keeps the spent fuel inside dry and nonreactive (see Figure 43).

The NRC authorizes storage of spent fuel at an ISFSI under two licensing options:

- Site-specific licensing
- General licensing

Figure 41. Storage of Commercial Spent Fuel by State through 2008



Note: Idaho is holding used fuel from Three Mile Island, Unit 2. Data are rounded up to the nearest 10 tons.
Source: ACI Nuclear Energy Solutions and U.S. Department of Energy (Updated May 2009)

RADIOACTIVE WASTE

Table 15. **Commercial Nuclear Spent Fuel and Payments to the Nuclear Waste Fund by State**

State	Metric Tons of Uranium	Nuclear Waste Fund Contributions ($ M)
Alabama	2,660	719.2
Arizona	1,620	508.7
Arkansas	1,120	285.6
California	2,510	795.7
Colorado	30	0.2
Connecticut	1,830	353.0
Florida	2,660	743.4
Georgia	2,210	662.3
Idaho	90	NA*
Illinois	7,120	1,706.9
Iowa	430	108.7
Kansas	530	180.9
Louisiana	1,010	309.5
Maine	550	65.5
Maryland	1,180	343.5
Massachusetts	610	156.8
Michigan	2,280	503.0
Minnesota	1,060	375.9
Mississippi	690	194.0
Missouri	570	187.3
Nebraska	740	252.5
New Hampshire	440	146.3
New Jersey	2,180	574.8
New York	3,130	762.9
North Carolina	3,100	801.7
Ohio	980	287.5
Oregon	350	75.5
Pennsylvania	5,240	1,502.4
South Carolina	3,460	1,197.9
Tennessee	1,280	439.5
Texas	1,660	580.3
Vermont	560	89.8
Virginia	2,180	672.1
Washington	570	152.8
Wisconsin	1,200	344.2
Other	NA	7.6
Total	57,650	16,088.3

Note: Idaho is holding spent fuel from Three Mile Island, Unit 2.

Used fuel data are rounded up to the nearest 10 tons and are current as of January 2008. Nuclear waste fund contributions are current as of September 2008.

*NA: not available

Source: ACI Nuclear Energy Solutions and U.S. Department of Energy

Currently, there are 54 licensed ISFSIs in the United States (see Figure 44). As of 2009, NRC-licensed ISFSIs were storing spent fuel in over 1,100 loaded dry casks. To meet storage needs, the use of ISFSIs has increased and is expected to continue to grow (see Figure 45).

To obtain a site-specific license, an applicant submits a license application to the NRC, which performs a technical review of the safety aspects of the proposed ISFSI. If the agency finds that the ISFSI is safe, it approves the application and issues a license. A spent fuel storage license contains technical requirements and operating conditions for the ISFSI and specifies what the licensee is authorized to store at the site. The license term for an ISFSI is 20 years from the date of issuance. However, licenses may be renewed, and the Commission has approved 40-year renewals.

A general license from the NRC authorizes a licensee who operates a nuclear power reactor to store spent fuel onsite in dry storage casks. The NRC documents its approval by issuing a certificate of compliance to the cask vendor through rulemaking. Several dry storage cask designs have received certificates. Refer to Appendix H for a list of dry spent fuel storage systems that are approved for use with a general license.

The general license terminates 20 years after the date that the cask is first used for storage. If the NRC renews the cask's certificate, the general license terminates 20 years after the certificate renewal date. Thirty days before the certificate expiration date, the cask vendor may apply for reapproval. In the event that the cask vendor does not apply for reapproval, a general licensee may apply for reapproval.

Before using the cask, general licensees must perform written evaluations that establish that the cask meets the conditions in the certificate, that the concrete pads underneath the casks can adequately support the static and dynamic loads, and that the level of radioactive materials in effluents and the direct radiation meets NRC standards.

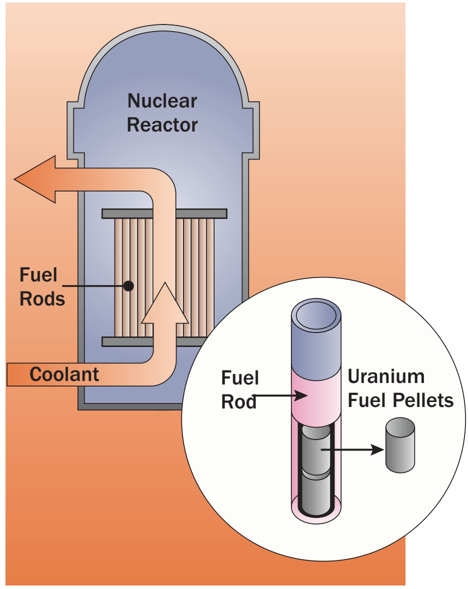
The public can participate in decisions about spent fuel storage, as they can in many licensing and rulemaking decisions. The Atomic Energy Act of 1954, as amended, and the NRC's own regulations, provide the opportunity for public hearings for site-specific licensing actions and allow for public comments on certificate rulemakings. Interested members of the public may also file petitions for rulemaking.

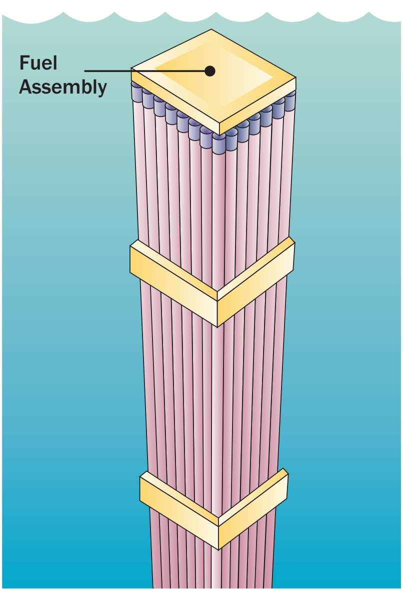
Appendix I lists dry spent fuel storage licensees.

Additional information on ISFSIs is available on the NRC Web site (see Web Link Index).

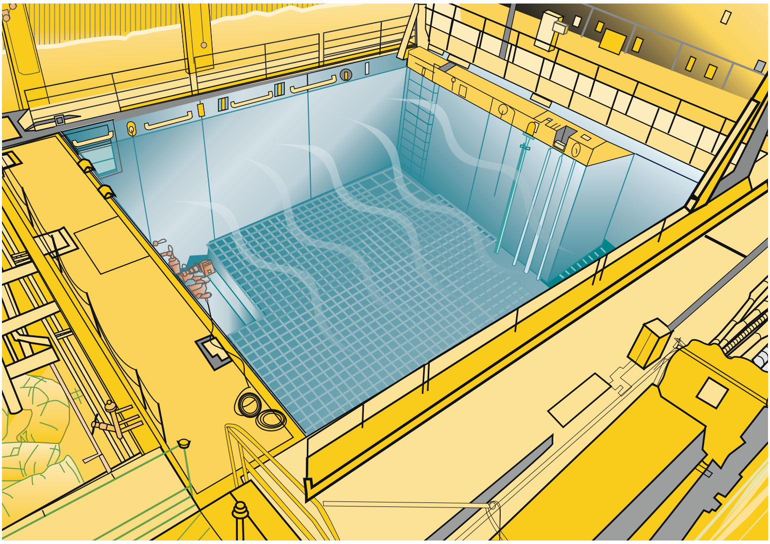
Figure 42. Spent Fuel Generation and Storage after Use

1 A nuclear reactor is powered by enriched uranium-235 fuel. Fission (splitting of atoms) generates heat, which produces steam that turns turbines to produce electricity. A reactor rated at several hundred megawatts may contain 100 or more tons of fuel in the form of bullet-sized pellets loaded into long metal rods that are bundled together into fuel assemblies. Pressurized-water reactors (PWRs) contain between 150–200 fuel assemblies. Boiling-water reactors (BWRs) contain between 370–800 fuel assemblies.

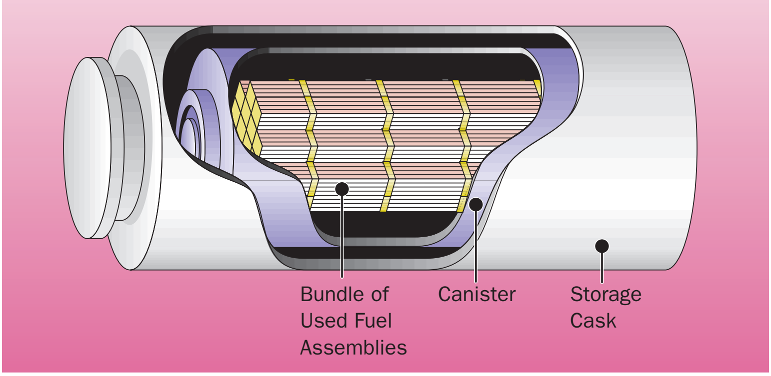




2 After about 6 years, spent fuel assemblies—typically 14 feet (4.3 meters) long and containing nearly 200 fuel rods for PWRs and 80–100 fuel rods for BWRs—are removed from the reactor and allowed to cool in storage pools for a few years. At this point, the 900-pound (40.8 kilograms) assemblies contain only about one-fifth the original amount of uranium-235.



3 Commercial light-water nuclear reactors store spent radioactive fuel in a steel-lined, seismically designed concrete pool under about 40 feet (12.2 meters) of water that provides shielding from radiation. Water pumps supply continuously flowing water to cool the spent fuel. Extra water for the pool is provided by other pumps that can be powered from an onsite emergency diesel generator. Support features, such as water-level monitors and radiation detectors, are also in the pool. Spent fuel is stored in the pool until it can be transferred to dry casks onsite (as shown in Figure 43) or transported offsite to a high-level radioactive waste disposal site.

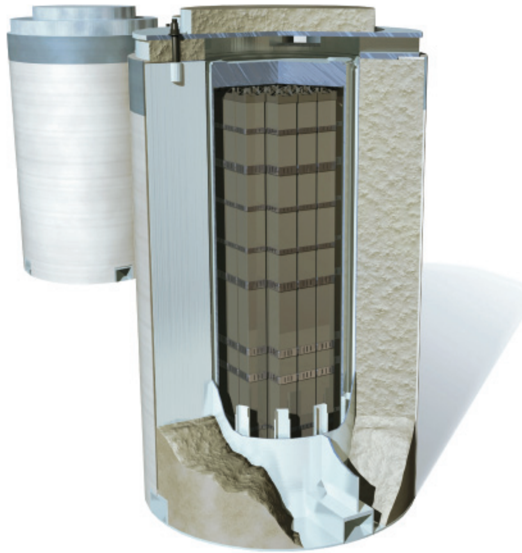


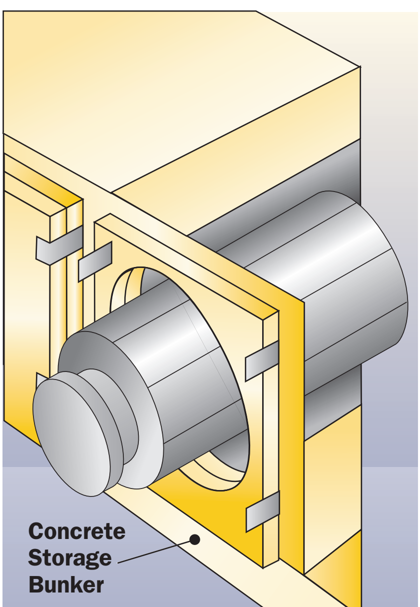
Source: U.S. Department of Energy and the Nuclear Energy Institute

Figure 43. **Dry Storage of Spent Nuclear Fuel**

At some nuclear reactors across the country, spent fuel is kept onsite, typically above ground, in systems basically similar to the ones shown here.

1 Once the spent fuel has cooled, it is loaded into special canisters that are designed to hold nuclear fuel assemblies. Water and air are removed. The canister is filled with inert gas, welded shut, and rigorously tested for leaks. It is then placed in a cask for storage or transportation. The NRC has approved the storage of up to 40 pressurized-water reactor assemblies and up to 68 boiling-water reactor assemblies in each canister. The dry casks are then loaded onto concrete pads.

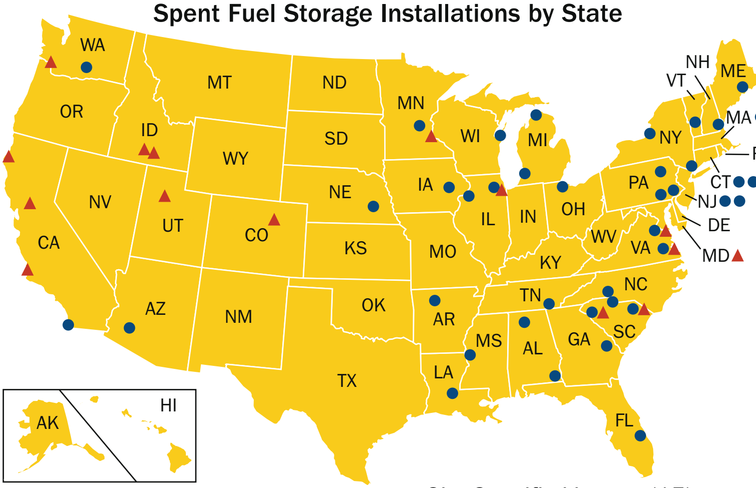




2 The canisters can also be stored in aboveground concrete bunkers, each of which is about the size of a one-car garage.

Source: U.S. Nuclear Regulatory Commission

Figure 44. Licensed/Operating Independent Spent Fuel Storage Installations by State



▲ Site-Specific License (15)
● General License (39)

33 States have at least one ISFSI

ALABAMA
- ● Browns Ferry
- ● Farley

ARIZONA
- ● Palo Verde

ARKANSAS
- ● Arkansas Nuclear

CALIFORNIA
- ▲ Diablo Canyon
- ▲ Rancho Seco
- ● San Onofre
- ▲ Humboldt Bay

COLORADO
- ▲ Fort St. Vrain

CONNECTICUT
- ● Haddam Neck
- ● Millstone

FLORIDA
- ● St. Lucie

GEORGIA
- ● Hatch

IDAHO
- ▲ DOE: TMI-2 (Fuel Debris)
- ▲ Idaho Spent Fuel Facility

ILLINOIS
- ▲ GE Morris (Wet)
- ● Dresden
- ● Quad Cities

IOWA
- ● Duane Arnold

LOUISIANA
- ● River Bend

MAINE
- ● Maine Yankee

MARYLAND
- ▲ Calvert Cliffs

MASSACHUSETTS
- ● Yankee Rowe

MICHIGAN
- ● Big Rock Point
- ● Palisades

MINNESOTA
- ● Monticello
- ▲ Prairie Island

MISSISSIPPI
- ● Grand Gulf

NEBRASKA
- ● Ft. Calhoun

NEW HAMPSHIRE
- ● Seabrook

NEW JERSEY
- ● Hope Creek/Salem
- ● Oyster Creek

NEW YORK
- ● Indian Point
- ● FitzPatrick

NORTH CAROLINA
- ● McGuire

OHIO
- ● Davis-Besse

OREGON
- ▲ Trojan

PENNSYLVANIA
- ● Limerick
- ● Susquehanna
- ● Peach Bottom

SOUTH CAROLINA
- ● ▲ Oconee
- ● ▲ Robinson
- ● Catawba

TENNESSEE
- ● Sequoyah

UTAH
- ▲ Private Fuel Storage

VERMONT
- ● Vermont Yankee

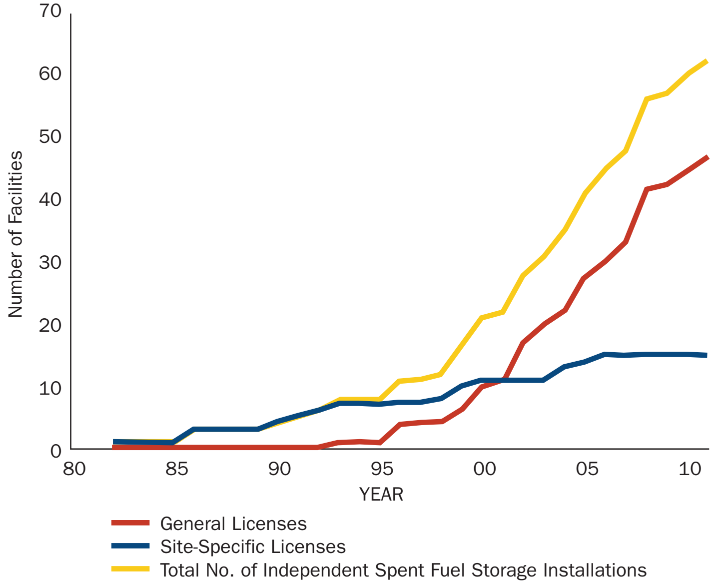
VIRGINIA
- ● ▲ Surry
- ● ▲ North Anna

WASHINGTON
- ● Columbia

WISCONSIN
- ● Point Beach

Note: Data are current as of June 2009
NRC-abbreviated unit names used
Source: U.S. Nuclear Regulatory Commission

Figure 45. Independent Spent Fuel Storage Installation Growth with Time



Source: U.S. Nuclear Regulatory Commission

Proposed Yucca Mountain Repository

U.S. policies governing permanent disposal of high-level radioactive waste (HLW) are defined by the Nuclear Waste Policy Act of 1982, as amended, and the Energy Policy Act of 1992. These acts specify that high-level radioactive waste will be disposed of underground, in a deep geologic repository. The Nuclear Waste Policy Act of 1982, amended in 1987, names Yucca Mountain, a high ridge in the Nevada desert, as the single candidate site for this potential geologic repository (see Figure 46).

Three Federal agencies perform key roles in the disposal of spent nuclear fuel and other HLW.

- The U.S. Department of Energy (DOE) is charged with constructing and operating a repository for spent fuel and other HLW.
- The U.S. Environmental Protection Agency (EPA) issues environmental standards that the NRC will use to evaluate the safety of a geologic repository.
- The NRC issues regulations that implement the EPA's standards. It also reviews the DOE application and decides whether to license the proposed repository. If the NRC grants the license, it must ensure that DOE safely constructs, operates, and eventually closes the repository.

The DOE submitted its license application to the NRC on June 3, 2008. The NRC formally accepted it for review in September 2008. In early 2009, the administration of President Barack Obama announced that it would terminate the Yucca Mountain program, while developing a disposal alternative. However, the administration indicated that the NRC licensing review of DOE's application should continue. Accordingly, the agency is proceeding with its safety and environmental reviews, as well as adjudicatory hearings, on nearly 300 contentions raised by the State of Nevada and seven other parties.

Decisions about licensing a geologic repository will occur in the following three phases:

(1) Licensing repository construction

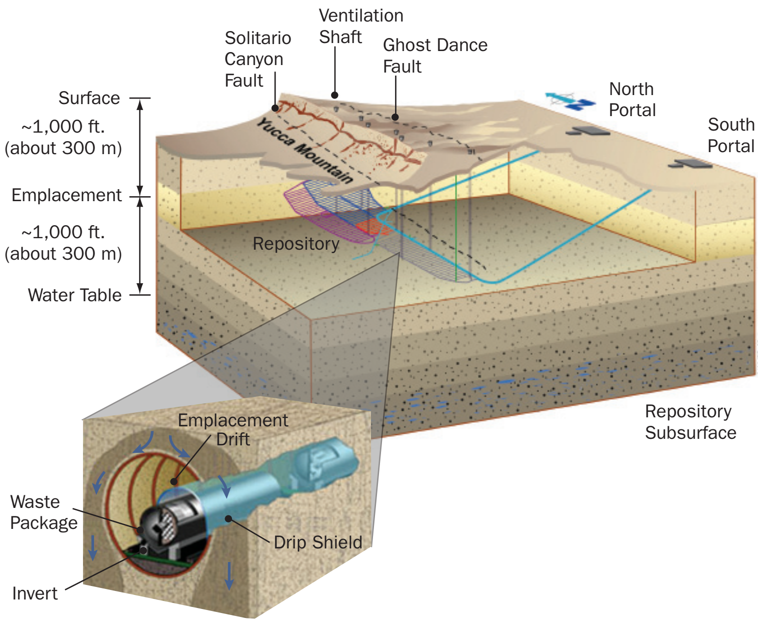
(2) Licensing the opening of the constructed repository

(3) Licensing closing or decommissioning once the repository is full

In the first phase, the NRC is to complete its safety review, conduct a public hearing before an independent licensing board, and decide whether to authorize construction of the repository.

Should the NRC authorize construction, the process enters the

Figure 46. Proposed Yucca Mountain Repository



This cutaway image of Yucca Mountain details its planned network of repository surface facilities, ramps, tunnels, and cask emplacement.

Source: U.S. Department of Energy

RADIOACTIVE WASTE

second phase. As construction of the repository nears completion, DOE must update its license application. The NRC must again complete a safety review and would conduct a public hearing before a licensing board in order to decide whether DOE can safely receive and dispose of waste at the repository. If the NRC grants the license to receive and possess HLW, DOE could begin placing HLW in the repository.

The third phase would begin once the repository becomes full. DOE would update its application again and apply for a license amendment to decommission repository surface facilities and permanently close the repository.

Information on HLW can be found on the NRC Web site (see Web Link Index).

TRANSPORTATION

About 3 million packages of radioactive materials are shipped each year in the United States, either by road, rail, air, or water. This represents less than 1 percent of the Nation's yearly hazardous material shipments. Regulating the safety of commercial radioactive material shipments is the joint responsibility of the NRC and the U.S. Department of Transportation (DOT).

Empty storage transport container on a semi tractor-trailer rig.

The vast majority of these shipments consist of small amounts of radioactive materials used in industry, research, and medicine. The NRC requires such materials to be shipped in accordance with DOT's hazardous materials transportation safety regulations.

The NRC is also involved in the transportation of spent nuclear fuel. The NRC establishes safety criteria for spent fuel shipping casks and certifies cask designs. Casks are designed to meet the following safety criteria under both normal and accident conditions:

- Prevent the loss or dispersion of radioactive contents
- Provide shielding and heat dissipation
- Prevent nuclear criticality (a self-sustaining nuclear chain reaction)

Spent fuel shipping casks must be designed to survive a sequence of tests, including a 30-foot (9-meter) drop onto an unyielding surface, a puncture test, and a fully engulfing fire of 1,475 degrees Fahrenheit (802 Celsius) for 30 minutes. This is a very severe test sequence akin to the cask striking a concrete pillar along a highway at a high speed and being engulfed in a very severe and long-lasting fire, and simulates conditions more severe than 99 percent of vehicle accidents.

Principal Licensing and Inspection Activities

The NRC conducts about 1,000 transportation safety inspections of fuel, reactor, and materials licensees annually.

The NRC reviews, evaluates, and certifies approximately 80 new, renewal, or amended package design applications for the transport of nuclear materials annually.

The NRC inspects about 20 dry storage and transport package licensees annually.

The NRC reviews and evaluates approximately 150 license applications for the import or export of nuclear materials annually.

Additional information on materials transportation is available on the NRC Web site (see Web Link Index).

DECOMMISSIONING

Decommissioning is the safe removal of a facility from service and the reduction of residual radioactivity to a level that permits release of the property and termination of the license. The NRC rules establish site-release criteria and provide for unrestricted and, under certain conditions, restricted release of a site.

The NRC regulates the decontamination and decommissioning of materials and fuel cycle facilities, nuclear power plants, research and test reactors, and uranium recovery facilities, with the ultimate goal of license termination. Approximately 200 materials licenses are terminated each year. Most of these license terminations are routine, and the sites require little, if any, remediation to meet the NRC's release criteria for unrestricted access. The decommissioning program focuses on the termination of licenses that are not routine because the sites involve more complex decommissioning activities.

As of June 30, 2009, there are 14 nuclear power reactors, 11 research and test reactors, 14 complex decommissioning materials facilities, 1 fuel cycle facility, and 11 uranium recovery facilities decommissioning or in safe storage under NRC jurisdiction. Table 16 and Appendices B and F list complex decommissioning sites and permanently shutdown and decommissioning nuclear power, research, and test reactors. The 2008 annual report, NUREG-1814, Rev. 2, "Status of the NRC Decommissioning Program," provides additional information on the decommissioning programs of the NRC and Agreement States. More information is on the NRC Web site (see Web Link Index).

Table 16. **NRC-Regulated Complex Material Sites Undergoing Decommissioning**

Company	Location
AAR Manufacturing, Inc. (Brooks & Perkins)	Livonia, MI
ABC Labs	Columbia, MO
Army, Department of, Jefferson Proving Ground	Madison, IN
Babcock & Wilcox SLDA	Vandergrift, PA
ABB Prospects, Inc.	Windsor, CT
Fansteel, Inc.	Muskogee, OK
Kerr-McGee	Cimarron, OK
Mallinckrodt Chemical, Inc.	St. Louis, MO
NWI Breckenridge	Breckenridge, MI
Shieldalloy Metallurgical Corporation	Newfield, NJ
Stepan Chemical Corporation	Maywood, NJ
UNC Naval Products	New Haven, CT
West Valley Demonstration Project	West Valley, NY
Westinghouse Electric Corporation—Hematite	Festus, MO

Source: U.S. Nuclear Regulatory Commission

A security guard in a bullet-resistant enclosure at a nuclear power plant.

SECURITY AND EMERGENCY PREPAREDNESS

OVERVIEW

Nuclear security is a high priority for the U.S. Nuclear Regulatory Commission. For the last several decades, effective NRC regulation and strong partnerships with a variety of Federal, State, Tribal, and local authorities have ensured security at nuclear power plants across the country. In fact, nuclear plants are likely the best protected private sector facilities in the United States. However, given today's threat environment, the agency recognizes the need for continued vigilance and high levels of security.

In recent years, the NRC has undertaken many enhancements to bolster the security of the Nation's nuclear facilities and radioactive materials. Because nuclear power plants are inherently robust structures, these additional security upgrades largely focus on the following improvements:

- Well-trained and armed security officers
- High-tech equipment and physical barriers
- Greater standoff distances for vehicle checks
- Intrusion detection and surveillance systems
- Tested emergency preparedness and response plans
- Restrictive site access control, including background checks and fingerprinting

Additional layers of security are provided by coordinating and sharing threat information among the U.S. Department of Homeland Security, the U.S. Federal Bureau of Investigation, intelligence agencies, the U.S. Department of Defense, and local law enforcement.

