

Decommissioning Nuclear Power Plants

When a power company decides to close its nuclear power plant permanently, the facility must be decommissioned by safely removing it from service and reducing residual radioactivity to a level that permits release of the property and termination of the operating license. The Nuclear Regulatory Commission has strict rules governing nuclear power plant decommissioning, involving cleanup of radioactively contaminated plant systems and structures and removal of the radioactive fuel. These requirements protect workers and the public during the entire decommissioning process and the public after the license is terminated.

Discussion

Licensees may choose from three alternative decommissioning strategies: DECON, SAFSTOR, or ENTOMB.

Under DECON (immediate dismantling), soon after the nuclear facility closes, equipment, structures, and portions of the facility containing radioactive contaminants are removed or decontaminated to a level that permits release of the property and termination of the NRC license.

Under SAFSTOR, often considered “deferred dismantling,” a nuclear facility is maintained and monitored in a condition that allows the radioactivity to decay; afterwards