FACILITIES SECURITY

Nuclear power plants and fuel fabrication facilities must be able to defend successfully against a set of hypothetical threats that the agency calls the design basis threat (DBT). These hypothetical adversaries include threats that challenge a plant's physical security, personnel security, and cyber security. The NRC does not make details of the DBT public due to security concerns. However, the agency continuously evaluates this set of hypothetical threats against real-world intelligence to ensure the agency remains current and prepared.

To test the adequacy of a nuclear power plant licensee's defenses against the DBT, the NRC conducts rigorous "force-on-force" inspections. During these inspections, exercises are conducted where a highly trained mock adversary force "attacks" a nuclear facility. Beginning in 2004, the NRC began conducting more challenging and realistic force-on-force exercises that also occur more frequently.

The NRC focuses considerable effort towards ensuring that facilities meet its security requirements. As part of the Reactor Oversight

Process, the NRC performs a baseline level of inspection at a plant. In 2000, NRC inspectors spent about 1,600 hours directly inspecting plant security (excluding force-on-force inspections). Today, highly qualified NRC inspectors spend more than 8,000 hours a year scrutinizing nuclear power plant security. Publicly available portions of the security-related inspection reports for 2008 can be found on the NRC Web site (see Web Link Index).

MATERIALS SECURITY

The security of radioactive materials is important for a number of reasons. For example, terrorists could use radioactive materials to make a radiological dispersal device such as a dirty bomb. The NRC works with its Agreement States, other Federal agencies, the International Atomic Energy Agency, and licensees to protect radioactive material from theft or diversion. The agency has made improvements and upgrades to the joint NRC-Department of Energy database that tracks the movement and location of certain forms and quantities of special nuclear material. In early 2009, the NRC deployed its new National Source Tracking System, designed to track the most risk-sensitive sources on a continual basis. Other improvements allow U.S. Customs and Border Protection agents to promptly validate whether radioactive materials coming into the United States are properly licensed by the NRC.

EMERGENCY PREPAREDNESS

Well-developed and practical emergency preparedness plans ensure that a nuclear power plant operator can protect public health and safety in the unlikely event of an emergency.

The NRC staff participates in emergency preparedness exercises, some of which include security and terrorism-based scenarios. As part of these exercises, the NRC works with licensees; Federal agencies; State, Tribal, and local officials; and first responders to form a coordinated system of emergency preparedness and response. This system includes public information, preparations for evacuation, instructions for sheltering, and other actions to protect the residents near nuclear power plants in the event of a serious incident.

As a condition of their license, operators of nuclear power plants develop and maintain effective emergency preparedness plans and procedures. The NRC inspects plants to ensure they are meeting security requirements for emergencies and evaluates the implementation of those requirements. In addition, the agency monitors certain performance indicators related to emergency preparedness. For increased confidence in public protection, the NRC inspects emergency preparedness requirements and evaluates their implementation. The agency also monitors performance indicators submitted by plants (see Figure 47).

The NRC assesses the ability of nuclear power plant operators to protect the public by requiring full-scale emergency preparedness exercises at least once every 2 years. These exercises maintain the skills of the emergency responders and identify and correct any weaknesses. The NRC and the Federal Emergency Management Agency evaluate the exercises. Between these 2-year exercises, nuclear power plant operators conduct additional emergency preparedness drills that NRC inspectors also evaluate.

Additional information on emergency preparedness is available on the NRC Web site (see Web Link Index).

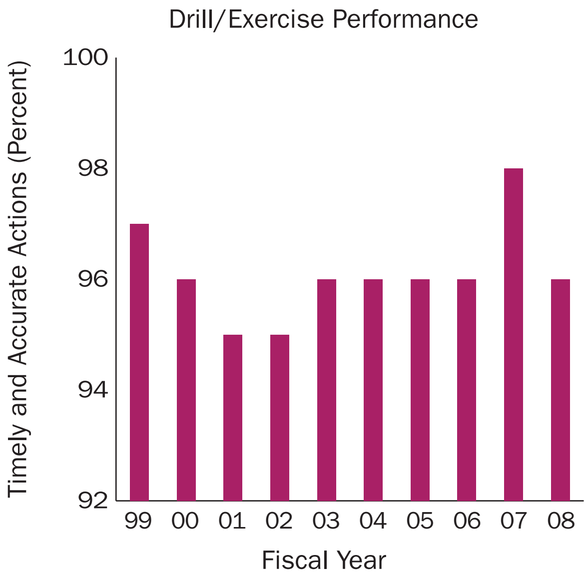
INCIDENT RESPONSE

Sharing information quickly among the NRC, other Federal agencies, and the nuclear industry is critical to responding promptly to any incident. The NRC staff supports several important Federal incident response centers for interagency coordinated assessments of event-related information. The NRC Headquarters Operations Center, located in the agency's headquarters in Rockville, MD, is staffed around the clock to disseminate information and coordinate responses. To ensure the timely distribution of threat information, the NRC continuously reviews intelligence and assesses suspicious activity.

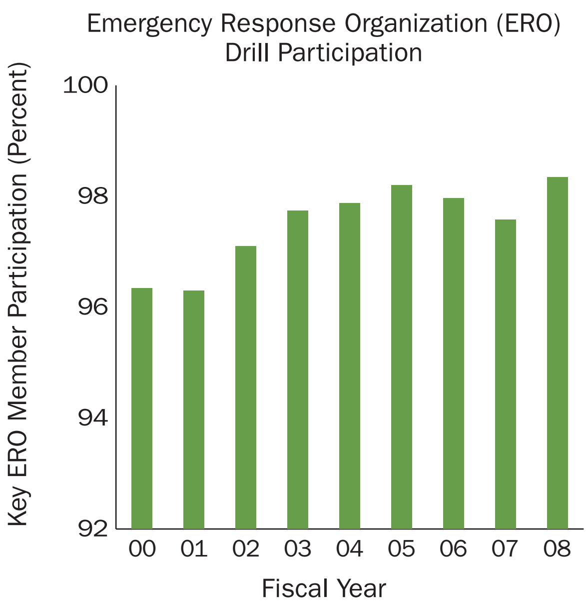
As described in the Federal National Response Framework, the NRC is the coordinating agency for events occurring at NRC-licensed facilities. In this role, the NRC has technical leadership for the Federal Government's response to an event.

During an exercise, the NRC staff briefs Commissioner Kristine L. Svinicki (center) on the current status.

Figure 47. **Industry Performance Indicators: Annual Industry Percentages, FYs 1999–2008**



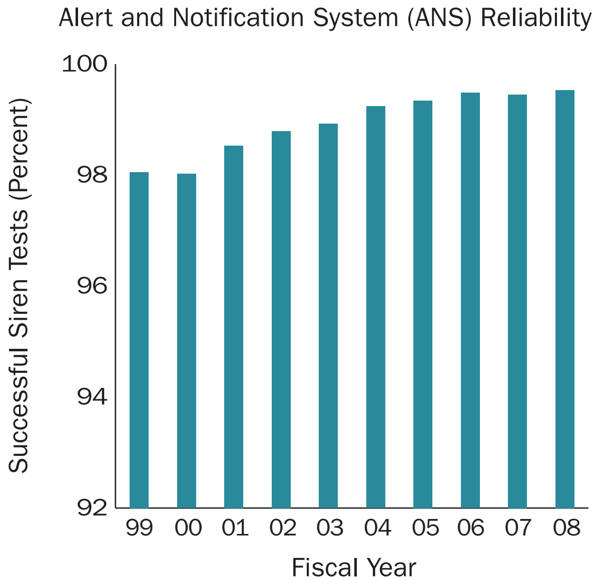
The percentage of timely and accurate actions taken by plant personnel (emergency classifications, Protective Action Recommendations, and notification to offsite authorities) in drills and actual events during the previous 2 years.



The percent of participation by key plant personnel in drills or actual events in the previous 2 years, indicating proficiency and readiness to respond to emergencies.

Note: Complete Fiscal Year 1999 data are not available.
Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

Figure 47. Industry Performance Indicators: Annual Industry Percentages, FYs 1999–2008 (Continued)



The percentage of ANS sirens that successfully operated during periodic tests in the previous year. The result is an indicator of the reliability of the ANS to alert the public in the event of an emergency.

Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

As the severity of an event worsens, the U.S. Department of Homeland Security coordinates the overall Federal response to the event.

In response to an incident involving possible releases of radioactive materials, the NRC activates its incident response program at its Headquarters Operations Center and one of its four regional incident response centers. Teams of specialists assemble at the centers to evaluate event information and assess the potential impact on public health and safety. The NRC staff provides expert consultation, support, and assistance to State and local public safety officials and keeps the public informed of agency actions. Scientists and engineers at the operations centers analyze the event and evaluate possible recovery strategies. Meanwhile, other experts evaluate the effectiveness of protective actions that the licensee has recommended that State and local officials implement. If needed, the NRC will dispatch a team of technical experts from the closest regional office to the site of the incident. Augmenting the NRC's resident inspector, who works onsite, the team serves as the agency's onsite eyes and ears, allowing a firsthand assessment and face-to-face communications with all participants. The Headquarters Operations Center continues to provide around the clock Federal communications, logistical support, and technical analysis throughout the response.

Additional information is available on incident response in NUREG-0728, Rev. 4, "NRC Incident Response Plan" (see Web Link Index).

Exercise Participation at NRC Headquarters Operations Center

Once every 2 years, each nuclear power plant performs a full-scale emergency exercise at the plant site. NRC headquarters participates in about four of these exercises a year.

R. William Borchardt, NRC Executive Director for Operations, addresses the NRC technical staff assigned to review the DOE Yucca Mountain license application at a routine technical meeting with the Center for Nuclear Waste Regulatory Analyses at Southwest Research Institute in San Antonio, TX.

APPENDICES

ABBREVIATIONS USED IN APPENDICES

AC	Allis Chalmers
AE	Architect-Engineer
AEC	Atomic Energy Commission (U.S.)
AI	Atomics International
B&R	Burns & Roe
B&W	Babcock & Wilcox
BECH	Bechtel
BLH	Baldwin Lima Hamilton
BRRT	Brown & Root
BWR	boiling-water reactor
CE	Combustion Engineering
COMM. OP.	date of commercial operation
CON TYPE	containment type
DRYAMB	dry, ambient pressure
DRYSUB	dry, subatmospheric
HTG	high-temperature gas-cooled
ICECND	wet, ice condenser
LMFB	liquid metal fast breeder
MARK 1	wet, Mark I
MARK 2	wet, Mark II
MARK 3	wet, Mark III
CP	construction permit
CP ISSUED	date of construction permit issuance
CVTR	Carolinas-Virginia Tube Reactor
CWE	Commonwealth Edison Company
DANI	Daniel International
DBDB	Duke & Bechtel
DOE	Department of Energy
DPR	demonstration power reactor
DUKE	Duke Power Company
EIA	Energy Information Administration (DOE)
EBSO	Ebasco
ERO	Emergency Response Organization
EVESR	ESADA (Empire States Atomic Development Associates) Vallecitos Experimental Superheat Reactor
EXP. DATE	expiration date of operating license
FBR	fast breeder reactor
FLUR	Fluor Pioneer
FR	Federal Register
FW	Foster Wheeler
FY	fiscal year
G&H	Gibbs & Hill
GA	General Atomic
GCR	gas-cooled reactor
GE	General Electric
GETR	General Electric Test Reactor
GHDR	Gibbs & Hill & Durham & Richardson
GIL	Gilbert Associates
GPC	Georgia Power Company
HTG	high-temperature, gas (reactor)
HWR	pressurized heavy-water reactor
INEEL	Idaho National Engineering and Environmental Laboratory
ISFSI	Independent Spent Fuel Storage Installation
JONES	J.A. Jones
KAIS	Kaiser Engineers
kW	Kilowatt
LLP	B&W Lowered Loop
LMFB	liquid metal fast breeder
LR ISSUED	License Renewal Issued
LWGR	graphite-moderated light-water reactor
MHI	Mitsubishi Heavy Industries, Ltd.
MW	megawatts
MWe	megawatts electrical
MWh	megawatthour
MWt	megawatts thermal
NIAG	Niagara Mohawk Power Corporation
NPF	nuclear power facility
NRC	U.S. Nuclear Regulatory Commission
NSP	Northern States Power Company
NSSS	nuclear steam system supplier & design type
GE 1	GE Type 1
GE 2	GE Type 2
GE 3	GE Type 3
GE 4	GE Type 4
GE 5	GE Type 5
GE 6	GE Type 6
WEST 2LP	Westinghouse Two-Loop
WEST 3LP	Westinghouse Three-Loop
WEST 4LP	Westinghouse Four-Loop

OCM organically cooled and moderated
OL operating license
OL ISSUED date of latest full power operating license
OL-FP operating license—full power
OL-LP operating license—low power
PG&E Pacific Gas & Electric Company
PHWR pressurized heavy-water-moderated and -cooled
PSE Pioneer Services & Engineering
PSEG Public Service Electric and Gas Company
PTHW pressure tube heavy water
PUBS Public Service Electric & Gas Company
PWR pressurized-water reactor
RLP B&W Raised Loop
S&L Sargent & Lundy
S&W Stone & Webster
SCF sodium-cooled fast (reactor)
SCGM sodium-cooled, graphite-moderated
SI systéme internationale (d'unités) (International System of Units)
SSI Southern Services Incorporated
STP South Texas Project
TNPG The Nuclear Power Group
TRIGA Training Reactor and Isotopes Production, General Atomics
TVA Tennessee Valley Authority
UE&C United Engineers & Constructors
USEC U.S. Enrichment Corporation
VBWR Vallecitos Boiling-Water Reactor
WDCO Westinghouse Development Corporation
WEST Westinghouse Electric
WMT waste management tank

State and Territory Abbreviations

State/Possession	Abbreviation
Alabama	AL
Alaska	AK
Arizona	AZ
Arkansas	AR
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
District of Columbia	DC
Florida	FL
Georgia	GA
Guam	GU
Hawaii	HI
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO

State/Possession	Abbreviation
Montana	MT
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Jersey	NJ
New Mexico	NM
New York	NY
North Carolina	NC
North Dakota	ND
Ohio	OH
Oklahoma	OK
Oregon	OR
Pennsylvania	PA
Puerto Rico	PR
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virgin Islands	VI
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY

APPENDIX A
U.S. Commercial Nuclear Power Reactors

Operating Reactors

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Arkansas Nuclear One, Unit 1 Entergy Operations, Inc. Russellville, AR (6 miles WNW of Russellville, AR) 050-00313 www.nrc.gov/info-finder/reactor/ano1.html	IV	PWR-DRYAMB B&W LLP BECH BECH	2,568 843	12/06/1968 05/21/1974 12/19/1974 06/20/2001 05/20/2034	92 92 78 102 94 83
Arkansas Nuclear One, Unit 2 Entergy Operations, Inc. Russellville, AR (6 miles WNW of Russellville, AR) 050-00368 www.nrc.gov/info-finder/reactor/ano2.html	IV	PWR-DRYAMB CE BECH BECH	3,026 995	12/06/1972 09/01/1978 03/26/1980 06/30/2005 07/17/2038	90 99 91 90 99 91
Beaver Valley Power Station, Unit 1 FirstEnergy Nuclear Operating Co. Shippingport, PA (17 miles W of McCandless, PA) 050-00334 www.nrc.gov/info-finder/reactor/bv1.html	I	PWR-DRYAMB WEST 3LP S&W S&W	2,900 892	06/26/1970 07/02/1976 10/01/1976 N/A 01/29/2016	83 93 101 78 95 101
Beaver Valley Power Station, Unit 2 FirstEnergy Nuclear Operating Co. Shippingport, PA (17 miles W of McCandless, PA) 050-00412 www.nrc.gov/info-finder/reactor/bv2.html	I	PWR-DRYAMB WEST 3LP S&W S&W	2,900 846	05/03/1974 08/14/1987 11/17/1987 N/A 05/27/2027	91 100 93 87 103 87
Braidwood Station, Unit 1 Exelon Generation Co., LLC Braceville, IL (20 miles SSW of Joilet, IL) 050-00456 www.nrc.gov/info-finder/reactor/brai1.html	III	PWR-DRYAMB WEST 4LP S&L CWE	3,586.6 1,178	12/31/1975 07/02/1987 07/29/1988 N/A 10/17/2026	97 95 100 96 92 101
Braidwood Station, Unit 2 Exelon Generation Co., LLC Braceville, IL (20 miles SSW of Joilet, IL) 050-00457 www.nrc.gov/info-finder/reactor/brai2.html	III	PWR-DRYAMB WEST 4LP S&L CWE	3,586.6 1,152	12/31/1975 05/20/1988 10/17/1988 N/A 12/18/2027	96 101 94 95 100 92
Browns Ferry Nuclear Plant, Unit 1 Tennessee Valley Authority Athens, AL (32 miles W of Huntsville, AL) 050-00259 www.nrc.gov/info-finder/reactor/bf1.html	II	BWR-MARK 1 GE 4 TVA TVA	3,458 1,065	05/10/1967 12/20/1973 08/01/1974 05/04/2006 12/20/2033	– – – – 49 88

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Browns Ferry Nuclear Plant, Unit 2 Tennessee Valley Authority † Athens, AL (32 miles W of Huntsville, AL) 050-00260 www.nrc.gov/info-finder/reactor/bf2.html	II	BWR-MARK 1 GE 4 TVA TVA	3,458 1,104	05/10/1967 08/02/1974 03/01/1975 05/04/2006 06/28/2034	86 100 90 94 78 98
Browns Ferry Nuclear Plant, Unit 3 Tennessee Valley Authority † Wheeler Lake, AL (10 miles SW of Athens, AL) 050-00296 www.nrc.gov/info-finder/reactor/bf3.html	II	BWR-MARK 1 GE 4 TVA TVA	3,458 1,115	07/31/1968 08/18/1976 03/01/1977 05/04/2006 07/02/2036	96 89 94 89 93 81
Brunswick Steam Electric Plant, Unit 1 Carolina Power & Light Co. Southport, NC (2 miles N of Southport, NC) 050-00325 www.nrc.gov/info-finder/reactor/bru1.html	II	BWR-MARK 1 GE 4 UE&C BRRT	2,923 938	02/07/1970 09/08/1976 03/18/1977 06/26/2006 09/08/2036	101 86 94 87 96 85
Brunswick Steam Electric Plant, Unit 2 Carolina Power & Light Co. Southport, NC (2 miles N of Southport, NC) 050-00324 www.nrc.gov/info-finder/reactor/bru2.html	II	BWR-MARK 1 GE 4 UE&C BRRT	2,923 937	02/07/1970 12/27/1974 11/03/1975 06/26/2006 12/27/2034	99 98 86 90 87 95
Byron Station, Unit 1 Exelon Generation Co., LLC Byron, IL (17 miles SW of Rockford, IL) 050-00454 www.nrc.gov/info-finder/reactor/byro1.html	III	PWR-DRYAMB WEST 4LP S&L CWE	3,586.6 1,164	12/31/1975 02/14/1985 09/16/1985 N/A 10/31/2024	94 102 94 91 98 95
Byron Station, Unit 2 Exelon Generation Co., LLC Byron, IL (17 miles SW of Rockford, IL) 050-00455 www.nrc.gov/info-finder/reactor/byro2.html	III	PWR-DRYAMB WEST 4LP S&L CWE	3,586.6 1,136	12/31/1975 01/30/1987 08/02/1987 N/A 11/06/2026	101 96 96 102 89 96
Callaway Plant Union Electric Co. Fulton, MO (25 miles ENE of Jefferson City, MO) 050-00483 www.nrc.gov/info-finder/reactor/call.html	IV	PWR-DRYAMB WEST 4LP BECH DANI	3,565 1,236	04/16/1976 10/18/1984 12/19/1984 N/A 10/18/2024	97 78 77 97 90 90

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Calvert Cliffs Nuclear Power Plant, Unit 1 Calvert Cliffs Nuclear Power Plant Inc. Lusby, MD (40 miles S of Annapolis, MD) 050-00317 www.nrc.gov/info-finder/reactor/calv1.html	I	PWR-DRYAMB CE BECH BECH	2,700 873	07/07/1969 07/31/1974 05/08/1975 03/23/2000 07/31/2034	102 92 100 84 99 93
Calvert Cliffs Nuclear Power Plant, Unit 2 Calvert Cliffs Nuclear Power Plant Inc. Lusby, MD (40 miles S of Annapolis, MD) 050-00318 www.nrc.gov/info-finder/reactor/calv2.html	I	PWR-DRYAMB CE BECH BECH	2,700 862	07/07/1969 08/13/1976 04/01/1977 03/23/2000 08/13/2036	82 100 94 98 90 99
Catawba Nuclear Station, Unit 1 Duke Energy Carolinas, LLC York, SC (18 miles S of Charlotte, NC) 050-00413 www.nrc.gov/info-finder/reactor/cat1.html	II	PWR-ICECND WEST 4LP DUKE DUKE	3,411 1,129	08/07/1975 01/17/1985 06/29/1985 12/05/2003 12/05/2043	83 98 93 82 102 89
Catawba Nuclear Station, Unit 2 Duke Energy Carolinas, LLC York, SC (18 miles S of Charlotte, NC) 050-00414 www.nrc.gov/info-finder/reactor/cat2.html	II	PWR-ICECND WEST 4LP DUKE DUKE	3,411 1,129	08/07/1975 05/15/1986 08/19/1986 12/05/2003 12/05/2043	94 89 102 89 84 103
Clinton Power Station, Unit 1 Exelon Generation Co., LLC Clinton, IL (6 miles E of Clinton, IL) 050-00461 www.nrc.gov/info-finder/reactor/clin.html	III	BWR-MARK 3 GE 6 S&L BALD	3,473 1,065	02/24/1976 04/17/1987 11/24/1987 N/A 09/29/2026	97 88 94 90 101 99
Columbia Generating Station Energy Northwest Richland, WA (12 miles NW of Richland, WA) 050-00397 www.nrc.gov/info-finder/reactor/wash2.html	IV	BWR-MARK 2 GE 5 B&R BECH	3,486 1,190	03/19/1973 04/13/1984 12/13/1984 N/A 12/20/2023	79 91 83 94 82 93
Comanche Peak Steam Electric Station, Unit 1 Luminant Generation Co., LLC Glen Rose, TX (4 miles N of Glen Rose, TX) 050-00445 www.nrc.gov/info-finder/reactor/cp1.html	IV	PWR-DRYAMB WEST 4LP G&H BRRT	3,612 1,200	12/19/1974 04/17/1990 08/13/1990 N/A 02/08/2030	101 90 92 102 85 96

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Comanche Peak Steam Electric Station, Unit 2 Luminant Generation Company, LLC Glen Rose, TX (4 miles N of Glen Rose, TX) 050-00446 www.nrc.gov/info-finder/reactor/cp2.html	IV	PWR-DRYAMB WEST 4LP BECH BRRT	3,458 1,150	12/19/1974 04/06/1993 08/03/1993 N/A 02/02/2033	83 99 92 95 102 95
Cooper Nuclear Station Nebraska Public Power District Brownville, NE (23 miles S of Nebraska City, NE) 050-00298 www.nrc.gov/info-finder/reactor/cns.html	IV	BWR-MARK 1 GE 4 B&R B&R	2,419 830	06/04/1968 01/18/1974 07/01/1974 N/A 01/18/2014	68 93 89 89 100 90
Crystal River Nuclear Generating Plant, Unit 3 Florida Power Corp. Crystal River, FL (80 miles N of Tampa, FL) 050-00302 www.nrc.gov/info-finder/reactor/cr3.html	II	PWR-DRYAMB B&W LLP GIL JONES	2,609 838	09/25/1968 12/03/1976 03/13/1977 N/A 12/03/2016	90 99 87 95 91 95
Davis-Besse Nuclear Power Station, Unit 1 FirstEnergy Nuclear Operating Co. Oak Harbor, OH (21 miles ESE of Toledo, OH) 050-00346 www.nrc.gov/info-finder/reactor/davi.html	III	PWR-DRYAMB B&W LLP BECH	2,817 893	03/24/1971 04/22/1977 07/31/1978 N/A 04/22/2017	(–0.9) 75 94 82 99 97
Diablo Canyon Nuclear Power Plant, Unit 1 Pacific Gas & Electric Co. Avila Beach, CA (12 miles WSW of San Luis Obispo, CA) 050-00275 www.nrc.gov/info-finder/reactor/diab1.html	IV	PWR-DRYAMB WEST 4LP PG&E PG&E	3,411 1,120	04/23/1968 11/02/1984 05/07/1985 N/A 11/02/2024	101 76 87 101 90 98
Diablo Canyon Nuclear Power Plant, Unit 2 Pacific Gas & Electric Co. Avila Beach, CA 12 miles WSW of San Luis Obispo, CA) 050-00323 www.nrc.gov/info-finder/reactor/diab2.html	IV	PWR-DRYAMB WEST 4LP PG&E PG&E	3,411 1,120	12/09/1970 08/26/1985 03/13/1986 N/A 08/20/2025	81 84 99 87 99 74
Donald C. Cook Nuclear Plant, Unit 1 Indiana Michigan Power Co. Stevensville, MI (11 miles S of Benton Harbor, MI) 050-00315 www.nrc.gov/info-finder/reactor/cook1.html	III	PWR-ICECND WEST 4LP AEP AEP	3,304 1,009	03/25/1969 10/25/1974 08/28/1975 N/A 10/25/2034	74 99 91 81 103 64

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Donald C. Cook Nuclear Plant, Unit 2 Indiana Michigan Power Co. Stevensville, MI (11 miles S of Benton Harbor, MI) 050-00316 www.nrc.gov/info-finder/reactor/cook2.html	III	PWR-ICECND WEST 4LP AEP AEP	3,468 1,060	03/25/1969 12/23/1977 07/01/1978 10/03/2005 12/23/2037	75 84 100 89 86 101
Dresden Nuclear Power Station, Unit 2 Exelon Generation Co., LLC Morris, IL (9 miles E of Morris, IL) 050-00237 www.nrc.gov/info-finder/reactor/dres2.html	III	BWR-MARK 1 GE 3 S&L UE&C	2,957 867	01/10/1966 02/20/1991 06/09/1970 10/28/2004 12/22/2029	90 78 87 96 92 98
Dresden Nuclear Power Station, Unit 3 Exelon Generation Co., LLC Morris, IL (9 miles E of Morris, IL) 050-00249 www.nrc.gov/info-finder/reactor/dres3.html	III	BWR-MARK 1 GE 3 S&L UE&C	2,957 867	10/14/1966 01/12/1971 11/16/1971 10/28/2004 01/12/2031	94 85 93 94 100 93
Duane Arnold Energy Center FPL Energy Duane Arnold, LLC Palo, IA (8 miles NW of Cedar Rapids, IA) 050-00331 www.nrc.gov/info-finder/reactor/duan.html	III	BWR-MARK 1 GE 4 BECH BECH	1,912 640	06/22/1970 02/22/1974 02/01/1975 N/A 02/21/2014	81 100 89 100 89 103
Edwin I. Hatch Nuclear Plant, Unit 1 Southern Nuclear Operating Co. Baxley, GA (20 miles S of Vidalia, GA) 050-00321 www.nrc.gov/info-finder/reactor/hat1.html	II	BWR-MARK 1 GE 4 BECH GPC	2,804 876	09/30/1969 10/13/1974 12/31/1975 01/15/2002 08/06/2034	95 90 91 84 98 84
Edwin I. Hatch Nuclear Plant, Unit 2 Southern Nuclear Operating Co. Baxley, GA (20 miles S of Vidalia, GA) 050-00366 www.nrc.gov/info-finder/reactor/hat2.html	II	BWR-MARK 1 GE 4 BECH GPC	2,804 883	12/27/1972 06/13/1978 09/05/1979 01/15/2002 06/13/2038	90 97 87 99 87 96
Fermi, Unit 2 The Detroit Edison Co. Newport, MI (25 miles NE of Toledo, OH) 050-00341 www.nrc.gov/info-finder/reactor/ferm2.html	III	BWR-MARK 1 GE 4 S&L DANI	3,430 1,122	09/26/1972 07/15/1985 01/23/1988 N/A 03/20/2025	83 87 90 76 85 98

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Fort Calhoun Station, Unit 1	IV	PWR-DRYAMB	1,500	06/07/1968	84
Omaha Public Power District		CE	482	08/09/1973	97
Ft. Calhoun, NE		GHDR		09/26/1973	70
(19 miles N of Omaha, NE)		GHDR		11/04/2003	74
050-00285				08/09/2033	104
www.nrc.gov/info-finder/reactor/fcs.html					83
Grand Gulf Nuclear Station, Unit 1	IV	BWR-MARK 3	3,898	09/04/1974	99
Entergy Nuclear Operations, Inc.		GE 6	1,297	11/01/1984	92
Port Gibson, MS		BECH		07/01/1985	91
(20 miles SW of Vicksburg, MS)		BECH		N/A	94
050-00416				11/01/2024	84
www.nrc.gov/info-finder/reactor/gg1.html					86
H.B. Robinson Steam Electric Plant, Unit 2	II	PWR-DRYAMB	2,339	04/13/1967	104
Carolina Power & Light Co.,		WEST 3LP	710	07/31/1970	92
Hartsville, SC		EBSO		03/07/1971	93
(26 miles NW of Florence, SC)		EBSO		04/19/2004	104
050-00261				07/31/2030	92
www.nrc.gov/info-finder/reactor/rob2.html					87
Hope Creek Generating Station, Unit 1	I	BWR-MARK 1	3,840	11/04/1974	79
PSEG Nuclear, LLC		GE 4	1,061	07/25/1986	65
Hancock Bridge, NJ		BECH		12/20/1986	83
(18 miles S of Wilmington, DE)		BECH		N/A	92
050-00354				04/11/2026	87
www.nrc.gov/info-finder/reactor/hope.html					108
Indian Point Nuclear Generating, Unit 2	I	PWR-DRYAMB	3,216	10/14/1966	99
Entergy Nuclear Operations, Inc.		WEST 4LP	1,020	09/28/1973	88
Buchanan, NY		UE&C		08/01/1974	99
(24 miles N of New York City, NY)		WDCO		N/A	89
050-00247				09/28/2013	99
www.nrc.gov/info-finder/reactor/ip2.html					91
Indian Point Nuclear Generating, Unit 3	I	PWR-DRYAMB	3,216	08/13/1969	88
Entergy Nuclear Operations, Inc.		WEST 4LP	1,025	12/12/1975	101
Buchanan, NY		UE&C		08/30/1976	90
(24 miles N of New York City, NY)		WDCO		N/A	100
050-00286				12/12/2015	87
www.nrc.gov/info-finder/reactor/ip3.html					107
James A. FitzPatrick Nuclear Power Plant	I	BWR-MARK 1	2,536	05/20/1970	96
Entergy Nuclear Operations, Inc.		GE 4	852	10/17/1974	87
Scriba, NY		S&W		07/28/1975	95
(6 miles NE of Oswego, NY)		S&W		08/08/2008	91
050-00333				10/17/2034	93
www.nrc.gov/info-finder/reactor/fitz.html					89

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Joseph M. Farley Nuclear Plant, Unit 1	II	PWR-DRYAMB	2,775	08/16/1972	91
Southern Nuclear Operating Co.		WEST 3LP	851	06/25/1977	86
Columbia, AL		SSI		12/01/1977	99
(18 miles S of Dothan, AL)		DANI		05/12/2005	86
050-00348				06/25/2037	88
www.nrc.gov/info-finder/reactor/far1.html					97
Joseph M. Farley Nuclear Plant, Unit 2	II	PWR-DRYAMB	2,775	08/16/1972	100
Southern Nuclear Operating Co.		WEST 3LP	860	03/31/1981	89
Columbia, AL		SSI		07/30/1981	84
(18 miles S of Dothan, AL)		BECH		05/12/2005	101
050-00364				03/31/2041	87
www.nrc.gov/info-finder/reactor/far2.html					90
Kewaunee Power Station	III	PWR-DRYAMB	1,772	08/06/1968	88
Dominion Energy Kewaunee, Inc.		WEST 2LP	556	12/21/1973	79
Kewaunee, WI		PSE		06/16/1974	63
27 miles ESE of Green Bay, WI		PSE		N/A	75
050-00305				12/21/2013	95
www.nrc.gov/info-finder/reactor/kewa.html					90
LaSalle County Station, Unit 1	III	BWR-MARK 2	3,489	09/10/1973	92
Exelon Generation Co., LLC		GE 5	1,118	04/17/1982	92
Marseilles, IL		S&L		01/01/1984	100
(11 miles SE of Ottawa, IL)		CWE		N/A	93
050-00373				04/17/2022	99
www.nrc.gov/info-finder/reactor/lasa1.html					100
LaSalle County Station, Unit 2	III	BWR-MARK 2	3,489	09/10/1973	91
Exelon Generation Co., LLC		GE 5	1,120	12/16/1983	101
Marseilles, IL		S&L		10/19/1984	91
(11 miles SE of Ottawa, IL)		CWE		N/A	102
050-00374				12/16/2023	95
www.nrc.gov/info-finder/reactor/lasa2.html					94
Limerick Generating Station, Unit 1	I	BWR-MARK 2	3,458	06/19/1974	101
Exelon Generation Co., LLC		GE 4	1,134	08/08/1985	95
Limerick, PA		BECH		02/01/1986	99
(21 miles NW of Philadelphia, PA)		BECH		N/A	93
050-00352				10/26/2024	101
www.nrc.gov/info-finder/reactor/lim1.html					95
Limerick Generating Station, Unit 2	I	BWR-MARK 2	3,458	06/19/1974	94
Exelon Generation Co., LLC		GE 4	1,134	08/25/1989	99
Limerick, PA		BECH		01/08/1990	91
(21 miles NW of Philadelphia, PA)		BECH		N/A	100
050-00353				06/22/2029	91
www.nrc.gov/info-finder/reactor/lim2.html					101

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
McGuire Nuclear Station, Unit 1 Duke Energy Carolinas, LLC Huntsville, NC (17 miles N of Charlotte, NC) 050-00369 www.nrc.gov/info-finder/reactor/mcg1.html	II	PWR-ICECND WEST 4LP DUKE DUKE	3,411 1,100	02/23/1973 07/08/1981 12/01/1981 12/05/2003 06/12/2041	103 85 93 103 79 87
McGuire Nuclear Station, Unit 2 Duke Energy Carolinas, LLC Huntsville, NC (17 miles N of Charlotte, NC) 050-00370 www.nrc.gov/info-finder/reactor/mcg2.html	II	PWR-ICECND WEST 4LP DUKE DUKE	3,411 1,100	02/23/1973 05/27/1983 03/01/1984 12/05/2003 03/03/2043	94 103 89 87 103 90
Millstone Power Station, Unit 2 Dominion Nuclear Connecticut, Inc. Waterford, CT (3.2 miles WSW of New London, CT) 050-00336 www.nrc.gov/info-finder/reactor/mill2.html	I	PWR-DRYAMB CE BECH BECH	2,700 884	12/11/1970 09/26/1975 12/26/1975 11/28/2005 07/31/2035	80 98 88 84 100 86
Millstone Power Station, Unit 3 Dominion Nuclear Connecticut, Inc. Waterford, CT (3.2 miles WSW of New London, CT) 050-00423 www.nrc.gov/info-finder/reactor/mill3.html	I	PWR-DRYSUB WEST 4LP S&W S&W	3,650 1,227	08/09/1974 01/31/1986 04/23/1986 11/28/2005 11/25/2045	101 88 86 100 86 88
Monticello Nuclear Generating Plant, Unit 1 Northern States Power Company Monticello, MN (35 miles NW of Minneapolis, MN) 050-00263 www.nrc.gov/info-finder/reactor/mont.html	III	BWR-MARK 1 GE 3 BECH BECH	1,775 572	06/19/1967 01/09/1981 06/30/1971 11/08/2006 09/08/2030	92 101 89 101 84 97
Nine Mile Point Nuclear Station, Unit 1 Nine Mile Point Nuclear Station, LLC Scriba, NY (6 miles NE of Oswego, NY) 050-00220 www.nrc.gov/info-finder/reactor/nmp1.html	I	BWR-MARK 1 GE 2 NIAG S&W	1,850 621	04/12/1965 12/26/1974 12/01/1969 10/31/2006 08/22/2029	80 92 85 98 88 98
Nine Mile Point Nuclear Station, Unit 2 Nine Mile Point Nuclear Station, LLC Scriba, NY (6 miles NE of Oswego, NY) 050-00410 www.nrc.gov/info-finder/reactor/nmp2.html	I	BWR-MARK 2 GE 5 S&W S&W	3,467 1,140	06/24/1974 07/02/1987 03/11/1988 10/31/2006 10/31/2046	96 86 100 90 92 90

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
North Anna Power Station, Unit 1 Virginia Electric & Power Co. Louisa, VA (40 miles NW of Richmond, VA) 050-00338 www.nrc.gov/info-finder/reactor/na1.html	II	PWR-DRYSUB WEST 3LP S&W S&W	2,893 903	02/19/1971 04/01/1978 06/06/1978 03/20/2003 04/01/2038	81 91 95 88 89 101
North Anna Power Station, Unit 2 Virginia Electric & Power Co. Louisa, VA (40 miles NW of Richmond, VA) 050-00339 www.nrc.gov/info-finder/reactor/na2.html	II	PWR-DRYSUB WEST 3LP S&W S&W	2,893 903	02/19/1971 08/21/1980 12/14/1980 03/20/2003 08/21/2040	90 92 87 100 85 82
Oconee Nuclear Station, Unit 1 Duke Energy Carolinas, LLC Seneca, SC (30 miles W of Greenville, SC) 050-00269 www.nrc.gov/info-finder/reactor/oco1.html	II	PWR-DRYAMB B&W LLP DBDB DUKE	2,568 846	11/06/1967 02/06/1973 07/15/1973 05/23/2000 02/06/2033	71 98 91 79 99 84
Oconee Nuclear Station, Unit 2 Duke Energy Carolinas, LLC Seneca, SC (30 miles W of Greenville, SC) 050-00270 www.nrc.gov/info-finder/reactor/oco2.html	II	PWR-DRYAMB B&W LLP DBDB DUKE	2,568 846	11/06/1967 10/06/1973 09/09/1974 05/23/2000 10/06/2033	102 76 90 100 91 86
Oconee Nuclear Station, Unit 3 Duke Energy Carolinas, LLC Seneca, SC (30 miles W of Greenville, SC) 050-00287 www.nrc.gov/info-finder/reactor/oco3.html	II	PWR-DRYAMB B&W LLP DBDB DUKE	2,568 846	11/06/1967 07/19/1974 12/16/1974 05/23/2000 07/19/2034	85 77 98 91 87 102
Oyster Creek Nuclear Generating Station Exelon Generation Co., LLC Forked River, NJ (9 miles S of Toms River, NJ) 050-00219 www.nrc.gov/info-finder/reactor/oc.html	I	BWR-MARK 1 GE 2 B&R B&R	1,930 619	12/15/1964 07/02/1991 12/01/1969 04/08/2009 04/09/2029	97 89 99 86 94 83
Palisades Nuclear Plant Entergy Nuclear Operations, Inc. Covert, MI (5 miles S of South Haven, MI) 050-00255 www.nrc.gov/info-finder/reactor/pali.html	III	PWR-DRYAMB CE BECH BECH	2,565 778	03/14/1967 03/24/1971 12/31/1971 01/17/2007 03/24/2031	95 92 79 98 86 99

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Palo Verde Nuclear Generating Station, Unit 1 Arizona Public Service Company Wintersburg, AZ (50 miles W of Phoenix, AZ) 050-00528 www.nrc.gov/info-finder/reactor/palo1.html	IV	PWR-DRYAMB CE80-2L BECH BECH	3,990 1,335	05/25/1976 06/01/1985 01/28/1986 N/A 06/01/2025	97 85 63 42 77 86
Palo Verde Nuclear Generating Station, Unit 2 Arizona Public Service Company Wintersburg, AZ (50 miles W of Phoenix, AZ) 050-00529 www.nrc.gov/info-finder/reactor/palo2.html	IV	PWR-DRYAMB CE80-2L BECH BECH	3,990 1,335	05/25/1976 04/24/1986 09/19/1986 N/A 04/24/2026	72 92 82 85 95 74
Palo Verde Nuclear Generating Station, Unit 3 Arizona Public Service Company Wintersburg, AZ (50 miles W of Phoenix, AZ) 050-00530 www.nrc.gov/info-finder/reactor/palo3.html	IV	PWR-DRYAMB COMB CE80-2L BECH BECH	3,990 1,335	05/25/1976 11/25/1987 01/08/1988 N/A 11/25/2027	88 75 84 86 64 97
Peach Bottom Atomic Power Station, Unit 2 Exelon Generation Co., LLC Delta, PA (17.9 miles S of Lancaster, PA) 050-00277 www.nrc.gov/info-finder/reactor/pb2.html	I	BWR-MARK 1 GE 4 BECH BECH	3,514 1,112	01/31/1968 10/25/1973 07/05/1974 05/07/2003 08/08/2033	95 91 98 93 101 89
Peach Bottom Atomic Power Station, Unit 3 Exelon Generation Co., LLC Delta, PA (17.9 miles S of Lancaster, PA) 050-00278 www.nrc.gov/info-finder/reactor/pb3.html	I	BWR-MARK 1 GE 4 BECH BECH	3,514 1,112	01/31/1968 07/02/1974 12/23/1974 05/07/2003 07/02/2034	91 102 91 102 93 99
Perry Nuclear Power Plant, Unit 1 FirstEnergy Nuclear Operating Co. Perry, OH (35 miles NE of Cleveland, OH) 050-00440 www.nrc.gov/info-finder/reactor/perr1.html	III	BWR-MARK 3 GE 6 GIL KAIS	3,758 1,235	05/03/1977 11/13/1986 11/18/1987 N/A 03/18/2026	79 94 71 97 75 98
Pilgrim Nuclear Power Station Entergy Nuclear Operations, Inc. Plymouth, MA (4 miles E of Plymouth, MA) 050-00293 www.nrc.gov/info-finder/reactor/pilg.html	I	BWR-MARK 1 GE 3 BECH BECH	2,028 685	08/26/1968 06/08/1972 12/01/1972 N/A 06/08/2012	83 99 91 97 85 97

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Point Beach Nuclear Plant, Unit 1 FPL Energy Point Beach, LLC Two Rivers, WI (13 miles NNW of Manitowoc, WI) 050-00266 www.nrc.gov/info-finder/reactor/poin1.html	III	PWR-DRYAMB WEST 2LP BECH BECH	1,540 512	07/19/1967 10/05/1970 12/21/1970 12/22/2005 10/05/2030	97 81 81 100 85 87
Point Beach Nuclear Plant, Unit 2 FPL Energy Point Beach, LLC Two Rivers, WI (13 miles NNW of Manitowoc, WI) 050-00301 www.nrc.gov/info-finder/reactor/poin2.html	III	PWR-DRYAMB WEST 2LP BECH BECH	1,540 514	07/25/1968 03/08/1973 10/01/1972 12/22/2005 03/08/2033	83 97 72 91 99 89
Prairie Island Nuclear Generating Plant, Unit 1 Northern States Power Co. Minnesota Welch, MN (28 miles SE of Minneapolis, MN) 050-00282 www.nrc.gov/info-finder/reactor/prai1.html	III	PWR-DRYAMB WEST 2LP FLUR NSP	1,650 551	06/25/1968 04/05/1974 12/16/1973 N/A 08/09/2013	101 79 99 85 92 84
Prairie Island Nuclear Generating Plant, Unit 2 Northern States Power Co. Minnesota Welch, MN (28 miles SE of Minneapolis, MN) 050-00306 www.nrc.gov/info-finder/reactor/prai2.html	III	PWR-DRYAMB WEST 2LP FLUR NSP	1,650 545	06/25/1968 10/29/1974 12/21/1974 N/A 10/29/2014	93 102 84 84 93 85
Quad Cities Nuclear Power Station, Unit 1 Exelon Generating Co., LLC Cordova, IL (20 miles NE of Moline, IL) 050-00254 www.nrc.gov/info-finder/reactor/quad1.html	III	BWR-MARK 1 GE 3 S&L UE&C	2,957 867	02/15/1967 12/14/1972 02/18/1973 N/A 12/14/2032	90 85 83 89 92 96
Quad Cities Nuclear Power Station, Unit 2 Exelon Generating Co., LLC Cordova, IL (20 miles NE of Moline, IL) 050-00265 www.nrc.gov/info-finder/reactor/quad2.html	III	BWR-MARK 1 GE 3 S&L UE&C	2,957 869	02/15/1967 12/14/1972 03/10/1973 10/28/2004 12/14/2032	92 81 93 86 99 86
River Bend Station, Unit 1 Entergy Operations, Inc. St. Francisville, LA (24 miles NNW of Baton Rouge, LA) 050-00458 www.nrc.gov/info-finder/reactor/rbs1.html	IV	BWR-MARK 3 GE 6 S&W S&W	3,091 989	03/25/1977 11/20/1985 06/16/1986 N/A 08/29/2025	89 87 93 88 85 82

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
R.E. Ginna Nuclear Power Plant R.E. Ginna Nuclear Power Plant, LLC Ontario, NY (20 miles NE of Rochester, NY) 050-00244 www.nrc.gov/info-finder/reactor/ginn.html	I	PWR-DRYAMB WEST 2LP GIL BECH	1,775 498	04/25/1966 09/19/1969 07/01/1970 05/19/2004 09/18/2029	89 99 92 95 113 109
St. Lucie Plant, Unit 1 Florida Power & Light Co. Jensen Beach, FL (10 miles SE of Ft. Pierce, FL) 050-00335 www.nrc.gov/info-finder/reactor/stl1.html	II	PWR-DRYAMB CE EBSO EBSO	2,700 839	07/01/1970 03/01/1976 12/21/1976 10/02/2003 03/01/2036	102 86 83 102 85 91
St. Lucie Plant, Unit 2 Florida Power & Light Co. Jensen Beach, FL (10 miles SE of Ft. Pierce, FL) 050-00389 www.nrc.gov/info-finder/reactor/stl2.html	II	PWR-DRYAMB CE EBSO EBSO	2,700 839	05/02/1977 06/10/1983 08/08/1983 10/02/2003 04/06/2043	80 92 86 82 70 99
Salem Nuclear Generating Station, Unit 1 PSEG Nuclear, LLC Hancock Bridge, NJ (18 miles S of Wilmington, DE) 050-00272 http://www.nrc.gov/info-finder/reactor/salm1.html	I	PWR-DRYAMB WEST 4LP PUBS UE&C	3,459 1,174	09/25/1968 12/01/1976 06/30/1977 N/A 08/13/2016	94 72 92 99 89 91
Salem Nuclear Generating Station, Unit 2 PSEG Nuclear, LLC Hancock Bridge, NJ (18 miles S of Wilmington, DE) 050-00311 http://www.nrc.gov/info-finder/reactor/salm2.html	I	PWR-DRYAMB WEST 4LP PUBS UE&C	3,459 1,130	09/25/1968 05/20/1981 10/13/1981 N/A 04/18/2020	82 88 90 92 98 83
San Onofre Nuclear Generating Station, Unit 2 Southern California Edison Co. San Clemente, CA (4 miles SE of San Clemente, CA) 050-00361 www.nrc.gov/info-finder/reactor/sano2.html	IV	PWR-DRYAMB CE BECH BECH	3,438 1,070	10/18/1973 02/16/1982 08/08/1983 N/A 02/16/2022	104 86 95 72 89 91
San Onofre Nuclear Generating Station, Unit 3 Southern California Edison Co. San Clemente, CA (4 miles SE of San Clemente, CA) 050-00362 www.nrc.gov/info-finder/reactor/sano3.html	IV	PWR-DRYAMB CE BECH BECH	3,438 1,080	10/18/1973 11/15/1982 04/01/1984 N/A 11/15/2022	91 74 100 72 94 69

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Seabrook Station, Unit 1 FPL Energy Seabrook, LLC Seabrook, NH (13 miles S of Portsmouth, NH) 050-00443 www.nrc.gov/info-finder/reactor/seab1.html	I	PWR-DRYAMB WEST 4LP UE&C UE&C	3,648 1,295	07/07/1976 03/15/1990 08/19/1990 N/A 03/15/2030	91 100 89 86 99 89
Sequoyah Nuclear Plant, Unit 1 Tennessee Valley Authority Soddy-Daisy, TN (16 miles NE of Chattanooga, TN) 050-00327 www.nrc.gov/info-finder/reactor/seq1.html	II	PWR-ICECND WEST 4LP TVA TVA	3,455 1,148	05/27/1970 09/17/1980 07/01/1981 N/A 09/17/2020	73 92 100 90 87 101
Sequoyah Nuclear Plant, Unit 2 Tennessee Valley Authority Soddy-Daisy, TN (16 miles NE of Chattanooga, TN) 050-00328 www.nrc.gov/info-finder/reactor/seq2.html	II	PWR-ICECND WEST 4LP TVA TVA	3,455 1,126	05/27/1970 09/15/1981 06/01/1982 N/A 09/15/2021	84 96 90 90 100 89
Shearon Harris Nuclear Power Plant, Unit 1 Carolina Power & Light Co. New Hill, NC (20 miles SW of Raleigh, NC) 050-00400 www.nrc.gov/info-finder/reactor/har1.html	II	PWR-DRYAMB WEST 3LP EBSO DANI	2,900 900	01/27/1978 10/24/1986 05/02/1987 12/17/2008 10/24/2046	92 89 101 89 94 99
South Texas Project, Unit 1 STP Nuclear Operating Co. Bay City, TX (12 miles SSW of Bay City, TX) 050-00498 www.nrc.gov/info-finder/reactor/stp1.html	IV	PWR-DRYAMB WEST 4LP BECH EBSO	3,853 1,265	12/22/1975 03/22/1988 08/25/1988 N/A 08/20/2027	61 99 88 91 105 95
South Texas Project, Unit 2 STP Nuclear Operating Co. Bay City, TX (12 miles SSW of Bay City, TX) 050-00499 www.nrc.gov/info-finder/reactor/stp2.html	IV	PWR-DRYAMB WEST 4LP BECH EBSO	3,853 1,265	12/22/1975 03/28/1989 06/19/1989 N/A 12/15/2028	79 92 89 100 93 95
Surry Power Station, Unit 1 Virginia Electric and Power Co. Surry, VA (17 miles NW of Newport News, VA) 050-00280 www.nrc.gov/info-finder/reactor/sur1.html	II	PWR-DRYSUB WEST 3LP S&W S&W	2,546 799	06/25/1968 05/25/1972 12/22/1972 03/20/2003 05/25/2032	76 92 96 90 89 98
Surry Power Station, Unit 2 Virginia Electric and Power Co. Surry, VA (17 miles NW of Newport News, VA) 050-00281 www.nrc.gov/info-finder/reactor/sur2.html	II	PWR-DRYSUB WEST 3LP S&W S&W	2,546 799	06/25/1968 01/29/1973 05/01/1973 03/20/2003 01/29/2033	79 101 93 88 101 94

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Susquehanna Steam Electric Station, Unit 1 PPL Susquehanna, LLC Berwick, PA (7 miles NE of Berwick, PA) 050-00387 www.nrc.gov/info-finder/reactor/susq1.html	I	BWR-MARK 2 GE 4 BECH BECH	3,952 1,149	11/02/1973 07/17/1982 06/08/1983 N/A 07/17/2022	96 80 95 86 95 89
Susquehanna Steam Electric Station, Unit 2 PPL Susquehanna, LLC Berwick, PA (7 miles NE of Berwick, PA) 050-00388 www.nrc.gov/info-finder/reactor/susq2.html	I	BWR-MARK 2 GE 4 BECH BECH	3,952 1,140	11/02/1973 03/23/1984 02/12/1985 N/A 03/23/2024	86 100 89 93 88 100
Three Mile Island Nuclear Station, Unit 1 Exelon Generating Co., LLC Middletown, PA (10 miles SE of Harrisburg, PA) 050-00289 www.nrc.gov/info-finder/reactor/tmi1.html	I	PWR-DRYAMB B&W LLP GIL UE&C	2,568 786	05/18/1968 04/19/1974 09/02/1974 N/A 04/19/2014	90 102 98 105 97 107
Turkey Point Nuclear Generating, Unit 3 Florida Power & Light Co. Homestead, FL (20 miles S of Miami, FL) 050-00250 www.nrc.gov/info-finder/reactor/tp3.html	II	PWR-DRYAMB WEST 3LP BECH BECH	2,300 693	04/27/1967 07/19/1972 12/14/1972 06/06/2002 07/19/2032	90 78 96 92 97 101
Turkey Point Nuclear Generating, Unit 4 Florida Power & Light Co. Homestead, FL (20 miles S of Miami, FL) 050-00251 www.nrc.gov/info-finder/reactor/tp4.html	II	PWR-DRYAMB WEST 3LP BECH BECH	2,300 693	04/27/1967 04/10/1973 09/07/1973 06/06/2002 04/10/2033	92 100 70 89 100 86
Vermont Yankee Nuclear Power Station Entergy Nuclear Operations, Inc. Vernon, VT (5 miles S of Brattleboro, VT) 050-00271 www.nrc.gov/info-finder/reactor/vy.html	I	BWR-MARK 1 GE 4 EBSO EBSO	1,912 620	12/11/1967 03/21/1972 11/30/1972 N/A 03/21/2012	100 87 92 115 87 89
Virgil C. Summer Nuclear Station, Unit 1 South Carolina Electric & Gas Co. Jenkinsville, SC (26 miles NW of Columbia, SC) 050-00395 www.nrc.gov/info-finder/reactor/sum.html	II	PWR-DRYAMB WEST 3LP GIL DANI	2,900 966	03/21/1973 11/12/1982 01/01/1984 04/23/2004 08/06/2042	87 97 88 89 85 87
Vogtle Electric Generating Plant, Unit 1 Southern Nuclear Operating Co. Waynesboro, GA (26 miles SE of Augusta, GA) 050-00424 www.nrc.gov/info-finder/reactor/vog1.html	II	PWR-DRYAMB WEST 4LP SBEC GPC	3,625 1,109	06/28/1974 03/16/1987 06/01/1987 N/A 01/16/2047	93 100 91 86 99 93

APPENDIX A
U.S. Commercial Nuclear Power Reactors (continued)

Plant Name, Unit Number Licensee Location Docket Number NRC Web Page Address	NRC Region	Con Type NSSS Architect Engineer Constructor	Licensed MWt/ Net Summer Capacity (MW)*	CP Issued OL Issued Comm. Op. LR Issued Exp. Date	2003-2008** Capacity Factor (Percent)
Vogtle Electric Generating Plant, Unit 2 Southern Nuclear Operating Co. Waynesboro, GA (26 miles SE of Augusta, GA) 050-00425 www.nrc.gov/info-finder/reactor/vog2.html	II	PWR-DRYAMB WEST 4LP SBEC GPC	3,625 1,127	06/28/1974 03/31/1989 05/20/1989 N/A 02/09/2049	97 91 85 92 83 88
Waterford Steam Electric Station, Unit 3 Entergy Operations, Inc. Killona, LA (25 miles W of New Orleans, LA) 050-00382 www.nrc.gov/info-finder/reactor/wat3.html	IV	PWR-DRYAMB COMB CE EBSO EBSO	3,716 1,157	11/14/1974 03/16/1985 09/24/1985 N/A 12/18/2024	89 101 78 92 98 89
Watts Bar Nuclear Plant, Unit 1 Tennessee Valley Authority Spring City, TN (60 miles SW of Knoxville, TN) 050-00390 www.nrc.gov/info-finder/reactor/wb1.html	II	PWR-ICECND WEST 4LP TVA TVA	3,459 1,123	01/23/1973 02/07/1996 05/27/1996 N/A 11/09/2035	87 100 90 68 102 82
Wolf Creek Generating Station, Unit 1 Wolf Creek Nuclear Operating Corp. Burlington, KS (3.5 miles NE of Burlington, KS) 050-00482 www.nrc.gov/info-finder/reactor/wc.html	IV	PWR-DRYAMB WEST 4LP BECH DANI	3,565 1,166	05/31/1977 06/04/1985 09/03/1985 11/20/2008 03/11/2045	87 99 86 92 102 83

Reactors Under Active Construction or Deferred Policy

Bellefonte Nuclear Power Station, Unit 1*** Tennessee Valley Authority (6 miles NE of Scottsboro, AL) 050-00438	II	PWR-DRYAMB B&W 205 TVA TVA	3,763 1,235	12/24/1974	N/A
Bellefonte Nuclear Power Station, Unit 2*** Tennessee Valley Authority (6 miles NE of Scottsboro, AL) 050-00439	II	PWR-DRYAMB B&W 205 TVA TVA	3,763 1,235	12/24/1974	N/A
Watts Bar Nuclear Plant, Unit 2**** Tennessee Valley Authority Spring City, TN (60 miles SW of Knoxville, TN) 050-00391	II	PWR-ICECND WEST 4LP TVA TVA	3,411 1,150	01/23/1973	

* Data calculations compiled by estimate for 2008 are not final. Plant names as identified on license as of June 30, 2009.
** Average capacity factor is listed in year order starting with 2003.
***Bellefonte Units 1 & 2 are under Commission Policy Statement on Deferred Plants (52 FR 38077; October 14, 1987).
****Watts Bar 2 is currently under active construction.

Source: NRC, with some data compiled from EIA/DOE

APPENDIX B
U.S. Commercial Nuclear Power Reactors Formerly Licensed To Operate (Permanently Shut Down)

Unit Location	Reactor Type MWt	NSSS Vendor	OL Issued Shut Down	Decommissioning Alternative Selected Current Status
Big Rock Point Charlevoix, MI	BWR 240	GE	05/01/1964 08/29/1997	DECON DECON Completed
GE Bonus* Punta Higuera, PR	BWR 50	CE	04/02/1964 06/01/1968	ENTOMB ENTOMB
CVTR** Parr, SC	PTHW 65	WEST	11/27/1962 01/01/1967	SAFSTOR SAFSTOR
Dresden 1 Morris, IL	BWR 700	GE	09/28/1959 10/31/1978	SAFSTOR SAFSTOR
Elk River* Elk River, MN	BWR 58	AC/S&L	11/06/1962 02/01/1968	DECON DECON Completed
Fermi 1 Newport, MI	SCF 200	CE	05/10/1963 09/22/1972	SAFSTOR in Progress DECON
Fort St. Vrain Platteville, CO	HTG 842	GA	12/21/1973 08/18/1989	DECON DECON Completed
GE VBWR Sunol, CA	BWR 50	GE	08/31/1957 12/09/1963	SAFSTOR SAFSTOR
Haddam Neck Meriden, CT	PWR 1,825	WEST	12/27/1974 12/05/1996	DECON DECON Completed
Hallam* Hallam, NE	SCGM 256	BLH	01/02/1962 09/01/1964	ENTOMB ENTOMB
NS Savannah Baltimore, MD	PWR 74	B&W	08/1965 11/1970	SAFSTOR SAFSTOR
Humboldt Bay 3 Eureka, CA	BWR 200	GE	08/28/1962 07/02/1976	SAFSTOR DECON In Progress
Indian Point 1 Buchanan, NY	PWR 615	B&W	03/26/1962 10/31/1974	SAFSTOR SAFSTOR
La Crosse Genoa, WI	BWR 165	AC	07/03/1967 04/30/1987	SAFSTOR SAFSTOR
Maine Yankee Wiscasset, ME	PWR 2,700	CE	06/29/1973 12/06/1996	DECON DECON Completed
Millstone 1 Waterford, CT	BWR 2,011	GE	10/31/1986 07/21/1998	SAFSTOR SAFSTOR
Pathfinder Sioux Falls, SD	BWR 190	AC	03/12/1964 09/16/1967	DECON DECON Completed
Peach Bottom 1 Delta, PA	HTG 115	GA	01/24/1966 10/31/1974	SAFSTOR SAFSTOR

APPENDIX B
U.S. Commercial Nuclear Power Reactors Formerly Licensed To Operate (Permanently Shut Down) (continued)

Unit Location	Reactor Type WMt	NSSS Vendor	OL Issued Shut Down	Decommissioning Alternative Selected Current Status
General Electric Company Sunol, CA	EVESR 17	GE	11/12/63 02/01/67	SAFSTOR SAFSTOR
Piqua* Piqua, OH	OCM 46	AI	08/23/1962 01/01/1966	ENTOMB ENTOMB
Rancho Seco Herald, CA	PWR 2,772	B&W	08/16/1974 06/07/1989	DECON DECON In Progress
San Onofre 1 San Clemente, CA	PWR 1,347	WEST	03/27/1967 11/30/1992	SAFSTOR DECON In Progress
Saxton Saxton, PA	PWR 23.5	WEST	11/15/1961 05/01/1972	DECON DECON Completed
Shippingport* Shippingport, PA	PWR 236	WEST	N/A 1982	DECON DECON Completed
Shoreham Wading River, NY	BWR 2,436	GE	04/21/1989 06/28/1989	DECON DECON Completed
Three Mile Island 2 Middletown, PA	PWR 2,770	B&W	02/08/1978 03/28/1979	(1)
Trojan Rainier, OR	PWR 3,411	WEST	11/21/1975 11/09/1992	DECON DECON Completed
Yankee-Rowe Rowe, MA	PWR 600	WEST	12/24/1963 10/01/1991	DECON DECON Completed
Zion 1 Zion, IL	PWR 3,250	WEST	10/19/1973 02/21/1997	SAFSTOR SAFSTOR
Zion 2 Zion, IL	PWR 3,250	WEST	11/14/1973 09/19/1996	SAFSTOR SAFSTOR

* AEC/DOE owned; not regulated by the U.S. Nuclear Regulatory Commission.

** Holds byproduct license from the State of South Carolina.

Notes: See Glossary for definitions of decommissioning alternatives.

(1) Three Mile Island 2 has been placed in a postdefueling monitored storage mode until Unit 1 permanently ceases operation, at which time both units are planned to be decommissioned.

Source: DOE Integrated Database for 1990; U.S. Spent Fuel and Radioactive Waste, Inventories, Projections, and Characteristics (DOE/RW-0006, Rev. 6), and U.S. Nuclear Regulatory Commission, Nuclear Power Plants in the World, Edition #6

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
Allens Creek 1 Houston Lighting & Power Company 4 miles NW of Wallis, TX	BWR 1,150	1982 Under CP Review
Allens Creek 2 Houston Lighting & Power Company 4 miles NW of Wallis, TX	BWR 1,150	1976 Under CP Review
Atlantic 1 & 2 Public Service Electric & Gas Company Floating Plants off the Coast of NJ	PWR 1,150	1978 Under CP Review
Bailly 1 Northern Indiana Public Service Company 12 miles NNE of Gary, IN	BWR 645	1981 With CP
Barton 1 & 2 Alabama Power & Light 15 miles SE of Clanton, AL	BWR 1,159	1977 Under CP Review
Barton 3 & 4 Alabama Power & Light 15 miles SE of Clanton, AL	BWR 1,159	1975 Under CP Review
Black Fox 1 & 2 Public Service Company of Oklahoma 3.5 miles S of Inola, OK	BWR 1,150	1982 Under CP Review
Blue Hills 1 & 2 Gulf States Utilities Company SW tip of Toledo Bend Reservoir, TX	PWR 918	1978 Under CP Review
Callaway 2 Union Electric Company 25 miles ENE of Jefferson City, MO	PWR 1,150	1981 With CP
Cherokee 1 Duke Power Company 6 miles SSW of Blacksburg, SC	PWR 1,280	1983 With CP
Cherokee 2 & 3 Duke Power Company 6 miles SSW of Blacksburg, SC	PWR 1,280	1982 With CP
Clinch River Project Management Corp., DOE, TVA 23 miles W of Knoxville, in Oak Ridge, TN	LMFB 350	1983 Under CP Review

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors (continued)

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
Clinton 2 Illinois Power Company 6 miles E of Clinton, IL	BWR 933	1983 With CP
Davis-Besse 2 & 3 Toledo Edison Company 21 miles ESE of Toledo, OH	PWR 906	1981 Under CP Review
Douglas Point 1 & 2 Potomac Electric Power Company Charles County, MD	BWR 1,146	1977 Under CP Review
Erie 1 & 2 Ohio Edison Company Berlin, OH	PWR 1,260	1980 Under CP Review
Forked River 1 Jersey Central Power & Light Company 2 miles S of Forked River, NJ	PWR 1,070	1980 With CP
Fort Calhoun 2 Omaha Public Power District 19 miles N of Omaha, NE	PWR 1,136	1977 Under CP Review
Fulton 1 & 2 Philadelphia Electric Company 17 miles S of Lancaster, PA	HTG 1,160	1975 Under CP Review
Grand Gulf 2 Entergy Nuclear Operations, Inc. 20 miles SW of Vicksburg, MS	BWR 1,250	1990 With CP
Greene County Power Authority of the State of NY 20 miles N of Kingston, NY	PWR 1,191	1980 Under CP Review
Greenwood 2 & 3 Detroit Edison Company Greenwood Township, MI	PWR 1,200	1980 Under CP Review
Hartsville A1 & A2 Tennessee Valley Authority 5 miles SE of Hartsville, TN	BWR 1,233	1984 With CP
Hartsville B1 & B2 Tennessee Valley Authority 5 miles SE of Hartsville, TN	BWR 1,233	1982 With CP

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors (continued)

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
Haven 1 (formerly Koshkonong) Wisconsin Electric Power Company 4.2 miles SSW of Fort Atkinson, WI	PWR 900	1980 Under CP Review
Haven 2 (formerly Koshkonong) Wisconsin Electric Power Company 4.2 miles SSW of Fort Atkinson, WI	PWR 900	1978 Under CP Review
Hope Creek 2 Public Service Electric & Gas Company 18 miles SE of Wilmington, DE	BWR 1,067	1981 With CP
Jamesport 1 & 2 Long Island Lighting Company 65 miles E of New York City, NY	PWR 1,150	1980 With CP
Marble Hill 1 & 2 Public Service of Indiana 6 miles NE of New Washington, IN	PWR 1,130	1985 With CP
Midland 1 Consumers Power Company S of City of Midland, MI	PWR 492	1986 With CP
Midland 2 Consumers Power Company S of City of Midland, MI	PWR 818	1986 With CP
Montague 1 & 2 Northeast Nuclear Energy Company 1.2 miles SSE of Turners Falls, MA	BWR 1,150	1980 Under CP Review
New England 1 & 2 New England Power Company 8.5 miles E of Westerly, RI	PWR 1,194	1979 Under CP Review
New Haven 1 & 2 New York State Electric & Gas Corporation 3 miles NW of New Haven, NY	PWR 1,250	1980 Under CP Review
North Anna 3 Virginia Electric & Power Company 40 miles NW of Richmond, VA	PWR 907	1982 With CP
North Anna 4 Virginia Electric & Power Company 40 miles NW of Richmond, VA	PWR 907	1980 With CP

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors (continued)

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
North Coast 1 Puerto Rico Water Resources Authority 4.7 miles ESE of Salinas, PR	PWR 583	1978 Under CP Review
Palo Verde 4 & 5 Arizona Public Service Company 36 miles W of Phoenix, AZ	PWR 1,270	1979 Under CP Review
Pebble Springs 1 & 2 Portland General Electric Company 55 miles WSW of Tri Cities (Kenewick-Pasco-Richland, WA), OR	PWR 1,260	1982 Under CP Review
Perkins 1, 2, & 3 Duke Power Company 10 miles N of Salisbury, NC	PWR 1,280	1982 Under CP Review
Perry 2 Cleveland Electric Illuminating Co. 35 miles NE of Cleveland, OH	BWR 1,205	1994 Under CP Review
Phipps Bend 1 & 2 Tennessee Valley Authority 15 miles SW of Kingsport, TN	BWR 1,220	1982 With CP
Pilgrim 2 Boston Edison Company 4 miles SE of Plymouth, MA	PWR 1,180	1981 Under CP Review
Pilgrim 3 Boston Edison Company 4 miles SE of Plymouth, MA	PWR 1,180	1974 Under CP Review
Quanicassee 1 & 2 Consumers Power Company 6 miles E of Essexville, MI	PWR 1,150	1974 Under CP Review
River Bend 2 Gulf States Utilities Company 24 miles NNW of Baton Rouge, LA	BWR 934	1984 With CP
Seabrook 2 Public Service Co. of New Hampshire 13 miles S of Portsmouth, NH	PWR 1,198	1988 With CP
Shearon Harris 2 Carolina Power & Light Company 20 miles SW of Raleigh, NC	PWR 900	1983 With CP

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors (continued)

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
Shearon Harris 3 & 4 Carolina Power & Light Company 20 miles SW of Raleigh, NC	PWR 900	1981 With CP
Skagit/Hanford 1 & 2 Puget Sound Power & Light Company 23 miles SE of Bellingham, WA	PWR 1,277	1983 Under CP Review
Sterling Rochester Gas & Electric Corporation 50 miles E of Rochester, NY	PWR 1,150	1980 With CP
Summit 1 & 2 Delmarva Power & Light Company 15 miles SSW of Wilmington, DE	HTG 1,200	1975 Under CP Review
Sundesert 1 & 2 San Diego Gas & Electric Company 16 miles SW of Blythe, CA	PWR 974	1978 Under CP Review
Surry 3 & 4 Virginia Electric & Power Company 17 miles NW of Newport News, VA	PWR 882	1977 With CP
Tyrone 1 Northern States Power Company 8 miles NE of Durond, WI	PWR 1,150	1981 Under CP Review
Tyrone 2 Northern States Power Company 8 miles NE of Durond, WI	PWR 1,150	1974 With CP
Vogtle 3 & 4 Georgia Power Company 26 miles SE of Augusta, GA	PWR 1,113	1974 With CP
Washington Nuclear 1 Energy Northwest 10 miles E of Aberdeen, WA	PWR 1,266	1995 With CP
Washington Nuclear 3 Energy Northwest 16 miles E of Aberdeen, WA	PWR 1,242	1995 With CP
Washington Nuclear 4 Energy Northwest 10 miles E of Aberdeen, WA	PWR 1,218	1982 With CP

APPENDIX C
Canceled U.S. Commercial Nuclear Power Reactors (continued)

Unit Utility Location	Con Type MWe per Unit	Canceled Date Status
Washington Nuclear 5 Energy Northwest 16 miles E of Aberdeen, WA	PWR 1,242	1982 With CP
Yellow Creek 1 & 2 Tennessee Valley Authority 15 miles E of Corinth, MS	BWR 1,285	1984 With CP
Zimmer 1 Cincinnati Gas & Electric Company 25 miles SE of Cincinnati, OH	BWR 810	1984 With CP

Note: Cancellation is defined as public announcement of cancellation or written notification to the NRC.
Only NRC-docketed applications are included. Status is the status of the application at the time of cancellation.

Source: DOE/EIA Commercial Nuclear Power 1991 (DOE/EIA-0438 (91)), Appendix E (page 105) and
U.S. Nuclear Regulatory Commission

APPENDIX D
U.S. Commercial Nuclear Power Reactors by Parent Company

Utility	NRC-Abbreviated Reactor Unit Name
AmerenUE www.ameren.com	Callaway*
Arizona Public Service Company www.aps.com	Palo Verde 1, 2, & 3*
Constellation Energy www.constellation.com	Calvert Cliffs 1 & 2 Ginna Nine Mile Point 1 & 2
Detroit Edison Company www.dteenergy.com	Fermi 2
Dominion Generation www.dom.com	Kewaunee Millstone 2 & 3 North Anna 1 & 2 Surry 1 & 2
Duke Energy Carolinas, LLC www.duke-energy.com	Catawba 1 & 2 McGuire 1 & 2 Oconee 1, 2, & 3
Energy Northwest www.energy-northwest.com	Columbia
Entergy Nuclear Operations, Inc. www.entergy-nuclear.com	Arkansas Nuclear One 1 & 2 FitzPatrick Grand Gulf 1 Indian Point 2 & 3 Palisades Pilgrim 1 River Bend 1 Vermont Yankee Waterford 3
Exelon Corporation, LLC www.exeloncorp.com	Braidwood 1 & 2 Byron 1 & 2 Clinton Dresden 2 & 3 LaSalle 1 & 2 Limerick 1 & 2 Oyster Creek Peach Bottom 2 & 3 Quad Cities 1 & 2 Three Mile Island 1
FirstEnergy Nuclear Generating Corp. www.firstenergycorp.com	Beaver Valley 1 & 2 Davis-Besse Perry 1

APPENDIX D
U.S. Commercial Nuclear Power Reactors by Parent Company (continued)

Utility	NRC-Abbreviated Reactor Unit Name
FPL Group, Inc. www.fplgroup.com	Duane Arnold Point Beach 1 & 2 Seabrook 1 St. Lucie 1 & 2 Turkey Point 3 & 4
Indiana Michigan Power Company www.indianamichiganpower.com	Cook 1 & 2
Luminant Generation Company, LLC www.luminant.com	Comanche Peak 1 & 2*
Nebraska Public Power District www.nppd.com	Cooper
Northern States Power Company www.nmcco.com	Monticello Prairie Island 1 & 2
Omaha Public Power District www.oppd.com	Fort Calhoun
Pacific Gas & Electric Company www.pge.com	Diablo Canyon 1 & 2*
PPL Susquehanna, LLC www.pplweb.com	Susquehanna 1 & 2
Progress Energy www.progress-energy.com	Brunswick 1 & 2 Crystal River 3 Robinson 2 Harris 1
PSEG Nuclear, LLC www.pseg.com	Hope Creek 1 Salem 1 & 2
South Carolina Electric & Gas Company www.sceg.com	Summer
Southern California Edison Company www.sce.com	San Onofre 2 & 3
Southern Nuclear Operating Company www.southerncompany.com	Hatch 1 & 2 Farley 1 & 2 Vogtle 1 & 2
STP Nuclear Operating Company www.stpnoc.com	South Texas Project 1 & 2*
Tennessee Valley Authority www.tva.gov	Browns Ferry 1, 2, & 3 Sequoyah 1 & 2 Watts Bar 1
Wolf Creek Nuclear Operating Corporation www.wcnoc.com	Wolf Creek 1*

*These plants have a joint program called the Strategic Teaming and Resource Sharing (STARS) group. They share resources for refueling outages and to develop some shared licensing applications.

Source: U.S. Nuclear Regulatory Commission

APPENDIX E
U.S. Nuclear Research and Test Reactors (Operating) Regulated by the NRC

Licensee Location	Reactor Type OL Issued	Power Level (kW)	Licensee Number Docket Number
Aerotest San Ramon, CA	TRIGA (Indus) 07/02/1965	250	R-98 50-228
Armed Forces Radiobiology Research Institute Bethesda, MD	TRIGA 06/26/1962	1,100	R-84 50-170
Dow Chemical Company Midland, MI	TRIGA 07/03/1967	300	R-108 50-264
General Electric Company Sunol, CA	Nuclear Test 10/31/1957	100	R-33 50-73
Idaho State University Pocatello, ID	AGN-201 #103 10/11/1967	0.005	R-110 50-284
Kansas State University Manhattan, KS	TRIGA 10/16/1962	250	R-88 50-188
Massachusetts Institute of Technology Cambridge, MA	HWR Reflected 06/09/1958	5,000	R-37 50-20
National Institute of Standards & Technology Gaithersburg, MD	Nuclear Test 05/21/1970	20,000	TR-5 50-184
North Carolina State University Raleigh, NC	Pulstar 08/25/1972	1,000	R-120 50-297
Ohio State University Columbus, OH	Pool 02/24/1961	500	R-75 50-150
Oregon State University Corvallis, OR	TRIGA Mark II 03/07/1967	1,100	R-106 50-243
Pennsylvania State University State College, PA	TRIGA 07/08/1955	1,100	R-2 50-5
Purdue University West Lafayette, IN	Lockheed 08/16/1962	1	R-87 50-182
Reed College Portland, OR	TRIGA Mark I 07/02/1968	250	R-112 50-288
Rensselaer Polytechnic Institute Troy, NY	Critical Assembly 07/03/1964	0.1	CX-22 50-225
Rhode Island Atomic Energy Commission Narragansett, RI	GE Pool 07/23/1964	2,000	R-95 50-193

APPENDIX E
U.S. Nuclear Research and Test Reactors (Operating) Regulated by the NRC (continued)

Licensee Location	Reactor Type OL Issued	Power Level (kW)	Licensee Number Docket Number
Texas A&M University College Station, TX	AGN-201M #106 08/26/1957	0.005	R-23 50-59
Texas A&M University College Station, TX	TRIGA 12/07/1961	1,000	R-128 50-128
U.S. Geological Survey Denver, CO	TRIGA Mark I 02/24/1969	1,000	R-113 50-274
University of Arizona Tucson, AZ	TRIGA Mark I 12/05/1958	110	R-52 50-113
University of California/Davis Sacramento, CA	TRIGA 08/13/1998	2,300	R-130 50-607
University of California/Irvine Irvine, CA	TRIGA Mark I 11/24/1969	250	R-116 50-326
University of Florida Gainesville, FL	Argonaut 05/21/1959	100	R-56 50-83
University of Maryland College Park, MD	TRIGA 10/14/1960	250	R-70 50-166
University of Massachusetts/Lowell Lowell, MA	GE Pool 12/24/1974	1,000	R-125 50-223
University of Missouri/Columbia Columbia, MO	Tank 10/11/1966	10,000	R-103 50-186
University of Missouri/Rolla Rolla, MO	Pool 11/21/1961	200	R-79 50-123
University of New Mexico Albuquerque, NM	AGN-201M #112 09/17/1966	0.005	R-102 50-252
University of Texas Austin, TX	TRIGA Mark II 01/17/1992	1,100	R-92 50-602
University of Utah Salt Lake City, UT	TRIGA Mark I 09/30/1975	100	R-126 50-407
University of Wisconsin Madison, WI	TRIGA 11/23/1960	1,000	R-74 50-156
Washington State University Pullman, WA	TRIGA 03/06/1961	1,000	R-76 50-27

Source: U.S. Nuclear Regulatory Commission

APPENDIX F

U.S. Nuclear Research and Test Reactors (under Decommissioning) Regulated by the NRC

Licensee Location	Reactor Type Power Level (kW)	OL Issued Shutdown	Decommissioning Alternative Selected Current Status
General Atomics San Diego, CA	TRIGA Mark F 1,500	07/01/60 09/07/94	DECON SAFSTOR
General Atomics San Diego, CA	TRIGA Mark I 250	05/03/58 12/17/96	DECON SAFSTOR
General Electric Company Sunol, CA	GETR (Tank) 50,000	01/07/59 06/26/85	SAFSTOR SAFSTOR
National Aeronautics and Space Administration Sandusky, OH	Test 60,000	05/02/62 07/07/73	DECON DECON In Progress
National Aeronautics and Space Administration Sandusky, OH	Mockup 100	06/14/61 07/07/73	DECON DECON In Progress
University of Buffalo Buffalo, NY	Pulstar 2,000	03/24/61 07/23/96	DECON SAFSTOR
University of Illinois Urbana-Champaign, IL	TRIGA 1,500	07/22/69 04/12/99	DECON DECON In Progress
University of Michigan Ann Arbor, MI	Pool 2,000	09/13/57 01/29/04	DECON DECON In Progress
Veterans Administration Omaha, NE	TRIGA 20	06/26/59 11/05/01	DECON SAFSTOR
Viacom Waltz Mill, PA	Tank 20,000	06/19/59 03/25/63	DECON DECON In Progress
Worcester Polytechnic Institute Worcester, MA	GE 10	12/16/59 06/30/07	DECON DECON Pending

Source: U.S. Nuclear Regulatory Commission

APPENDIX G
Industry Performance Indicators: Annual Industry Averages, FYs 1999–2008

Indicator	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Automatic Scrams	0.64	0.52	0.57	0.44	0.75	0.56	0.47	0.32	0.48	0.29
Safety System Actuations	0.29	0.29	0.19	0.18	0.41	0.24	0.38	0.22	0.25	0.14
Significant Events	0.03	0.04	0.07	0.05	0.07	0.04	0.05	0.03	0.02	0.02
Safety System Failures	1.68	1.40	0.82	0.88	0.96	0.78	0.99	0.59	0.65	0.64
Forced Outage Rate	5.20	4.24	3.00	1.70	3.04	1.88	2.44	1.47	1.43	1.34
Equipment-Forced Outage Rate	0.16	0.13	0.11	0.12	0.16	0.15	0.13	0.10	0.11	0.08
Collective Radiation Exposure	128	115	123	111	125	100	117	93	110	96
Drill/Exercise Performance	97	96	95	95	96	96	96	96	98	96
ERO Drill Participation	–	96	96	97	98	98	98	98	98	98
Alert and Notification System Reliability	98	98	99	99	99	99	99	99	99	100

Note: Drills and exercises were piloted in 1999 and became standard practice for all plants in 2000.

Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

APPENDIX H
Dry Spent Fuel Storage Designs: NRC-Approved for Use by General Licensees

Vendor	Docket #	Storage Design Model
General Nuclear Systems, Inc.	72-1000	CASTOR V/21
NAC International, Inc.	72-1002	NAC S/T
	72-1003	NAC-C28 S/T
	72-1015	NAC-UMS
	72-1025	NAC-MPC
	72-1031	Magnastor
Holtec International	72-1008	HI-STAR 100
	72-1014	HI-STORM 100
BNG Fuel Solutions Corporation	72-1007	VSC-24
	72-1026	Fuel Solutions (WSNF-220, -221, -223) W-150 Storage Cask W-100 Transfer Cask W-21, W-74 Canisters
Transnuclear, Inc.	72-1005	TN-24
	72-1027	TN-68
	72-1021	TN-32, 32A, 32B
	72-1004	Standardized NUHOMS-24P, 24PHB, 24PTH, 52B, 61BT, 32PT
	72-1029	Standardized Advanced NUHOMS-24PT1, 24PT4
	72-1030	NUHOMS HD-32PTH

Source: U.S. Nuclear Regulatory Commission data as of January 2009

APPENDIX I
Dry Spent Fuel Storage Licensees

Reactor Utility	License Type	Date Issued	Vendor	Storage Model	Docket #
Surry 1, 2 Virginia Electric & Power Company (Dominion Gen.)	SL	07/02/1986	General Nuclear Systems, Inc. Transnuclear, Inc. NAC International, Inc. Westinghouse, Inc.	CASTOR V/21 TN-32 NAC-128 CASTOR X/33 MC-10	72-2
Surry Virginia Electric & Power Company (Dominion Gen.)	GL	08/06/2007	Transnuclear, Inc.	NUHOMS-HD	72-55
H.B. Robinson 2 Carolina Power & Light Company	SL GL	08/13/1986 09/06/2005	Transnuclear, Inc. Transnuclear, Inc.	NUHOMS-7P NUHOMS-24P	72-3 72-60
Oconee 1, 2, 3 Duke Energy Company	SL GL	01/29/1990 03/05/1999	Transnuclear, Inc. Transnuclear, Inc.	NUHOMS-24P NUHOMS-24P	72-4 72-40
Fort St. Vrain* U.S. Department of Energy	SL	11/04/1991	FW Energy Applications, Inc.	Modular Vault Dry Store	72-9
Calvert Cliffs 1, 2 Calvert Cliffs Nuclear Power Plant	SL	11/25/1992	Transnuclear, Inc.	NUHOMS-24P NUHOMS-32P	72-8
Palisades Entergy Nuclear Operations, Inc.	GL	05/11/1993	BNG Fuel Solutions Transnuclear, Inc.	VSC-24 NUHOMS-32PT	72-7
Prairie Island 1, 2 Northern States Power Co., a Minnesota Corp.	SL	10/19/1993	Transnuclear, Inc.	TN-40	72-10
Point Beach 1, 2 Nuclear Management Company, LLC	GL	05/26/1996	BNG Fuel Solutions Transnuclear, Inc.	VSC-24 NUHOMS-32PT	72-5
Davis-Besse FirstEnergy Nuclear Operating Company	GL	01/01/1996	Transnuclear, Inc.	NUHOMS-24P	72-14
Arkansas Nuclear 1, 2 Entergy Nuclear Operations, Inc.	GL	12/17/1996	BNG Fuel Solutions Holtec International	VSC-24 HI-STORM 100	72-13
North Anna Virginia Electric & Power Company (Dominion Gen.)	SL GL	06/30/1998 03/10/2008	Transnuclear, Inc. Transnuclear, Inc.	TN-32 NUHOMS-HD	72-16 72-56
Trojan Portland General Electric Corp.	SL	03/31/1999	Holtec International	HI-STORM 100	72-17

APPENDIX I
Dry Spent Fuel Storage Licensees (continued)

Reactor Utility	License Type	Date Issued	Vendor	Storage Model	Docket #
Idaho National Lab TMI-2 Fuel Debris, U.S. Department of Energy	SL	03/19/1999	Transnuclear, Inc.	NUHOMS-12T	72-20
Susquehanna Pennsylvania Power and Light	GL	10/18/1999	Transnuclear, Inc.	NUHOMS-52B NUHOMS-61BT	72-28
Peach Bottom 2, 3 Exelon Generation Company, LLC	GL	06/12/2000	Transnuclear, Inc.	TN-68	72-29
Hatch 1, 2 Southern Nuclear Operating	GL	07/06/2000	Holtec International	HI-STAR 100 HI-STORM 100	72-36
Dresden 1, 2, 3 Exelon Generation Company, LLC	GL	07/10/2000	Holtec International	HI-STAR 100 HI-STORM 100	72-37
Rancho Seco Sacramento Municipal Utility District	SL	06/30/2000	Transnuclear, Inc.	NUHOMS-24P	72-11
McGuire Duke Power	GL	02/01/2001	Transnuclear, Inc.	TN-32	72-38
Big Rock Point Entergy Nuclear Operations, Inc.	GL	11/18/2002	BNG Fuel Solutions	Fuel Solutions W74	72-43
James A. FitzPatrick Entergy Nuclear Operations, Inc.	GL	04/25/2002	Holtec International	HI-STORM 100	72-12
Maine Yankee Maine Yankee Atomic Power Company	GL	08/24/2002	NAC International, Inc.	NAC-UMS	72-30
Columbia Generating Station Energy Northwest	GL	09/02/2002	Holtec International	HI-STORM 100	72-35
Oyster Creek Exelon Generation Company, LLC	GL	04/11/2002	Transnuclear, Inc.	NUHOMS-61BT	72-15
Yankee Rowe Yankee Atomic Electric	GL	06/26/2002	NAC International, Inc.	NAC-MPC	72-31

APPENDIX I
Dry Spent Fuel Storage Licensees (continued)

Reactor Utility	License Type	Date Issued	Vendor	Storage Model	Docket #
Duane Arnold Nuclear Management Corporation	GL	09/01/2003	Transnuclear, Inc.	NUHOMS-61BT	72-32
Palo Verde Arizona Public Service Company	GL	03/15/2003	NAC International, Inc.	NAC-UMS	72-44
San Onofre Southern California Edison Company	GL	10/03/2003	Transnuclear, Inc.	NUHOMS-24PT	72-41
Diablo Canyon Pacific Gas & Electric Co.	SL	03/22/2004	Holtec International	HI-STORM 100	72-26
Haddam Neck CT Yankee Atomic Power	GL	05/21/2004	NAC International, Inc.	NAC-MPC	72-39
Sequoyah Tennessee Valley Authority	GL	07/13/2004	Holtec International	HI-STORM 100	72-34
Idaho Spent Fuel Facility Foster Wheeler Environmental Corp.	SL	11/30/2004	Multiple	Multiple	72-25
Humboldt Bay Pacific Gas & Electric Co.	SL	11/30/2005	Holtec International	HI-STORM 100HB	72-27
Private Fuel Storage Facility	SL	02/21/2006	Holtec International	HI-STORM 100	72-22
Browns Ferry Tennessee Valley Authority	GL	08/21/2005	Holtec International	HI-STORM 100S	72-52
Joseph M. Farley Southern Nuclear Operating Co.	GL	08/25/2005	Transnuclear, Inc.	NUHOMS-32PT	72-42
Millstone Dominion Generation	GL	02/15/2005	Transnuclear, Inc.	NUHOMS-32PT	72-47
Quad Cities Exelon Generation Company, LLC	GL	12/02/2005	Holtec International	HI-STORM 100S	72-53
River Bend Entergy Nuclear Operations, Inc.	GL	12/29/2005	Holtec International	HI-STORM 100S	72-49
Fort Calhoun Omaha Public Power District	GL	07/29/2006	Transnuclear, Inc.	NUHOMS-32PT	72-54

APPENDIX I
Dry Spent Fuel Storage Licensees (continued)

Reactor Utility	License Type	Date Issued	Vendor	Storage Model	Docket #
Hope Creek/Salem Public Service Electric and Gas Company	GL	11/10/2006	Holtec International	HI-STORM 100	72-48
Grand Gulf Entergy Nuclear Operations, Inc.	GL	11/18/2006	Holtec International	HI-STORM 100S	72-50
Catawba Duke Energy Corporation	GL	07/30/2007	NAC International, Inc.	NAC-UMS	72-45
Indian Point Entergy Nuclear Operations, Inc.	GL	01/11/2008	Holtec International	HI-STORM 100	72-51
St. Lucie Florida Power and Light Company	GL	03/14/2008	Transnuclear, Inc.	NUHOMS-HD	72-61
Vermont Yankee Entergy Nuclear Operations, Inc.	GL	05/25/2008	Transnuclear, Inc.	HI-STORM100	72-59
Limerick Exelon Generation Co., LLC	GL	08/01/2008	Transnuclear, Inc.	NUHOMS-61BT	72-65
Seabrook FPL Energy	GL	08/07/2008	Transnuclear, Inc.	NUHOMS-HD-3PTM	72-61
Monticello Xcel Energy, Inc.	GL	09/17/2008	Transnuclear, Inc.	NUHOMS-61BT	72-58

*Fort St. Vrain is undergoing decommissioning and was transferred to DOE on June 4, 1999.

Note: NRC-abbreviated unit names

Source: U.S. Nuclear Regulatory Commission

APPENDIX J
Nuclear Power Units by Nation

	In Operation		Under Construction, or on Order as of December 31, 2008*			
Country	Number of Units	Capacity MWe Gross	Number of Units	Capacity Net	Total MWh Gross 2008	Shutdown
Argentina	2	1,005	1	692	7,380,388	0
Armenia	1	408	0	0	2,461,662	1[P]
Belgium	7	6,101	0	0	45,757,177	1[P]
Brazil	2	2,007	0	0	14,003,775	0
Bulgaria*	2	2,000	2	1,906	15,765,105	4[P]
Canada*	21	15,367	0	0	94,055,812	2[P] & 2[L]
China*	9	9,014	6	5,220	42,562,618	0
Taiwan	6	5,144	2	2,600	40,826,862	0
Czech Republic	6	3,834	0	0	26,502,309	0
Finland	4	2,800	1	1,600	22,958,414	0
France	58	65,880	1	1,330	438,641,923	11[P]
Germany	17	21,497	0	0	148,662,835	19[P]
Hungary	4	1,910	0	0	14,823,468	0
India	17	4,120	6	2,708	15,532,006	0
Iran	0	0	1	915	0	0
Italy	0	0	0	0	0	4[P]
Japan	55	49,580	1	866	251,744,159	3[P] & 1[L]
Kazakhstan	0	0	0	0	0	0
Korea, South	20	18,393	5	5,180	150,957,937	0
Lithuania	1	1,300	0	0	9,948,100	1[P]
Mexico	2	1,364	0	0	9,803,976	0
Netherlands	1	515	0	0	4,157,629	1[P]
Pakistan	2	462	1	300	1,882,858	0
Romania	2	1,412	0	0	11,225,808	0
Russia	31	23,266	7	4,789	162,289,470	5[P]
Slovakia	4	2,200	2	816	6,272,000	3[P]
Slovenia	1	727	0	0	5,695,020	0
South Africa	2	1,930	0	0	13,307,504	0
Spain	8	7,735	0	0	58,997,662	2[P]
Sweden	10	9,611	0	0	63,908,316	3
Switzerland	5	3,352	0	0	27,537,746	0

APPENDIX J
Nuclear Power Units by Nation (continued)

	In Operation		Under Construction, or on Order as of December 31, 2008*			
Country	Number of Units	Capacity MWe Gross	Number of Units	Capacity Net	Total MWh Gross 2008	Shutdown
Ukraine	15	13,880	2	900	89,841,302	4P
United Kingdom	19	12,540	0	0	39,370,000	26
United States	104	106,977	1	1,165	842,360,801	28

P = Permanent Shutdown
L = Long-term Shutdown

*Construction information from International Atomic Energy Agency—Power Reactor Information System.

Note: Operable, under construction, or on order as of December 31, 2008. Country's short-form name used.

Source: *Nucleonics Week*© and International Atomic Energy Agency analysis compiled by the U.S. Nuclear Regulatory Commission. Operation generation data are from *Nucleonics Week*©, March 5, 2009.

APPENDIX K
Nuclear Power Units by Reactor Type, Worldwide

	In Operation	
Reactor Type	Number of Units	Net MWe
Pressurized light-water reactors	264	243,079
Boiling light-water reactors	92	83,597
Heavy-water reactors, all types	44	22,441
Graphite-moderated light-water reactors	16	11,404
Gas-cooled reactors, all types	18	8,909
Liquid metal cooled fast-breeder reactors	2	690
Total	**436**	**370,120**

Note: MWe values rounded to the nearest whole number.
Source: International Atomic Energy Agency–Power Reactor Information System Database, www.iaea.org.
Data as compiled by the U.S. Nuclear Regulatory Commission. Data available as of March 2009.

APPENDIX L
Top 50 Reactors by Capacity Factor, Worldwide

Nation	Unit	Reactor Type	Vendor	2008 Gross Generation (MWh)	2008 Gross Capacity Factor (Percent)
United States	Calvert Cliffs-2	PWR	CE	7,835,619	101.37
United States	Catawba-2	PWR	West.	10,728,440	101.36
Japan	Ohi-2	PWR	West.	10,444,137	101.18
Japan	Fukushima II-1	BWR	Tosh.	9,771,906	101.12
Korea, South	Yonggwang-1	PWR	West.	8,737,294	100.97
United States	Sequoyah-1	PWR	West.	10,500,842	100.80
Korea, South	Ulchin-4	PWR	KHIC-CE	9,236,080	100.61
Japan	Fukushima I-3	BWR	Tosh.	6,924,798	100.54
Korea, South	Ulchin-5	PWR	KHIC-CE	9,234,124	100.30
United States	Indian Point-3	PWR	West.	9,468,174	100.03
Taiwan	Kuosheng-1	BWR	GE	8,648,583	99.95
United States	Braidwood-1	PWR	West.	10,896,382	99.87
Spain	Almaraz-2	PWR	West.	8,614,991	99.81
United States	Beaver Valley-1	PWR	West.	8,394,530	99.68
United States	LaSalle-2	BWR	GE	10,313,636	99.67
China	Daya Bay-1	PWR	Fram.	8,609,848	99.61
Canada	Darlington-3	PHWR	AECL	8,154,496	99.38
U.S.	Three Mile Island-1	PWR	BWX	7,768,614	99.37
Russia	Balakovo-4	PWR	MAE	8,699,650	99.04
Korea, South	Ulchin-1	PWR	Fram.	8,560,877	98.93
United States	Oconee-3	PWR	B&W	7,901,935	98.75
Taiwan	Maanshan-1	PWR	West.	8,253,002	98.70
United States	Quad Cities-1	BWR	GE	7,893,023	98.53
Canada	Darlington-2	PHWR	AECL	8,079,104	98.46
United States	Shearon-Harris	PWR	West.	8,301,637	98.45
Germany	Isar-1	BWR	KWU	7,884,456	98.42
United States	Diablo Canyon-1	PWR	West.	10,343,923	98.38
United States	Limerick-2	BWR	GE	10,043,110	98.31
United States	North Anna-1	PWR	West.	8,427,710	98.30
United States	Dresden-2	BWR	GE	7,845,352	98.26
Spain	Garona	BWR	GE	4,020,958	98.23
Slovenia	Krsko	PWR	West.	6,272,000	98.22
United States	Duane Arnold	BWR	GE	5,578,571	98.14

APPENDIX L
Top 50 Reactors by Capacity Factor, Worldwide (continued)

Nation	Unit	Reactor Type	Vendor	2008 Gross Generation (MWh)	2008 Gross Capacity Factor (Percent)
Canada	Darlington-4	PHWR	AECL	8,028,800	97.85
United States	Surry-1	PWR	West.	7,253,555	97.44
United States	Nine Mile Point-1	BWR	GE	5,476,785	97.42
Korea, South	Kori-4	PWR	West.	8,602,688	97.34
United States	Farley-1	PWR	West.	7,649,954	97.31
United States	Peach Bottom-3	BWR	GE	10,099,600	97.27
Mexico	Laguna Verde-2	BWR	GE	6,826,718	97.19
Japan	Hamaoka-4	BWR	Tosh.	9,696,012	97.07
United States	Palisades	PWR	CE	7,192,847	96.91
Finland	Oikiluoto-2	BWR	Asea	7,575,760	96.90
Romania	Cernavoda-2	PHWR	AECL	5,997,832	96.72
United States	St. Lucie-2	PWR	CE	7,472,330	96.45
United States	Turkey Point-3	PWR	West.	6,435,284	96.40
United States	Hope Creek	BWR	GE	10,406,890	96.39
United States	Hatch-2	BWR	GE	7,810,154	96.23
India	Tarapur-2	BWR	GE	1,351,000	96.12
Germany	Biblis B	PWR	KWU	10,975,041	96.11

Source: Excerpted from *Nucleonics Week*©, March 5, 2009, by McGraw Hill, Inc. Reproduced by permission. Further reproduction prohibited.

APPENDIX M
Top 50 Reactors by Generation, Worldwide

Nation	Unit	Reactor Type	Vendor	2008 Gross Generation (MWh)	2008 Gross Capacity Factor (Percent)
France	Chooz-B1	PWR	Fram.	12,839,417	93.70
Germany	Isar-2	PWR	KWU	12,093,046	93.34
Germany	Brokdorf	PWR	KWU	12,042,399	92.63
France	Civaux-2	PWR	Fram.	11,825,203	86.24
Germany	Emsland	PWR	KWU	11,490,541	93.44
France	Chooz-B2	PWR	Fram	11,445,894	83.53
Germany	Neckar-2	PWR	KWU	11,431,720	92.96
Germany	Philippsburg-2	PWR	KWU	11,359,676	88.70
United States	South Texas-1	PWR	West.	11,322,224	91.22
United States	Palo Verde-3	PWR	CE	11,298,490	89.57
United States	South Texas-2	PWR	West.	11,257,764	90.70
Germany	Grohnde	PWR	KWU	11,169,846	88.92
France	Penly-1	PWR	Fram.	11,165,719	91.98
United States	Perry	BWR	GE	11,111,044	95.54
Germany	Biblis B	PWR	KWU	10,975,041	96.11
United States	Braidwood-1	PWR	West.	10,896,382	99.87
United States	Catawba-2	PWR	West.	10,728,440	101.36
France	Paluel-3	PWR	Fram.	10,550,232	86.91
United States	Palo Verde-1	PWR	CE	10,534,838	83.99
United States	Sequoyah-1	PWR	West.	10,500,842	100.80
Brazil	Angra-2	PWR	KWU	10,488,289	88.44
Japan	Ohi-2	PWR	West.	10,444,137	101.18
Germany	Gundremmingen-C	BWR	KWU	10,416,885	88.24
United States	Hope Creek	BWR	GE	10,406,890	96.39
France	Civaux-1	PWR	Fram.	10,347,0351	75.46
United States	Diablo Canyon-1	PWR	West.	10,343,923	98.38
Germany	Grafenrheinfeld	PWR	KWU	10,330,499	87.44
United States	LaSalle-2	BWR	GE	10,313,636	99.67
United States	Byron-1	PWR	West.	10,284,699	94.27
France	Paluel-1	PWR	Fram.	10,244,228	84.39
Germany	Gundremmingen-B	BWR	KWU	10,164,555	86.10
United States	Byron-2	PWR	West.	10,162,396	95.61

APPENDIX M
Top 50 Reactors by Generation, Worldwide (continued)

Nation	Unit	Reactor Type	Vendor	2008 Gross Generation (MWh)	2008 Gross Capacity Factor (Percent)
France	Belleville-2	PWR	Fram.	10,158,776	84.85
United States	Peach Bottom-3	BWR	GE	10,099,600	97.27
United States	Limerick-2	BWR	GE	10,043,110	98.31
United States	Fermi-2	BWR	GE	10,035,825	94.66
United States	Comanche Peak-1	PWR	West.	10,028,301	93.96
France	Cattenom-4	PWR	Fram.	10,020,388	83.76
United States	Comanche Peak-2	PWR	West.	9,960,983	93.33
Lithuania	Ignalina-2	RBMK	MAE	9,948,100	87.11
France	Penly-2	PWR	Fram.	9,858,101	81.21
United States	Callaway	PWR	West.	9,818,249	87.41
Switzerland	Leibstadt	BWR	GE	9,777,797	92.76
United States	Grand Gulf-1	BWR	GE	9,777,303	84.32
Germany	Unterweser	PWR	KWU	9,776,487	78.94
Japan	Fukushima II-1	BWR	Tosh.	9,771,906	101.12
United States	Braidwood-2	PWR	West.	9,763,562	91.83
France	Paluel-2	PWR	Fram.	9,723,509	80.10
United States	Columbia	BWR	GE	9,707,690	94.21
United States	Cook-2	PWR	West.	9,696,184	95.90

Note: Country's short-form name used.

Source: Excerpted from *Nucleonics Week*©, March 5, 2009, by McGraw Hill, Inc. Reproduced by permission. Further reproduction prohibited. Abbreviated unit names listed.

APPENDIX N
Quick-Reference Metric Conversion Tables

SPACE AND TIME

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Length	mi (statute)	km	1.609 347
	yd	m	*0.914 4
	ft (int)	m	*0.304 8
	in	cm	*2.54
Area	mi^2	km^2	2.589 998
	acre	m^2	4 046.873
	yd^2	m^2	0.836 127 4
	ft^2	m^2	*0.092 903 04
	in^2	cm^2	*6.451 6
Volume	acre foot	m^3	1 233.489
	yd^3	m^3	0.764 554 9
	ft^3	m^3	0.028 316 85
	ft^3	L	28.316 85
	gal	L	3.785 412
	fl oz	mL	29.573 53
	in^3	cm^3	16.387 06
Velocity	mi/h	km/h	1.609 347
	ft/s	m/s	*0.304 8
Acceleration	ft/s^2	m/s^2	*0.304 8

NUCLEAR REACTION AND IONIZING RADIATION

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Activity (of a radionuclide)	curie (Ci)	MBq	*37,000.0
	dpm	Becquerel (Bq)	0.016 667
Absorbed dose	rad	Gray (Gy)	*0.01
	rad	cGy	*1.0
Dose equivalent	rem	Sievert (Sv)	*0.01
	rem	mSv	*10.0
	mrem	mSv	*0.01
	mrem	μSv	*10.0
Exposure (X-rays and gamma rays)	roentgen (R)	C/kg (coulomb)	0.000 258

APPENDIX N
Quick-Reference Metric Conversion Tables (continued)

HEAT

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Thermodynamic temperature	°F	K	*K = (°F + 59.67)/1.8
Celsius temperature	°F	°C	*°C = (°F–32)/1.8
Linear expansion coefficient	1/°F	1/K or 1/°C	*1.8
Thermal conductivity	(Btu · in)/(ft^2 · h · °F)	W/(m · °C)	0.144 227 9
Coefficient of heat transfer	Btu / (ft^2 · h · °F)	W/(m^2 · °C)	5.678 263
Heat capacity	Btu/°F	kJ/°C	1.899 108
Specific heat capacity	Btu/(lb · °F)	kJ/(kg · °C)	*4.186 8
Entropy	Btu/°F	kJ/°C	1.899 108
Specific entropy	Btu/(lb · °F)	kJ/(kg · °C)	*4.186 8
Specific internal energy	Btu/lb	kJ/kg	*2.326

MECHANICS

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Mass (weight)	ton (short) lb (avdp)	t (metric ton) kg	*0.907 184 74 *0.453 592 37
Moment of mass	lb · ft	kg · m	0.138 255
Density	ton (short)/yd^3 lb/ft^3	t/m^3 g/m^3	1.186 553 16.018 46
Concentration (mass)	lb/gal	g/L	119.826 4
Momentum	lb · ft/s	kg · m/s	0.138 255
Angular momentum	lb · ft^2/s	kg · m^2/s	0.042 140 11
Moment of inertia	lb · ft^2	kg · m^2	0.042 140 11
Force	kip (kilopound) lbf	kN (kilonewton) N (newton)	4.448 222 4.448 222
Moment of force, torque	lbf · ft	N · m	1.355 818
	lbf · in	N · m	0.122 984 8
Pressure	atm (std) bar lbf/in^2 (formerly psi) inHg (32 °F) ftH$_2$0 (39.2 °F) inH$_2$0 (60 °F) mmHg (0 °C)	kPa (kilopascal) kPa kPa kPa kPa kPa kPa	*101.325 *100.0 6.894 757 3.386 38 2.988 98 0.248 84 0.133 322

APPENDIX N
Quick-Reference Metric Conversion Tables (continued)

MECHANICS (continued)

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Stress	kip/in2 (formerly ksi)	MPa	6.894 757
	lbf/in2 (formerly psi)	MPa	0.006 894 757
	lbf/in2 (formerly psi)	kPa	6.894 757
	lbf/ft2	kPa	0.047 880 26
Energy, work	kWh	MJ	*3.6
	cal^{th}	J (joule)	*4.184
	Btu	kJ	1.055 056
	ft • lbf	J	1.355 818
	therm (US)	MJ	105.480 4
Power	Btu/s	kW	1.055 056
	hp (electric)	kW	*0.746
	Btu/h	W	0.293 071 1

Note: The information contained in this table is intended to familiarize NRC personnel with commonly used SI units and provide a quick reference to aid in the understanding of documents containing SI units. The conversion factors provided have not been approved as NRC guidelines for the development of licensing actions, regulations, or policy.

To convert from metric units to inch-pound units, divide the metric unit by the conversion factor.

* Exact conversion factors

Source: Federal Standard 376B (January 27, 1993), "Preferred Metric Units for General Use by the Federal Government"; and International Commission on Radiation Units and Measurements, ICRU Report 33 (1980), "Radiation Quantities and Units"

GLOSSARY (ABBREVIATIONS AND TERMS DEFINED)

Agreement State

A State that has signed an agreement with the NRC authorizing the State to regulate certain uses of radioactive materials within the State.

Atomic energy

The energy that is released through a nuclear reaction or radioactive decay process. Of particular interest is the process known as fission, which occurs in a nuclear reactor and produces energy usually in the form of heat. In a nuclear power plant, this heat is used to boil water in order to produce steam that can be used to drive large turbines. This, in turn, activates generators to produce electrical power. Atomic energy is more correctly called nuclear energy.

Background radiation

The natural radiation that is always present in the environment. It includes cosmic radiation which comes from the sun and stars, terrestrial radiation which comes from the Earth, and internal radiation which exists in all living things. The typical average individual exposure in the United States from natural background sources is about 300 millirems per year.

Boiling-water reactor (BWR)

A common nuclear power reactor design in which water flows upward through the core, where it is heated by fission and allowed to boil in the reactor vessel. The resulting steam then drives turbines, which activate generators to produce electrical power. BWRs operate similarly to electrical plants using fossil fuel, except that the BWRs are powered by 370-800 nuclear fuel assemblies in the reactor core.

Brachytherapy

A nuclear medicine procedure during which a sealed radioactive source is implanted directly into a person being treated for cancer (usually of the mouth, breast, lung, prostate, ovaries, or uterus). The radioactive implant may be temporary or permanent, and the radiation attacks the tumor as long as the device remains in place. Brachytherapy uses radioisotopes, such as iridium-192 or iodine-125, which are regulated by the NRC and its Agreement States.

Byproduct material

As defined by NRC regulations includes any radioactive material (except enriched uranium or plutonium) produced by a nuclear reactor. It also includes the tailings or wastes produced by the extraction or concentration of uranium or thorium or the fabrication of fuel for nuclear reactors. Additionally, it is any material that has been made radioactive through the use of a particle accelerator or any discrete source of radium-226 used for a commercial, medical, or research activity. In addition, the NRC, in consultation with the EPA, DOE, DHS and others, can designate as byproduct material any source of naturally-occurring radioactive material, other than source material, that it determines would pose a threat to public health and safety or the common defense and security of the United States.

Canister
See *Dry cask storage.*

Capability
The maximum load that a generating unit, generating station, or other electrical apparatus can carry under specified conditions for a given period of time without exceeding approved limits of temperature and stress.

Capacity
The amount of electric power that a generating unit can produce. The amount of electric power that a manufacturer rates its generator, turbine transformer, transmission, circuit, or system, is able to produce.

Capacity charge
One of two elements in a two-part pricing method used in capacity transactions (the other element is the energy charge). The capacity charge, sometimes called the demand charge, is assessed on the capacity (amount of electric power) being purchased.

Capacity factor
The ratio of the available capacity (the amount of electrical power actually produced by a generating unit) to the theoretical capacity (the amount of electrical power that could theoretically have been produced if the generating unit had operated continuously at full power) during a given time period.

Capacity utilization
A percentage representing the extent to which a generating unit fulfilled its capacity in generating electric power over a given time period. This percentage is defined as the margin between the unit's available capacity (the amount of electrical power the unit actually produced) and its theoretical capacity (the amount of electrical power that could have been produced if the unit had operated continuously at full power) during a certain time period. Capacity utilization is computed by dividing the amount actually produced by the theoretical capacity, and multiplying by 100.

Cask
A heavily shielded container used for the dry storage or shipment (or both) of radioactive materials such as spent nuclear fuel or other high-level radioactive waste. Casks are often made from lead, concrete, or steel. Casks must meet regulatory requirements and are not intended for long-term disposal in a repository.

Classified information
Information that could be used by an adversary to harm the U.S. or its allies and thus must be protected. The NRC has two types of classified information. The first type, known as national security information, is information that is classified by an Executive Order. Its release would damage national security to some degree. The second type, known as restricted data, is information that is classified by the Atomic Energy Act. It would assist individuals or organizations in designing, manufacturing, or using nuclear weapons. Access to both types of information is restricted to authorized persons who have been properly cleared and have a "need to know" the information for their official duties.

Combined license (COL)

An NRC-issued license that authorizes a licensee to construct and (with certain specified conditions) operate a nuclear power plant at a specific site, in accordance with established laws and regulations. A COL is valid for 40 years (with the possibility of a 20-year renewal).

Commercial sector (energy users)

Generally, nonmanufacturing business establishments, including hotels, motels, and restaurants; wholesalers and retail stores; and health, social, and educational institutions. However, utilities may categorize commercial service as all consumers whose demand or annual usage exceeds some specified limit that is categorized as residential service.

Compact

A group of two or more States that have formed business alliances to dispose of low-level radioactive waste on a regional basis.

Construction recapture

The maximum number of years that could be added to a facility's license expiration date to recapture the period between the date the NRC issued the facility's construction permit to the date it granted an operating license. A licensee must submit an application to request this extension.

Containment structure

A gas-tight shell or other enclosure around a nuclear reactor to confine fission products that otherwise might be released to the atmosphere in the event of an accident. Such enclosures are usually dome-shaped and made of steel-reinforced concrete.

Contamination

Undesirable radiological, chemical, or biological material (with a potentially harmful effect) that is either airborne, or deposited in (or on the surface of) structures, objects, soil, water, or living organisms in a concentration that makes the medium unfit for its next intended use.

Criticality

The normal operating condition of a reactor, in which nuclear fuel sustains a fission chain reaction. A reactor achieves criticality (and is said to be critical) when each fission event releases a sufficient number of neutrons to sustain an ongoing series of reactions.

Decommissioning

The process of safely closing a nuclear power plant (or other facility where nuclear materials are handled) to retire it from service after its useful life has ended. This process primarily involves decontaminating the facility to reduce residual radioactivity and then releasing the property for unrestricted or (under certain conditions) restricted use. This often includes dismantling the facility or dedicating it to other purposes. Decommissioning begins after the nuclear fuel, coolant, and radioactive waste are removed.

Decon

A method of decommissioning, in which structures, systems, and components that contain radioactive contamination are removed from a site and safely disposed at a commercially operated low-level waste disposal facility, or decontaminated to a level that permits the site to be released for unrestricted use shortly after it ceases operation.

Decontamination

A process used to reduce, remove, or neutralize radiological, chemical, or biological contamination to reduce the risk of exposure. Decontamination may be accomplished by cleaning or treating surfaces to reduce or remove the contamination; filtering contaminated air or water; subjecting contamination to evaporation and precipitation; or covering the contamination to shield or absorb the radiation. The process can also simply allow adequate time for natural radioactive decay to decrease the radioactivity.

Defense-in-depth

An approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials. The key is creating multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. Defense-in-depth includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures.

Depleted uranium

Uranium with a percentage of uranium-235 lower than the 0.7 percent (by mass) contained in natural uranium. (The normal residual U-235 content in depleted uranium is 0.2–0.3 percent, with U-238 comprising the remaining 98.7–98.8 percent.) Depleted uranium is produced during uranium isotope separation and is typically found in spent fuel elements or byproduct tailings or residues. Depleted uranium can be blended with highly-enriched uranium, such as that from weapons, to make reactor fuel.

Design-basis threat (DBT)

A profile of the type, composition, and capabilities of an adversary. The NRC uses the DBT as a basis for designing safeguards systems to protect against acts of radiological sabotage and to prevent the theft of special nuclear material. Nuclear facility licensees are expected to demonstrate they can defend against the DBT.

Design certification

Certification and approval by the NRC of a standard nuclear power plant design independent of a specific site or an application to construct or operate a plant. A design certification is valid for 15 years from the date of issuance but can be renewed for an additional 10 to 15 years.

Dry cask storage

A method for storing spent nuclear fuel above ground in special containers known as casks. After fuel has been cooled in a spent fuel pool for at least 1 year, dry cask storage allows approximately one to six dozen spent fuel assemblies to be sealed in casks and surrounded by inert gas. The casks are large, rugged cylinders, made of steel or steel-reinforced concrete (18 or more inches thick or 45.72 or more centimeters). They are welded or bolted closed, and each cask is surrounded by steel, concrete, lead, or other material to provide leak-tight containment and radiation shielding. The casks may be placed horizontally in aboveground concrete bunkers, or vertically in concrete vaults or on concrete pads.

Early site permit (ESP)

A permit through which the NRC resolves site safety, environmental protection, and emergency preparedness issues, in order to approve one or more proposed sites for a nuclear power facility, independent of a specific nuclear plant design or an application for a construction permit or combined license. An ESP is valid for 10 to 20 years, but can be renewed for an additional 10 to 20 years.

Economic Simplified Boiling-Water Reactor (ESBWR)

A 4,500-MWt nuclear reactor design, which has passive safety features and uses natural circulation (with no recirculation pumps or associated piping) for normal operation. GE-Hitachi Nuclear Energy (GEH) submitted an application for final design approval and standard design certification for the ESBWR on August 24, 2005.

Efficiency, plant

The percentage of the total energy content of a power plant's fuel that is converted into electricity. The remaining energy is lost to the environment as heat.

Electric power grid

A system of synchronized power providers and consumers, connected by transmission and distribution lines and operated by one or more control centers. In the continental United States, the electric power grid consists of three systems–the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. In Alaska and Hawaii, several systems encompass areas smaller than the State.

Electric utility

A corporation, agency, authority, person, or other legal entity that owns and/or operates facilities within the United States, its territories, or Puerto Rico for the generation, transmission, distribution, or sale of electric power (primarily for use by the public). Facilities that qualify as cogenerators or small power producers under the Public Utility Regulatory Policies Act (PURPA) are not considered electric utilities.

Emergency classifications

Sets of plant conditions that indicate various levels of risk to the public and which might require response by an offsite emergency response organization to protect citizens near the site.

Both nuclear power plants and research and test reactors use the following emergency classifications:

- *Notification of Unusual Event*–Events that indicate potential degradation in the level of safety of the plant are in progress or have occurred. No release of radioactive material requiring offsite response or monitoring is expected unless further degradation occurs.

- *Alert*–Events that involve an actual or potential substantial degradation in the level of plant safety are in progress or have occurred. Any releases of radioactive material are expected to be limited to a small fraction of the limits set forth by the EPA.
- *Site Area Emergency*–Events that may result in actual or likely major failures of plant functions needed to protect the public are in progress or have occurred. Any releases of radioactive material are not expected to exceed the limits set forth by the EPA except near the site boundary.
- *General Emergency*–Events that involve actual or imminent substantial core damage or melting of reactor fuel with the potential for loss of containment integrity are in progress or have occurred. Radioactive releases can be expected to exceed the limits set forth by the EPA for more than the immediate site area.

Nuclear materials and fuel cycle facility licensees use the following emergency classifications:

- *Alert*–Events that could lead to a release of radioactive materials are in progress or have occurred. The release is not expected to but the release is not expected to require a response by an offsite response organization to protect citizens near the site.
- *Site Area Emergency*–Events that could lead to a significant release of radioactive materials are in progress or have occurred. The release could require a response by offsite response organizations to protect citizens near the site.

Emergency preparedness (EP)

The programs, plans, training, exercises, and resources necessary to prepare emergency personnel to rapidly identify, evaluate, and react to emergencies, including those arising from terrorism or natural events such as hurricanes. EP strives to ensure that nuclear power plant operators can implement measures to protect public health and safety in the event of a radiological emergency. Plant operators, as a condition of their licenses, must develop and maintain EP plans that meet NRC requirements.

Energy Information Administration (EIA)

The agency, within the U.S. Department of Energy, that provides policy-neutral statistical data, forecasts, and analyses to promote sound policymaking, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment.

Entomb

A method of decommissioning, in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombed structure is maintained and surveillance is continued until the entombed radioactive waste decays to a level permitting termination of the license and unrestricted release of the property.

During the entombment period, the licensee maintains the license previously issued by the NRC.

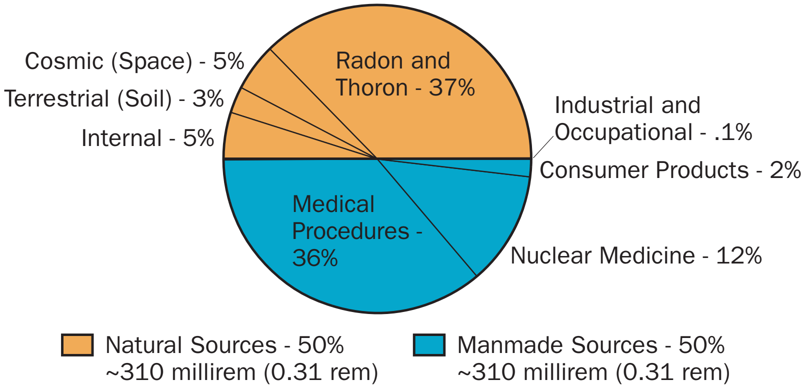
Event Notification (EN) System

An automated event tracking system used internally by the NRC's Headquarters Operations Center to track incoming notifications of significant nuclear events with an actual or potential effect on the health and safety of the public and the environment. Significant events are reported to the Operations Center by the NRC's licensees, Agreement States, other Federal agencies, the public, and other stakeholders.

Exposure

Absorption of ionizing radiation or ingestion of a radioisotope. Acute exposure is a large exposure received over a short period of time. Chronic exposure is exposure received over a long period of time, such as during a lifetime. The National Council on Radiation Protection and Measurements (NCRP) estimates that an average person in the United States receives a total annual dose of about 0.62 rem (620 millirem) from all radiations sources, a level that has not been shown to cause humans any harm. Of this total, natural background sources of radiation–including radon and thoron gas, natural radiation from soil and rocks, radiation from space and radiation sources that are found naturally within the human body–account for approximately 50 percent. Medical procedures such as computed tomography (CT scans) and nuclear medicine account approximately for another 48 percent. Other small contributors of exposure to the U.S. population includes consumer products and activities, industrial and research uses, and occupational tasks. The maximum permissible yearly dose for a person working with or around nuclear material is 5 rem.

Sources of Radiation Exposure in the United States



Source: NCRP Report No.160(2009)
Full report is available on the NCRP Web site at www.NCRPpublications.org.

Federal Emergency Management Agency (FEMA)

A component of U.S. Department of Homeland Security responsible for protecting the nation and reducing the loss of life and property from all hazards, such as natural disasters and acts of terrorism. FEMA leads and supports a risk-based, comprehensive emergency management system of preparedness, protection, response, recovery, and mitigation. FEMA also administers the National Flood Insurance Program.

Federal Energy Regulatory Commission (FERC)

An independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also regulates and oversees hydropower projects, and the construction of liquefied natural gas terminals and interstate natural gas pipelines. FERC protects the economic, environmental, and safety interests of the American public, while working abundant, reliable energy in a fair, competitive market.

Fiscal year (FY)

The 12-month period from October 1 through September 30 used by the Federal Government for budget formulation and execution. The fiscal year is designated by the calendar year in which it ends; for example, FY 2009 runs from October 1, 2008, through September 30, 2009.

Fissile material

A nuclide that is capable of undergoing fission after capturing low-energy thermal (slow) neutrons. Although sometimes used as a synonym for fissionable material, this term has acquired its more-restrictive interpretation with the limitation that the nuclide must be fissionable by *thermal neutrons.* With that interpretation, the three primary fissile materials are uranium-233, uranium-235, and plutonium-239. This definition excludes natural uranium and depleted uranium that have not been irradiated, or have only been irradiated in thermal reactors.

Fission (fissioning)

The splitting of an atom, which releases a considerable amount of energy (usually in the form of heat) that can be used to produce electricity. Fission may be spontaneous, but is usually caused by the nucleus of an atom becoming unstable (or "heavy") after capturing or absorbing a neutron. During fission, the heavy nucleus splits into roughly equal parts, producing the nuclei of at least two lighter elements. In addition to energy, this reaction usually releases gamma radiation and two or more daughter neutrons.

Force-on-Force (FOF)

Inspections designed to evaluate and improve the effectiveness of a licensee's security force and ability to defend a nuclear power plant and other nuclear facilities against a design-basis threat. An essential part of the security program instituted by the NRC, a full force-on-force inspection spans 2 weeks and includes tabletop drills and multiple simulated combat exercises between a mock commando-type adversary force and the plant's security force.

Foreign Assignee Program

An on-the-job training program, sponsored by the NRC for assignees from other countries, usually under bilateral information exchange arrangements with their respective regulatory organizations.

Freedom of Information Act (FOIA)

A Federal law that requires Federal agencies to provide, upon written request, access to records or information. Some material is exempt from FOIA, and FOIA does not apply to records that are maintained by State and local governments, or Federal contractors, grantees or private organizations or businesses.

Fuel assembly (fuel bundle, fuel element)

A structured group of fuel rods (long, slender, metal tubes containing pellets of fissionable material, which provide fuel for nuclear reactors). Depending on the design, each reactor vessel may have dozens of fuel assemblies (also known as fuel bundles), each of which may contain 200 or more fuel rods.

Fuel cycle

The series of steps involved in supplying fuel for nuclear power reactors include the following:

- Uranium recovery to extract (or mine) uranium ore, and concentrate (or mill) the ore to produce "yellowcake"
- Conversion of yellowcake into uranium hexafluoride (UF_6)
- Enrichment to increase the concentration of uranium-235 (U-235) in UF_6
- Fuel fabrication to convert enriched UF_6 into fuel for nuclear reactors
- Use of the fuel in reactors (nuclear power, research, or naval propulsion)
- Interim storage of spent nuclear fuel
- Reprocessing of high-level waste to recover the fissionable material remaining in the spent fuel (currently not done in the United States)
- Final disposition (disposal) of high-level waste

The NRC regulates these processes, as well as the fabrication of mixed oxide nuclear fuel, which is a combination of uranium and plutonium oxides.

Fuel reprocessing (recycling)

The processing of reactor fuel to separate the unused fissionable material from waste material. Reprocessing extracts isotopes from spent nuclear fuel so they can be used again as reactor fuel. Commercial reprocessing is not practiced in the U.S., although it has been practiced in the past. However, the U.S. Department of Defense oversees reprocessing programs at DOE facilities such as in Hanford, WA, and Savannah River, SC. These wastes as well as those wastes at a formerly operating commercial reprocessing facility at West Valley, NY are not regulated by the NRC.

Fuel rod

A long, slender, zirconium metal tube containing pellets of fissionable material, which provide fuel for nuclear reactors. Fuel rods are assembled into bundles called fuel assemblies, which are loaded individually into the reactor core.

Full-time equivalent

A human resources measurement equal to one staff person working full-time for one year.

Gas centrifuge

A uranium enrichment process used to prepare uranium for use in fabricating fuel for nuclear reactors by separating its isotopes (as gases) based on their slight difference in mass. This process uses a large number of interconnected centrifuge machines (rapidly spinning cylinders). No commercial gas centrifuge plants are operating in the United States; however, both Louisiana Energy Services (LES) and United States Enrichment Corporation (USEC) have received licenses to construct and operate such facilities, and both facilities are under construction.

Gas chromatography

A way of separating chemical substances from a mixed sample by passing the sample, carried by a moving stream of gas, through a tube packed with a finely divided solid that may be coated with a liquid film. Gas chromatography devices are used to analyze air pollutants, blood alcohol content, essential oils, and food products.

Gaseous diffusion

A uranium enrichment process used to prepare uranium for use in fabricating fuel for nuclear reactors by separating its isotopes (as gases) based on their slight difference in velocity. (Lighter isotopes diffuse faster through a porous membrane or vessel than do heavier isotopes.) This process involves filtering uranium hexafluoride (UF_6) gas to separate uranium-234 and uranium-235 from uranium-238, in order to increase the percentage of uranium-235 from 1 to 3 percent. The only gaseous diffusion plant in operation in the United States is in Paducah, KY. A similar plant near Piketon, OH, was closed in March 2001. Both plants are leased by the United States Enrichment Corporation (USEC) from the DOE and regulated by the NRC since March 4, 1997.

Gauging devices

Devices used to measure, monitor, and control the thickness of sheet metal, textiles, paper napkins, newspaper, plastics, photographic film, and other products as they are manufactured. Gauges mounted in fixed locations are designed for measuring or controlling material density, flow, level, thickness, or weight. The gauges contain sealed sources that radiate through the substance being measured to a readout or controlling device. Portable gauging devices, such as moisture density gauges, are used at field locations. These gauges contain a gamma-emitting sealed source, usually cesium-137, or a sealed neutron source, usually americium-241 or beryllium.

Generation (gross)

The total amount of electric energy produced by a generating station, as measured at the generator terminals.

Generation (net)

The gross amount of electric energy produced by a generating station, minus the amount used to operate the station. Net generation is usually measured in watthours (Wh).

Generator capacity

The maximum amount of electric energy that a generator can produce (from the mechanical energy of the turbine), adjusted for ambient conditions. Generator capacity is commonly expressed in megawatts (MW).

Generator nameplate capacity

The maximum amount of electric energy that a generator can produce under specific conditions, as rated by the manufacturer. Generator nameplate capacity is usually expressed in kilovolt-amperes (kVA) and kilowatts (kW), as indicated on a nameplate that is physically attached to the generator.

Geological repository

An excavated, underground facility that is designed, constructed, and operated for safe and secure permanent disposal of high-level radioactive waste. A geological repository uses an engineered barrier system and a portion of the site's natural geology, hydrology, and geochemical systems to isolate the radioactivity of the waste. The Nuclear Waste Policy Act of 1982, as amended, specifies that this waste will be disposed of in a deep geologic repository, and that Yucca Mountain, NV, will be the single candidate site for such a repository. On June 3, 2008, DOE submitted a license application to the NRC seeking authorization to construct the Yucca Mountain repository.

Gigawatt (GW)

A unit of power equivalent to one billion watts.

Gigawatthour (GWh)

One billion watthours.

Grid

See *Electric Power Grid*.

Half-life (radiological)

The time required for half the atoms of a particular radioisotope to decay into another isotope that has half the activity of the original radioisotope. A specific half-life is a characteristic property of each radioisotope. Measured half-lives range from millionths of a second to billions of years, depending on the stability of the nucleus. Radiological half-life is related to, but different from, the biological half-life and the effective half-life.

Health physics

The science concerned with recognizing and evaluating the effects of ionizing radiation on the health and safety of people and the environment, monitoring radiation exposure, and controlling the associated health risks and environmental hazards to permit the safe use of technologies that produce ionizing radiation.

High-level radioactive waste (HLW)

The highly radioactive materials produced as byproducts of fuel reprocessing or of the reactions that occur inside nuclear reactors. HLW includes:

- Irradiated spent nuclear fuel discharged from commercial nuclear power reactors
- The highly radioactive liquid and solid materials resulting from the reprocessing of spent nuclear fuel, which contain fission products in concentration (this includes some reprocessed HLW from defense activities and a small quantity of reprocessed commercial HLW)
- Other highly radioactive materials that the Commission may determine require permanent isolation

Highly (or High-) enriched uranium

Uranium enriched to at least 20 percent uranium-235 (a higher concentration than exists in natural uranium ore).

In situ recovery (ISR)

One of the two primary recovery methods that are currently used to extract uranium from ore bodies where they are normally found underground (in other words, in situ), without physical excavation. Also known as “solution mining” or in situ leaching.

Incident response (IR)

Activities that address the short-term, direct effects of a natural or human-caused event and require an emergency response to protect life or property.

Independent spent fuel storage installation (ISFSI)

A complex designed and constructed for the interim storage of spent nuclear fuel; solid, reactor-related, greater than Class C waste; and other associated radioactive materials. A spent fuel storage facility may be considered independent, even if it is located on the site of another NRC-licensed facility.

International Atomic Energy Agency (IAEA)

The center of worldwide cooperation in the nuclear field, through which member countries and multiple international partners work together to promote the safe, secure, and peaceful use of nuclear technologies. The United Nations established the IAEA in 1957 as “Atoms for Peace.”

International Nuclear Regulators Association (INRA)

An association established in January 1997 to give international nuclear regulators a forum to discuss nuclear safety. Countries represented include Canada, France, Japan, Spain, South Korea, Sweden, the United Kingdom, and the United States.

Irradiation

Exposure to ionizing radiation. Irradiation may be intentional, such as in cancer treatments or in sterilizing medical instruments. Irradiation may also be accidental, such as being exposed to an unshielded source. Irradiation does not usually result in radioactive contamination, but damage can occur, depending on the dose received.

Isotope

Two or more forms (or atomic configurations) of a given element that have identical atomic numbers (the same number of protons in their nuclei) and the same or very similar chemical properties but different atomic masses (different numbers of neutrons in their nuclei) and distinct physical properties. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, and the numbers denote the approximate atomic masses. Among their distinct physical properties, some isotopes (known as radioisotopes) are radioactive because their nuclei emit radiation as they strive toward a more stable nuclear configuration. For example, carbon-12 and carbon-13 are stable, but carbon-14 is unstable and radioactive.

Kilowatt (KW)

A unit of power equivalent to one thousand watts.

Licensed material

Source material, byproduct material, or special nuclear material that is received, possessed, used, transferred, or disposed of under a general or specific license issued by the NRC or Agreement States.

Licensee

A company, organization, institution, or other entity to which the NRC has granted a general or specific license to construct or operate a nuclear facility, or to receive, possess, use, transfer, or dispose of source, byproduct, or special nuclear material.

Licensing basis

The collection of documents or technical criteria that provides the basis upon which the NRC issues a license to construct or operate a nuclear facility; to conduct operations involving the emission of radiation; or to receive, possess, use, transfer, or dispose of source, byproduct, or special nuclear material.

Low-level radioactive waste (LLW)

A general term for a wide range of items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. A variety of industries, hospitals and medical institutions, educational and research institutions, private or government laboratories, and nuclear fuel cycle facilities generate LLW as part of their day-to-day use of radioactive materials. Some examples include radioactively contaminated protective shoe covers and clothing; cleaning rags, mops, filters, and reactor water treatment residues; equipment and tools; medical tubes, swabs, and hypodermic syringes; and carcasses and tissues from laboratory animals. The radioactivity in these wastes can range from just above natural background levels to much higher levels, such as seen in parts from inside the reactor vessel in a nuclear power plant. Low-level waste is typically stored onsite by licensees, either until it has decayed away and can be disposed of as ordinary trash, or until the accumulated amount becomes large enough to warrant shipment to a low-level waste disposal site.

Maximum dependable capacity (gross)

The maximum amount of electricity that the main generating unit of a nuclear power reactor can reliably produce during the summer or winter (usually summer, but whichever represents the most restrictive seasonal conditions, with the least electrical output). The dependable capacity varies during the year because temperature variations in cooling water affect the unit's efficiency. Thus, this is the gross electrical output as measured (in watts unless otherwise noted) at the output terminals of the turbine generator.

Maximum dependable capacity (net)

The gross maximum dependable capacity of the main generating unit in a nuclear power reactor, minus the amount used to operate the station. Net maximum dependable capacity is measured in watts unless otherwise noted.

Megawatt (MW)

A unit of power equivalent to one million watts.

Megawatthour (MWh)

One million watthours.

Metric ton

Approximately 2,200 pounds.

Mill tailings

Primarily, the sandy process waste material from a conventional uranium recovery facility. This naturally radioactive ore residue contains the radioactive decay products from the uranium chains (mainly the U-238 chain) and heavy metals. Although the milling process recovers about 93 percent of the uranium, the residues (known as "tailings") contain several naturally occurring radioactive elements, including uranium, thorium, radium, polonium, and radon.

Mixed oxide (MOX) fuel

A type of nuclear reactor fuel (often called "MOX") that contains plutonium oxide mixed with either natural or depleted uranium oxide, in ceramic pellet form. (This differs from conventional nuclear fuel, which is made of pure uranium oxide.) Using plutonium reduces the amount of highly enriched uranium needed to produce a controlled reaction in commercial light-water reactors. However, plutonium exists only in trace amounts in nature and, therefore, must be produced by neutron irradiation of uranium-238 or obtained from other manufactured sources. As directed by Congress, the NRC regulates the fabrication of MOX fuel by DOE, a program that is intended to dispose of plutonium from international nuclear disarmament agreements.

Monitoring of radiation

Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination in a region. Radiation monitoring is a safety measure to protect the health and safety of the public and the environment through the use of bioassay, alpha scans, and other radiological survey methods to monitor air, surface water and ground water, soil and sediment, equipment surfaces, and personnel.

National Response Framework (NRF)

The guiding principles, roles, and structures that enable all domestic incident response partners to prepare for and provide a unified national response to disasters and emergencies. It describes how the Federal Government, States, Tribes, communities, and the private sector work together to coordinate a national response. The framework, which became effective March 22, 2008, builds upon the National Incident Management System, which provides a template for managing incidents.

National Source Tracking System (NSTS)

A secure, Web-based data system that helps the NRC and its Agreement States track and regulate the medical, industrial, and academic uses of certain nuclear materials, from the time they are manufactured or imported to the time of their disposal or exportation. This information enhances the ability of the NRC and Agreement States to conduct inspections and investigations, communicate information to other government agencies, and verify the ownership and use of nationally tracked sources.

Natural uranium

Uranium containing the relative concentrations of isotopes found in nature (0.7 percent uranium-235, 99.3 percent uranium-238, and a trace amount of uranium-234 by mass). In terms of radioactivity, however, natural uranium contains approximately 2.2 percent uranium-235, 48.6 percent uranium-238, and 49.2 percent uranium-234. Natural uranium can be used as fuel in nuclear reactors.

Net electric generation

The gross amount of electric energy produced by a generating station, minus the amount used to operate the station. *Note*: Electricity required for pumping at pumped-storage plants is regarded as electricity for station operation and is deducted from gross generation. Net electric generation is measured in watthours (Wh), except as otherwise noted.

Net summer capacity

The steady hourly output that generating equipment is expected to supply to system load, exclusive of auxiliary power, as demonstrated by measurements at the time of peak demand (summer). Net summer capacity is measured in watts unless otherwise noted.

Nonpower reactor (research and test reactor)

A nuclear reactor that is used for research, training, or development purposes (which may include producing radioisotopes for medical and industrial uses) but has no role in producing electrical power. These reactors, which are also known as research and test reactors, contribute to almost every field of science, including physics, chemistry, biology, medicine, geology, archeology, and ecology.

NRC Operations Center

The primary center of communication and coordination among the NRC, its licensees, State and Tribal agencies, and other Federal agencies, regarding operating events involving nuclear reactors or materials. Located in Rockville, MD, the

Operations Center is staffed 24 hours a day by employees trained to receive and evaluate event reports and coordinate incident response activities.

Nuclear energy

See *Atomic energy.*

Nuclear Energy Agency (NEA)

A specialized agency within the Organisation for Economic Co-operation and Development, which was created to assist its Member countries in maintaining and further developing the scientific, technological, and legal bases for safe, environmentally friendly, and economical use of nuclear energy for peaceful purposes. The NEA's current membership consists of 28 countries in Europe, North America, and the Asia-Pacific region, which account for approximately 85 percent of the world's installed nuclear capacity.

Nuclear fuel

Fissionable material that has been enriched to a composition that will support a self-sustaining fission chain reaction when used to fuel a nuclear reactor, thereby producing energy (usually in the form of heat or useful radiation) for use in other processes.

Nuclear materials

See *Special nuclear material*, *Source material*, and *Byproduct material.*

Nuclear Material Management and Safeguards System (NMMSS)

A centralized U.S. Government database used to track and account for source and special nuclear material, to ensure that it has not been stolen or diverted to unauthorized users. The system contains current and historical data on the possession, use, and shipment of source and special nuclear material within the United States, as well as all exports and imports of such material. The database is jointly funded by the NRC and DOE and is operated under a DOE contract.

Nuclear poison (or neutron poison)

In reactor physics, a substance (other than fissionable material) that has a large capacity for absorbing neutrons in the vicinity of the reactor core. This effect may be undesirable in some reactor applications because it may prevent or disrupt the fission chain reaction, thereby affecting normal operation. However, neutron-absorbing materials (commonly known as "poisons") are intentionally inserted into some types of reactors to decrease the reactivity of their initial fresh fuel load. (Adding poisons, such as control rods or boron, is described as adding "negative reactivity" to the reactor.)

Nuclear power plant

A thermal power plant, in which the energy (heat) released by the fissioning of nuclear fuel is used to boil water to produce steam. The steam spins the propeller-like blades of a turbine that turns the shaft of a generator to produce electricity. Of the various nuclear power plant designs, only pressurized-water reactors (PWRs) and boiling-water reactors (BWRs) are in commercial operation in the United States. These facilities generate about 21 percent of U.S. electrical power.

Nuclear/Radiological Incident Annex

An annex to the National Response Framework, which provides for a timely, coordinated response by Federal agencies to nuclear or radiological accidents or incidents within the United States. This annex covers radiological dispersal devices and improvised nuclear devices, as well as accidents involving commercial reactors or weapons production facilities, lost radioactive sources, transportation accidents involving radioactive material, and foreign accidents involving nuclear or radioactive material.

Nuclear reactor

The heart of a nuclear power plant or nonpower reactor, in which nuclear fission may be initiated and controlled in a self-sustaining chain reaction to generate energy or produce useful radiation. Although there are many types of nuclear reactors, they all incorporate certain essential features, including the use of fissionable material as fuel, a moderator (such as water) to increase the likelihood of fission (unless reactor operation relies on fast neutrons), a reflector to conserve escaping neutrons, coolant provisions for heat removal, instruments for monitoring and controlling reactor operation, and protective devices (such as control rods and shielding).

Nuclear waste

A subset of radioactive waste that includes unusable byproducts produced during the various stages of the nuclear fuel cycle, including extraction, conversion, and enrichment of uranium; fuel fabrication; and use of the fuel in nuclear reactors. Specifically, these stages produce a variety of nuclear waste materials, including uranium mill tailings, depleted uranium, and spent (depleted) fuel, all of which are regulated by the NRC. (By contrast, "radioactive waste" is a broader term, which includes all wastes that contain radioactivity, regardless of how they are produced. It is not considered "nuclear waste" because it is not produced through the nuclear fuel cycle and is generally not regulated by the NRC.)

Occupational dose

The internal and external dose of ionizing radiation received by workers in the course of employment in such areas as fuel cycle facilities, industrial radiography, nuclear medicine, and nuclear power plants. These workers are exposed to varying amounts of radiation, depending on their jobs and the sources with which they work. The NRC requires its licensees to limit occupational exposure to 5,000 mrem (50 mSv) per year. Occupational dose does not include the dose received from natural background sources, doses received as a medical patient or participant in medical research programs, or "second-hand doses" received through exposure to individuals treated with radioactive materials.

Organisation for Economic Co-operation and Development (OECD)

An intergovernmental organization (based in Paris, France) which provides a forum for discussion and cooperation among the governments of industrialized countries committed to democracy and the market economy. The primary goal of the OECD and its member countries is to support sustainable economic growth, boost employment, raise living standards, maintain financial stability, assist other countries' economic development, and contribute to growth in world trade. In addition, the OECD is a reliable source of comparable statistics and economic and social data.

The OECD also monitors trends, analyzes and forecasts economic developments, and researches social changes and evolving patterns in trade, environment, agriculture, technology, taxation, and other areas.

Orphan sources (unwanted radioactive material)

Sealed sources of radioactive material contained in a small volume (but not radioactively contaminated soils and bulk metals) in any one or more of the following conditions:

- An uncontrolled condition that requires removal to protect public health and safety from a radiological threat
- A controlled or uncontrolled condition, for which a responsible party cannot be readily identified
- A controlled condition, compromised by an inability to ensure the continued safety of the material (e.g., the licensee may have few or no options to provide for safe disposition of the material)
- An uncontrolled condition, in which the material is in the possession of a person who did not seek, and is not licensed, to possess it
- An uncontrolled condition, in which the material is in the possession of a State radiological protection program solely to mitigate a radiological threat resulting from one of the above conditions, and for which the State does not have the necessary means to provide for the appropriate disposition of the material

Outage

The period during which a generating unit, transmission line, or other facility is out of service. Outages may be forced or scheduled, and full or partial.

Outage (forced)

The shutdown of a generating unit, transmission line, or other facility for emergency reasons, or a condition in which the equipment is unavailable as a result of an unanticipated breakdown. An outage (whether full, partial, or attributable to a failed start) is considered “forced” if it could not reasonably be delayed beyond 48 hours from identification of the problem, if there had been a strong commercial desire to do so. In particular, the following problems may result in forced outages:

- Any failure of mechanical, fuel handling, or electrical equipment or controls within the generator’s ownership or direct responsibility (i.e., from the point the generator is responsible for the fuel through to the electrical connection point)
- A failure of a mine or fuel transport system dedicated to that power station with a resulting fuel shortage that cannot be economically managed
- Inadvertent or operator error
- Limitations caused by fuel quality

Forced outages do not include scheduled outages for inspection, maintenance, or refueling.

Outage (full forced)

A forced outage that causes a generating unit to be removed from the Committed state (when the unit is electrically connected and generating or pumping) or the Available state (when the unit is available for dispatch as a generator or pump but is not electrically connected and not generating or pumping). Full-forced outages do not include failed starts.

Outage (scheduled)

The shutdown of a generating unit, transmission line, or other facility for inspection, maintenance, or refueling, which is scheduled well in advance (even if the schedule changes). Scheduled outages do not include forced outages and could be deferred if there were a strong commercial reason to do so.

Pellet, fuel

A thimble-sized ceramic cylinder (approximately 3/8-inch in diameter and 5/8-inch in length), consisting of uranium (typically uranium oxide, UO_2), which has been enriched to increase the concentration of uranium-235 (U-235) to fuel a nuclear reactor. Modern reactor cores in pressurized-water reactors (PWRs) and boiling-water reactors (BWRs) may contain up to 10 million pellets, stacked in the fuel rods that form fuel assemblies.

Performance-based regulation

A regulatory approach that focuses on desired, measurable outcomes, rather than prescriptive processes, techniques, or procedures. Performance-based regulation leads to defined results without specific direction regarding how those results are to be obtained. At the NRC, performance-based regulatory actions focus on identifying performance measures that ensure an adequate safety margin and offer incentives for licensees to improve safety without formal regulatory intervention by the agency.

Performance indicator

A quantitative measure of a particular attribute of licensee performance that shows how well a plant is performing when measured against established thresholds. Licensees submit their data quarterly; the NRC regularly conducts inspections to verify the submittals and then uses its own inspection data plus the licensees' submittals to assess each plant's performance.

Possession-only license

A license, issued by the NRC, that authorizes the licensee to possess specific nuclear material but does not authorize its use or the operation of a nuclear facility.

Power uprate

The process of increasing the maximum power level a commercial nuclear power plant may operate. This power level, regulated by the NRC, is included in the plant's operating license and technical specifications. A licensee may only change its maximum power output after the NRC approves an uprate application. The NRC analyses must demonstrate that the plant could continue to operate safely with its proposed new configuration. When all requisite conditions are fulfilled, the NRC may grant the power uprate by amending the plant's operating license and technical specifications.

Pressurized-water reactor (PWR)

A common nuclear power reactor design in which very pure water is heated to a very high temperature by fission, kept under high pressure (to prevent it from boiling), and converted to steam by a steam generator (rather than by boiling, as in a boiling-water reactor). The resulting steam is used to drive turbines, which activate generators to produce electrical power. A pressurized-water reactor (PWR) essentially operates like a pressure cooker, where a lid is tightly placed over a pot of heated water, causing the pressure inside to increase as the temperature increases (because the steam cannot escape) but keeping the water from boiling at the usual 212°F (100°C). About two-thirds of the operating nuclear reactor power plants in the United States are PWRs.

Probabilistic risk assessment (PRA)

A systematic method for assessing three questions that the NRC uses to define "risk." These questions consider (1) what can go wrong, (2) how likely it is, and (3) what its consequences might be. These questions allow the NRC to understand likely outcomes, sensitivities, areas of importance, system interactions, and areas of uncertainty, which the staff can use to identify risk-significant scenarios. The NRC uses PRA to determine a numeric estimate of risk to provide insights into the strengths and weaknesses of the design and operation of a nuclear power plant.

Production expense

Production expense is one component of the cost of generating electric power, which includes costs associated with fuel, as well as plant operation and maintenance.

Rad (radiation absorbed dose)

One of the two units used to measure the amount of radiation absorbed by an object or person, known as the "absorbed dose," which reflects the amount of energy that radioactive sources deposit in materials through which they pass. The radiation-absorbed dose (rad) is the amount of energy (from any type of ionizing radiation) deposited in any medium (e.g., water, tissue, air). An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy (a small but measurable amount) as a result of exposure to radiation. The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Radiation, ionizing

A form of radiation, which includes alpha particles, beta particles, gamma rays and x-rays, neutrons, high-speed electrons, and high-speed protons. Compared to non-ionizing radiation, such as found in ultraviolet light or microwaves, ionizing radiation is considerably more energetic. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to break molecular bonds and displace (or remove) electrons. This electron displacement may lead to changes in living cells. Given this ability, ionizing radiation has a number of beneficial uses, including treating cancer or sterilizing medical equipment. However, ionizing radiation is potentially harmful if not used correctly, and high doses may result in severe skin or tissue damage. It is for this reason that the NRC strictly regulates commercial and institutional uses of the various types of ionizing radiation.

Radiation, nuclear

Energy given off by matter in the form of tiny fast-moving particles (alpha particles, beta particles, and neutrons) or pulsating electromagnetic rays or waves (gamma rays) emitted from the nuclei of unstable radioactive atoms. All matter is composed of atoms, which are made up of various parts; the nucleus contains minute particles called protons and neutrons, and the atom's outer shell contains other particles called electrons. The nucleus carries a positive electrical charge, while the electrons carry a negative electrical charge. These forces work toward a strong, stable balance by getting rid of excess atomic energy (radioactivity). In that process, unstable radioactive nuclei may emit energy, and this spontaneous emission is called nuclear radiation. All types of nuclear radiation are also ionizing radiation, but the reverse is not necessarily true; for example, x-rays are a type of ionizing radiation, but they are not nuclear radiation because they do not originate from atomic nuclei. In addition, some elements are naturally radioactive, as their nuclei emit nuclear radiation as a result of radioactive decay, but others become radioactive by being irradiated in a reactor. Naturally occurring nuclear radiation is indistinguishable from induced radiation.

Radiation source

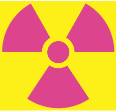
A radioactive material or byproduct that is specifically manufactured or obtained for the purpose of using the emitted radiation. Such sources are commonly used in teletherapy or industrial radiography; in various types of industrial gauges, irradiators, and gamma knives; and as power sources for batteries (such as those used in spacecraft). These sources usually consist of a known quantity of radioactive material, which is encased in a manmade capsule, sealed between layers of nonradioactive material, or firmly bonded to a nonradioactive substrate to prevent radiation leakage. Other radiation sources include devices such as accelerators and x-ray generators.

Radiation standards

Exposure limits; permissible concentrations; rules for safe handling; and regulations regarding receipt, possession, use, transportation, storage, disposal, and industrial control of radioactive material.

Radiation therapy (radiotherapy)

The therapeutic use of ionizing radiation to treat disease in patients. Although most radiotherapy procedures are intended to kill cancerous tissue or reduce the size of a tumor, therapeutic doses may also be used to reduce pain or treat benign conditions. For example, intervascular brachytherapy uses radiation to treat clogged blood vessels. Other common radiotherapy procedures include gamma stereotactic radiosurgery (gamma knife), teletherapy, and iodine treatment to correct an overactive thyroid gland. These procedures use radiation sources, regulated by the NRC and its Agreement States, that may be applied either inside or outside the body. In either case, the goal of radiotherapy is to deliver the required therapeutic or pain-relieving dose of radiation with high precision and for the required length of time, while preserving the surrounding healthy tissue.



Radiation warning symbol

An officially prescribed magenta or black trefoil on a yellow background, which must be displayed where certain quantities of radioactive materials are present or where certain doses of radiation could be received.

Radioactive contamination

Undesirable radioactive material (with a potentially harmful effect) that is either airborne or deposited in (or on the surface of) structures, objects, soil, water, or living organisms (people, animals, or plants) in a concentration that may harm people, equipment, or the environment.

Radioactive decay

The spontaneous transformation of one radioisotope into one or more different isotopes (known as "decay products" or "daughter products"), accompanied by a decrease in radioactivity (compared to the parent material). This transformation takes place over a defined period of time (known as a "half-life"), as a result of electron capture; fission; or the emission of alpha particles, beta particles or photons (gamma radiation or x-rays) from the nucleus of an unstable atom. Each isotope in the sequence (known as a "decay chain") decays to the next until it forms a stable, less energetic end product. In addition, radioactive decay may refer to gamma-ray and conversion electron emission, which only reduces the excitation energy of the nucleus.

Radioactivity

The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) of an unstable atom. Radioactivity is also the term used to describe the rate at which radioactive material emits radiation. Radioactivity is measured in units of Becquerels or disintegrations per second.

Radiography

The use of sealed sources of ionizing radiation for nondestructive examination of the structure of materials. When the radiation penetrates the material, it produces a shadow image by blackening a sheet of photographic film that has been placed behind the material, and the differences in blackening suggest flaws and unevenness in the material.

Radioisotope (Radionuclide)

An unstable isotope of an element that decays or disintegrates spontaneously, thereby emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

Radiopharmaceutical

A pharmaceutical drug that emits radiation and is used in diagnostic or therapeutic medical procedures. Radioisotopes that have short half-lives are generally preferred to minimize the radiation dose to the patient and the risk of prolonged exposure. In most cases, these short-lived radioisotopes decay to stable elements within minutes, hours, or days, allowing patients to be released from the hospital in a relatively short time.

Reactor core

The central portion of a nuclear reactor, which contains the fuel assemblies, water, and control mechanisms, as well as the supporting structure. The reactor core is where fission takes place.

Reactor Oversight Process (ROP)

The process by which the NRC monitors and evaluates the performance of commercial nuclear power plants. Designed to focus on those plant activities that are most important to safety, the process uses inspection findings and performance indicators to assess each plant's safety performance.

Regulation

The governmental function of controlling or directing economic entities through the process of rulemaking and adjudication.

Regulatory Information Conference (RIC)

An annual NRC conference that brings together NRC staff, regulated utilities, materials users, and other interested stakeholders to discuss nuclear safety topics and significant and timely regulatory activities through informal dialogue to ensure an open regulatory process.

REM (Roentgen equivalent man)

One of the two standard units used to measure the dose equivalent (or effective dose), which combines the amount of energy (from any type of ionizing radiation) that is deposited in human tissue), along with the medical effects of the given type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Thus, the dose equivalent (in rems) is equal to the absorbed dose (in rads) multiplied by the quality factor of the type of radiation (Title 10 of the *Code of Federal Regulations*, Section 20.1004, "Units of Radiation Dose"). The related international system unit is the sievert (Sv) , where 100 rem is equivalent to 1 Sv.

Renewable resources

Natural, but limited, energy resources that can be replenished, including biomass, hydro, geothermal, solar, and wind. These resources are virtually inexhaustible but limited in the amount of energy that is available per unit of time. In the future, renewable resources could also include the use of ocean thermal, wave, and tidal action technologies. Utility renewable resource applications include bulk electricity generation, onsite electricity generation, distributed electricity generation, nongrid-connected generation, and demand-reduction (energy efficiency) technologies. The Information Digest has included conventional hydroelectric and storage hydroelectric in a separate category from other resources.

Risk

The combined answer to three questions that consider (1) what can go wrong, (2) how likely it is, and (3) what its consequences might be. These three questions allow the NRC to understand likely outcomes, sensitivities, areas of importance, system interactions, and areas of uncertainty, which can be used to identify risk-significant scenarios.

Risk-based decisionmaking

An approach to regulatory decisionmaking that considers only the results of a probabilistic risk assessment.

Risk-informed decisionmaking

An approach to regulatory decisionmaking, in which insights from probabilistic risk assessment are considered with other engineering insights.

Risk-informed regulation

An approach to regulation taken by the NRC, which incorporates an assessment of safety significance or relative risk. This approach ensures that the regulatory burden imposed by an individual regulation or process is appropriate to its importance in protecting the health and safety of the public and the environment.

Risk-significant

"Risk-significant" can refer to a facility’s system, structure, component, or accident sequence that exceeds a predetermined limit for contributing to the risk associated with the facility. The term also describes a level of risk exceeding a predetermined "significance" level.

Safeguards

The use of material control and accounting programs to verify that all special nuclear material is properly controlled and accounted for, as well as the physical protection (or physical security) equipment and security forces. As used by the International Atomic Energy Agency, this term also means verifying that the peaceful use commitments made in binding nonproliferation agreements, both bilateral and multilateral, are honored.

Safeguards information (SGI)

A special category of sensitive unclassified information that must be protected. Safeguards information concerns the physical protection of operating power reactors, spent fuel shipments, strategic special nuclear material, or other radioactive material.

Safety-related

In the regulatory arena, this term applies to systems, structures, components, procedures, and controls (of a facility or process) that are relied upon to remain functional during and following design-basis events. Their functionality ensures that key regulatory criteria, such as levels of radioactivity released, are met. Examples of safety-related functions include shutting down a nuclear reactor and maintaining it in a safe-shutdown condition.

Safety-significant

When used to qualify an object, such as a system, structure, component, or accident sequence, this term identifies that object as having an impact on safety, whether determined through risk analysis or other means, that exceeds a predetermined significance criterion.

SAFSTOR
A method of decommissioning in which a nuclear facility is placed and maintained in a condition that allows the facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use.

Scram
The sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. Also known as a "reactor trip," "scram" is actually an acronym for "safety control rod axe man," the worker assigned to insert the emergency rod on the first reactor (the Chicago Pile) in the United States.

Sensitive unclassified nonsafeguards information (SUNSI)
Information that is generally not publicly available and that encompasses a wide variety of categories, such as proprietary information, personal and private information, or information subject to attorney-client privilege.

Shutdown
A decrease in the rate of fission (and heat/energy production) in a reactor (usually by the insertion of control rods into the core).

Source material
Uranium or thorium, or any combination thereof, in any physical or chemical form, or ores that contain, by weight, one-twentieth of one percent (0.05 percent) or more of (1) uranium, (2) thorium, or (3) any combination thereof. Source material does not include special nuclear material.

Special nuclear material
Plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235.

Spent fuel pool
An underwater storage and cooling facility for spent (depleted) fuel assemblies that have been removed from a reactor.

Spent (depleted or used) nuclear fuel
Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction.

Subcriticality
The condition of a nuclear reactor system, in which nuclear fuel no longer sustains a fission chain reaction (that is, the reaction fails to initiate its own repetition, as it would in a reactor's normal operating condition). A reactor becomes subcritical

when its fission events fail to release a sufficient number of neutrons to sustain an ongoing series of reactions, possibly as a result of increased neutron leakage or poisons.

Teletherapy

Treatment in which the source of the therapeutic radiation is at a distance from the body. Because teletherapy is often used to treat malignant tumors deep within the body by bombarding them with a high-energy beam of gamma rays (from a radioisotope such as cobalt-60) projected from outside the body, it is often called "external beam radiotherapy."

Title 10 of the *Code of Federal Regulations* (10 CFR)

Four volumes of the *Code of Federal Regulations* (CFR) address energy-related topics. Parts 1 to 199 contain the regulations (or rules) established by the NRC. These regulations govern the transportation and storage of nuclear materials; use of radioactive materials at nuclear power plants, research and test reactors, uranium recovery facilities, fuel cycle facilities, waste repositories, and other nuclear facilities; and use of nuclear materials for medical, industrial, and academic purposes.

Transient

A change in the reactor coolant system temperature, pressure, or both, attributed to a change in the reactor's power output. Transients can be caused by (1) adding or removing neutron poisons, (2) increasing or decreasing electrical load on the turbine generator, or (3) accident conditions.

Transuranic waste

Material contaminated with transuranic elements–artificially made, radioactive elements, such as neptunium, plutonium, americium, and others–that have atomic numbers higher than uranium in the periodic table of elements. Transuranic waste is primarily produced from recycling spent fuel or using plutonium to fabricate nuclear weapons.

Tritium

A radioactive isotope of hydrogen. Because it is chemically identical to natural hydrogen, tritium can easily be taken into the body by any ingestion path. It decays by emitting beta particles and has a half-life of about 12.5 years.

Uprate

See Power uprate.

Uranium

A radioactive element with the atomic number 92 and, as found in natural ores, an atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (which comprises 0.7 percent of natural uranium), which is fissile, and uranium-238 (99.3 percent of natural uranium), which is fissionable by fast neutrons and is fertile, meaning that it becomes fissile after absorbing one neutron. Natural uranium also includes a minute amount of uranium-234.

Uranium fuel fabrication facility

A facility that converts enriched uranium hexafluoride (UF_6) into fuel for commercial light-water power reactors, research and test reactors, and other nuclear reactors. The UF_6, in solid form in containers, is heated to a gaseous form and then chemically processed to form uranium dioxide (UO_2) powder. This powder is then processed into ceramic pellets and loaded into metal tubes, which are subsequently bundled into fuel assemblies. Fabrication also can involve Mixed oxide (MOX) fuel, which contains plutonium oxide mixed with either natural or depleted uranium oxide, in ceramic pellet form.

Uranium hexafluoride production facility (or uranium conversion facility)

A facility that receives natural uranium in the form of ore concentrate (known as "yellowcake") and converts it into uranium hexafluoride (UF_6), in preparation for fabricating fuel for nuclear reactors.

U.S. Department of Energy (DOE)

The Federal agency established by Congress to advance the national, economic, and energy security of the United States, among other missions.

U.S. Department of Homeland Security (DHS)

The Federal agency responsible for leading the unified national effort to secure the U.S. against those who seek to disrupt the American way of life. DHS is also responsible for preparing for and responding to all hazards and disasters and includes the formerly separate Federal Emergency Management Agency, the Coast Guard, and the Secret Service.

U.S. Environmental Protection Agency (EPA)

The Federal agency responsible for protecting human health and safeguarding the environment. The EPA leads the Nation's environmental science, research, education, and assessment efforts to ensure that efforts to reduce environmental risk are based on the best available scientific information. The EPA also ensures that environmental protection is an integral consideration in U.S. policies.

Viability assessment

A decisionmaking process used by the DOE to assess the prospects for safe and secure permanent disposal of high-level radioactive waste in an excavated, underground facility, known as a geologic repository. This decisionmaking process is based on (1) specific design work on the critical elements of the repository and waste package, (2) a total system performance assessment that will describe the probable behavior of the repository, (3) a plan and cost estimate for the work required to complete the license application, and (4) an estimate of the costs to construct and operate the repository.

Waste, radioactive

Radioactive materials at the end of their useful life or in a product that is no longer useful and requires proper disposal.

Waste classification (classes of waste)

Classification of low-level radioactive waste according to its radiological hazard. The classes include Class A, B, and C, with Class A being the least hazardous and accounting for 96 percent of LLW. As the waste class and hazard increase, the regulations established by the NRC require progressively greater controls to protect the health and safety of the public and the environment.

Watt

A unit of power (in the international system of units) defined as the consumption or conversion of one joule of energy per second. In electricity, a watt is equal to current (in amperes) multiplied by voltage (in volts).

Watthour

An unit of energy equal to one watt of power steadily supplied to, or taken from, an electrical circuit for one hour (or exactly $3.6x10^3$ J).

Well-logging

All operations involving the lowering and raising of measuring devices or tools that contain licensed nuclear material or are used to detect licensed nuclear materials in wells for the purpose of obtaining information about the well or adjacent formations that may be used in oil, gas, mineral, groundwater, or geological exploration.

Wheeling service

The movement of electricity from one system to another over transmission facilities of intervening systems. Wheeling service contracts can be established between two or more systems.

Yellowcake

The solid form of mixed uranium oxide, which is produced from uranium ore in the uranium recovery (milling) process. The material is a mixture of uranium oxides, which can vary in proportion and color from yellow to orange to dark green (blackish) depending on the temperature at which the material is dried (which affects the level of hydration and impurities), with higher drying temperatures producing a darker and less soluble material. (The yellowcake produced by most modern mills is actually brown or black, rather than yellow, but the name comes from the color and texture of the concentrates produced by early milling operations.) Yellowcake is commonly referred to as U_3O_8, because that chemical compound comprises approximately 85 percent of the yellowcake produced by uranium recovery facilities, and that product is then transported to a uranium conversion facility, where it is transformed into uranium hexafluoride (UF_6), in preparation for fabricating fuel for nuclear reactors.

WEB LINK INDEX

NRC: AN INDEPENDENT REGULATORY AGENCY

Mission, Goals, and Statutory Authority

Strategic Plan FY 2008-2013
www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1614/v4/sr1614v4.pdf

Statutory Authority
www.nrc.gov/about-nrc/governing-laws.html

Major Activities

Public Involvement
www.nrc.gov/public-involve.html

Freedom of Information Act (FOIA)
www.nrc.gov/reading-rm/foia/foia-privacy.html

Agency Rulemaking Actions
www.regulations.gov

Organizations and Functions

Organization Chart
www.nrc.gov/about-nrc/organization/nrcorg.pdf

The Commission
www.nrc.gov/about-nrc/organization/commfuncdesc.html

Commission Direction-Setting and Policymaking Activities
www.nrc.gov/about-nrc/policymaking.html

NRC Regions
www.nrc.gov/about-nrc/locations.html

NRC Budget

Performance Budget: Fiscal Year 2009 (NUREG-1100, Vol. 24)
www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1100/v24/

U.S. AND WORLDWIDE ENERGY

U.S. Electricity

Energy Information Administration
Official Energy Statistics from the U.S. Government
www.eia.doe.gov

Worldwide Electricity and Nuclear Power

International Atomic Energy Agency (IAEA)
www.iaea.org

IAEA Power Reactor Information System (PRIS)
www.iaea.org/programmes/a2

Nuclear Energy Agency (NEA)
www.nea.fr/

World Nuclear Association (WNA)
www.world-nuclear.org/

World Nuclear Power Reactors 2006-08 and Uranium Requirements
www.world-nuclear.org/info/reactors.html

WNA Reactor Database
www.world-nuclear.org/reference/default.aspx

WNA Global Nuclear Reactors Map
www.wano.org.uk/WANO_Documents/WANO_Map/WANO_Map.pdf

NRC Office of International Programs
www.nrc.gov/about-nrc/organization/oipfuncdesc.html

NRC 20th Regulatory Information Conference (RIC)
www.nrcric.org

International Activities

Treaties and Conventions
www.nrc.gov/about-nrc/ip/treaties-conventions.html

OPERATING NUCLEAR REACTORS

U.S. Commercial Nuclear Power Reactors

Commercial Reactors
www.nrc.gov/info-finder/reactor/

Oversight of U.S. Commercial Nuclear Power Reactors

Reactor Oversight Process (ROP)
www.nrc.gov/NRR/OVERSIGHT/ASSESS/index.html

NUREG-1649, “Reactor Oversight Process”
www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1649/r4/

ROP Performance Indicators Summary
www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi_summary.html

Future U.S. Commercial Nuclear Power Reactor Licensing

New Reactor License Process
www.nrc.gov/reactors/new-reactor-op-lic/licensing-process.html#licensing

New Reactors

New Reactor Licensing
www.nrc.gov/reactors/new-reactor-licensing.html

Reactor License Renewal

Reactor License Renewal Process
www.nrc.gov/reactors/operating/licensing/renewal/process.html

10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions"
www.nrc.gov/reading-rm/doc-collections/cfr/part051/

10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants"
www.nrc.gov/reading-rm/doc-collections/cfr/part054/

Status of License Renewal Applications and Industry Activities
www.nrc.gov/reactors/operating/licensing/renewal/applications.html

U.S. Nuclear Research and Test Reactors

Research and Test Reactors
www.nrc.gov/reactors/non-power.html

Nuclear Regulatory Research

Nuclear Reactor Safety Research
www.nrc.gov/about-nrc/regulatory/research/reactor-rsch.html

State-of-the-Art Reactor Consequence Analyses (SOARCA)
www.nrc.gov/about-nrc/regulatory/research/soar.html

Risk Assessment in Regulation
www.nrc.gov/about-nrc/regulatory/risk-informed.html

Digital Instrumentation and Controls
www.nrc.gov/about-nrc/regulatory/research/digital.html

Computer Codes
www.nrc.gov/about-nrc/regulatory/research/comp-codes.html

Generic Issues Program
www.nrc.gov/about-nrc/regulatory/gen-issues.html

The Committee To Review Generic Requirements (CRGR)
www.nrc.gov/about-nrc/regulatory/crgr.html

NUCLEAR MATERIALS

U.S. Fuel Cycle Facilities

U.S. Fuel Cycle Facilities
www.nrc.gov/info-finder/materials/fuel-cycle/

Uranium Recovery

Uranium Milling/Recovery
www.nrc.gov/info-finder/materials/uranium/

U.S. Materials Licenses

Materials Licensees Toolkits
www.nrc.gov/materials/miau/mat-toolkits.html

Medical Applications

Medical Applications
www.nrc.gov/materials/medical.html

Medical Uses

Medical Uses
www.nrc.gov/materials/miau/med-use.html

Nuclear Gauges and Commercial Product Irradiators

General Licenses Uses
www.nrc.gov/materials/miau/general-use.html

Industrial Uses of Nuclear Material

Industrial Applications
www.nrc.gov/materials/miau/industrial.html

Exempt Consumer Products
www.nrc.gov/materials/miau/consumer-pdts.html

RADIOACTIVE WASTE

U.S. Low-Level Radioactive Waste Disposal

Low-Level Radioactive Waste
www.nrc.gov/waste/low-level-waste.html

U.S. High-Level Radioactive Waste Management: Disposal and Storage

High-Level Radioactive Waste
www.nrc.gov/waste/high-level-waste.html

Spent Nuclear Fuel Storage

Spent Nuclear Fuel Storage
www.nrc.gov/waste/spent-fuel-storage.html

U.S. Nuclear Materials Transportation

Nuclear Materials Transportation
www.nrc.gov/materials/transportation.html

Decommissioning

Decommissioning
www.nrc.gov/about-nrc/regulatory/decommissioning.html

NUCLEAR SECURITY AND EMERGENCY PREPAREDNESS

Nuclear Security
(www.nrc.gov/security.html)

Domestic Safeguards

Domestic Safeguards
www.nrc.gov/security/domestic.html

Information Security

Information Security
www.nrc.gov/security/info-security.html

Assuring the Security of Radioactive Material
www.nrc.gov/security/byproduct.html

Emergency Preparedness and Response

Emergency Preparedness and Response
www.nrc.gov/about-nrc/emerg-preparedness.html

Research and Test Reactor Emergency Preparedness

Research and Test Reactors
www.nrc.gov/reactors/non-power.html

Stakeholder Meetings and Workshops

www.nrc.gov/public-involve/public-meetings/stakeholder-mtngs-wksps.html

Emergency Action Level Development

www.nrc.gov/about-nrc/emerg-preparedness/emerg-action-level-dev.html

Hostile Action Based Emergency Preparedness (EP) Drill

www.nrc.gov/about-nrc/emerg-preparedness/respond-to-emerg/hostile-action.html

Exercise Schedules

NRC Participation Exercise Schedule
www.nrc.gov/about-nrc/emerg-preparedness/exercise-schedules.html

Biennial FEMA-Graded Exercise Schedule
www.nrc.gov/about-nrc/emerg-preparedness/exercise-schedules/bi-annual-ex-schedule.html

OTHER WEB LINKS

Employment Opportunities

NRC–*A Great Place to Work*
www.nrc.gov/about-nrc/employment.html

Glossary

NRC Basic References
www.nrc.gov/reading-rm/basic-ref/glossary/full-text.html

Glossary of Electricity Terms

www.eia.doe.gov/cneaf/electricity/epav1/glossary.html

Glossary of Security Terms

https://hseep.dhs.gov/DHSResource/Glossary.aspx

Public Involvement

Electronic Reading Room
www.nrc.gov/reading-rm.html

Freedom of Information & Privacy Act
www.nrc.gov/reading-rm/foia/foia-privacy.html

Agencywide Documents Access Management System (ADAMS)
www.nrc.gov/reading-rm/adams.html

Public Meeting Schedule
www.nrc.gov/public-involve/public-meetings/index.cfm

Documents for Comments
www.nrc.gov/public-involve/doc-comment.html

Small Business and Civil Rights

Contracting Opportunities for Small Businesses
www.nrc.gov/about-nrc/contracting/small-business.html

Workplace Diversity
www.nrc.gov/about-nrc/employment/diversity.html

Discrimination Complaint Activity
www.nrc.gov/about-nrc/civil-rights.html

Equal Employment Opportunity Program
www.nrc.gov/about-nrc/civil-rights/eeo.html

Limited English Proficiency
www.nrc.gov/about-nrc/civil-rights/limited-english.html

Minority Serving Institutions Program
www.nrc.gov/about-nrc/grants.html#msip

NRC Comprehensive Diversity Management Plan brochure
www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0316

NRC Mentoring Program
www.nrc.gov/about-nrc/employment/diversity.html/

INDEX

NRC FORM 335
(9-2004)
NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER **(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)**

NUREG-1350, Vol. 21

2. TITLE AND SUBTITLE

U.S. Nuclear Regulatory Commission
Information Digest
2009-2010

3. DATE REPORT PUBLISHED

MONTH	YEAR
August	2009

4. FIN OR GRANT NUMBER

n/a

5. AUTHOR(S)

Ivonne Couret, et al.

6. TYPE OF REPORT

Annual

7. PERIOD COVERED *(Inclusive Dates)*

2008

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Public Affairs Staff
Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Same as 8, above

10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

The U.S. Nuclear Regulatory Commission (NRC) 2009–2010 Information Digest provides a summary of information about the NRC. It describes the agency's regulatory responsibilities and licensing activities and also provides general information on related topics.

To create the Information Digest, the agency compiled and organized NRC- and industry-related data into a quick reference on the agency and the industry it regulates. Data include activities through 2008 or the most current data available at manuscript completion. The NRC Web Link Index provides URL addresses for more information on major topics. Also available in the digest is a tear-out reference sheet with NRC Facts at a Glance. (In this edition, adjustments were made to previous year figures based on preliminary data. All information is final unless otherwise noted.)

The NRC reviewed information from industry sources but did not perform an independent verification.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Information Digest
2009-2010 Edition
NRC Facts
Nuclear Regulatory Commission

13. AVAILABILITY STATEMENT

unlimited

14. SECURITY CLASSIFICATION

(This Page)
unclassified

(This Report)
unclassified

15. NUMBER OF PAGES

190

16. PRICE

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC FACTS AT A GLANCE
AS OF JUNE 30, 2009

MISSION

The mission of the U.S. Nuclear Regulatory Commission is to license and regulate the Nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment.

COMMISSION

Chairman Gregory B. Jaczko
Term expires June 30, 2013
Commissioner Dale E. Klein
Term expires June 30, 2011
Commissioner Kristine L. Svinicki
Term expires June 30, 2012

NRC BUDGET

- Total authority: $1,046 million
- Total staff: 3,848
- Budget amount expected to be recovered by annual fees to licensees: $870.6 million
- NRC research program support: $64.5 million

NRC REGULATORY ACTIVITIES

- Regulation and guidance–rulemaking
- Policymaking
- Licensing, decommissioning, and certification
- Research
- Oversight
- Emergency preparedness and response
- Support of Commission decisions

NRC GOVERNING LEGISLATION

The NRC was established by the Energy Reorganization Act of 1974. A summary of laws that govern the agency's operations is provided below. The text of other laws may be found in NUREG-0980, "Nuclear Regulatory Legislation."

FUNDAMENTAL LAWS GOVERNING CIVILIAN USES OF RADIOACTIVE MATERIALS

Nuclear Materials and Facilities

- Atomic Energy Act of 1954, as amended
- Energy Reorganization Act of 1974

Radioactive Waste

- Nuclear Waste Policy Act of 1982, as amended
- Low-Level Radioactive Waste Policy Amendments Act of 1985
- Uranium Mill Tailings Radiation Control Act of 1978

Non-Proliferation

- Nuclear Non-Proliferation Act of 1978

FUNDAMENTAL LAWS GOVERNING THE PROCESSES OF REGULATORY AGENCIES

- Administrative Procedure Act (5 U.S.C. Chapters 5 through 8)
- National Environmental Policy Act
- Diplomatic Security and Anti-Terrorism Act of 1986
- Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990
- Energy Policy Act of 1992 Provisions
- Energy Policy Act of 2005

TREATIES AND AGREEMENTS

- Nuclear Non-Proliferation Treaty
- International Atomic Energy Agency/U.S. Safeguards Agreement
- Convention on the Physical Protection of Nuclear Material
- Convention on Early Notification of a Nuclear Accident
- Convention on Assistance in Case of a Nuclear Accident and Radiological Emergency
- Convention on Nuclear Safety
- Convention on Supplemental Liability and Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

U.S. COMMERCIAL NUCLEAR POWER REACTORS

- 20 percent of Nation's electricity is generated by nuclear power plants
- 104 nuclear power plants licensed to operate in the United States
  - 69 pressurized-water reactors (PWRs)
  - 35 boiling-water reactors (BWRs)
- 4 reactor fuel vendors
- 26 parent companies
- 80 different designs
- 65 commercial reactor sites
- 14 decommissioning power reactors
- Total inspection hours: 6,055 in calendar year 2008 at operating reactors; approximately 3,000 source documents concerning events reviewed

Reactor License Renewal

Commercial power reactor operating licenses are valid for 40 years and may be renewed for up to an additional 20 years.

- 30 sites and 52 units with renewal licenses issued at operating nuclear plants
- 13 sites with license renewal applications in review
- 18 sites with letters of intent for renewal licenses applications

NEW REACTOR LICENSE PROCESS

Early Site Permit (ESP)

- 3 ESPs issued
- 1 ESP application in review

Construction and Operating License (COL)

- 18 COL applications received/docketed for units
- 1 COL application in acceptance review

Reactor Design Certification (DC)

- 4 DCs issued
- 4 DCs in review

Nuclear Research and Test Reactors

- 43 licensed research reactors and test reactors
  - 32 reactors operating in 22 States
  - 11 reactors permanently shut down and in various stages of decommissioning (Since 1958, a total of 82 licensed research and test reactors have been decommissioned.)

NRC FACTS AT A GLANCE (Continued)

NUCLEAR SECURITY AND SAFEGUARDS

- Once every 2 years, each nuclear power plant performs full-scale emergency preparedness exercises.
- Plants also conduct additional emergency drills between full-scale exercises. The NRC evaluates all emergency exercises and drills.

PUBLIC MEETINGS AND INVOLVEMENT

- The NRC conducts 900 public meetings annually.
- The NRC hosts both the Regulatory Information Conference (RIC) and the Fuel Cycle Information Exchange (FCIX) where participants discuss the latest technical issues.

NEWS AND INFORMATION

NRC news releases are available through a free listserv subscription at www.nrc.gov/public-involve/listserver.html.

NUCLEAR MATERIALS

- The NRC and the Agreement States issue approximately 22,500 licenses for medical, academic, industrial, and general uses of nuclear materials.
- The NRC administers approximately 3,400 licenses.
- 36 Agreement States administer approximately 19,100 licenses.

15 Uranium Recovery Sites (4 sites are NRC licensed)

- 4 in situ recovery
- 11 conventional recovery
- 5 applications for new recovery sites
- 3 applications for restart/expansion of recovering sites

14 Fuel Cycle Facilities

- 1 uranium hexafluoride production facility
- 6 uranium fuel fabrication facilities
- 2 gaseous diffusion uranium enrichment facilities (1 in cold standby)
- 3 gas centrifuge uranium enrichment facilities, and of the 3, 2 are under construction and 1 is under review.
- 1 mixed oxide fuel fabrication facility (under review)
- 1 laser enrichment facility proposed
- 180 NRC-licensed facilities authorized to possess plutonium and enriched uranium with inventory registered in the Nuclear Materials Management and Safeguards System database

RADIOACTIVE WASTE

Low-Level Radioactive Waste

- 10 regional compacts (exclusion of waste generated outside a compact)
- 3 active licensed disposal facilities
- 4 closed disposal facilities

High-Level Radioactive Waste Management

Disposal and Storage

- On June 3, 2008, the U.S. Department of Energy (DOE) submitted a license application to the NRC. DOE is seeking authorization to construct a deep geologic repository for disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain, NV. The NRC is reviewing that application and evaluating a wide range of technical and scientific issues. The NRC will issue a construction authorization only if DOE can demonstrate that it can safely construct and operate the repository in compliance with the NRC's regulations. The review process is expected to take up to 4 years.
- The Nuclear Waste Policy Act of 1982, as amended, defines the roles of the three Federal agencies responsible for nuclear waste. DOE is responsible for developing permanent disposal capacity for spent fuel and other high-level radioactive waste. The U.S. Environmental Protection Agency (EPA) is responsible for developing environmental standards to evaluate the safety of a geologic repository. The NRC is responsible for developing regulations to implement the EPA safety standards and for licensing the repository.

Spent Nuclear Fuel Storage

- 54 licensed/operating independent spent fuel storage installations
- 15 site-specific licenses
- 39 general licenses

Transportation—Principal Licensing and Inspection Activities

- The NRC examines transport-related safety during approximately 1,000 safety inspections of fuel, reactor, and materials licensees annually.
- The NRC reviews, evaluates, and certifies approximately 80 new, renewal, or amended container-design applications for the transport of nuclear materials annually.
- The NRC reviews and evaluates approximately 150 license applications for the import/export of nuclear materials from the United States annually.
- The NRC inspects about 20 dry storage and transport package licensees annually.

Decommissioning

Approximately 200 material licenses are terminated each year. NRC's decommissioning program focuses on the termination of licenses that are not routine and that require complex activities.

- 14 nuclear power reactors
- 11 research and test reactors
- 14 complex decommissioning materials facilities
- 1 fuel cycle facility (partial decommissioning)
- 11 uranium recovery facilities in safe storage under NRC jurisdiction

AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at NRC's Public Electronic Reading Room at http://www.nrc.gov/reading-rm.html. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and *Title 10, Energy*, in the Code of *Federal Regulations* may also be purchased from one of these two sources.

1. The Superintendent of Documents
   U.S. Government Printing Office
   Mail Stop SSOP
   Washington, DC 20402–0001
   Internet: bookstore.gpo.gov
   Telephone: 202-512-1800
   Fax: 202-512-2250
2. The National Technical Information Service
   Springfield, VA 22161–0002
   www.ntis.gov
   1–800–553–6847 or, locally, 703–605–6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:

Address: U.S. Nuclear Regulatory Commission
Office of Administration
Mail, Distribution and Messenger Team
Washington, DC 20555-0001
E-mail: DISTRIBUTION@nrc.gov
Facsimile: 301–415–2289

Some publications in the NUREG series that are posted at NRC's Web site address http://www.nrc.gov/reading-rm/doc-collections/nuregs are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, and transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—

The NRC Technical Library
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852–2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—

American National Standards Institute
11 West 42nd Street
New York, NY 10036–8002
www.ansi.org
212–642–4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG–XXXX) or agency contractors (NUREG/CR–XXXX), (2) proceedings of conferences (NUREG/CP–XXXX), (3) reports resulting from international agreements (NUREG/IA–XXXX), (4) brochures (NUREG/BR–XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG–0750).

U.S. Nuclear Regulatory Commission

NUREG-1350, Volume 21
August 2009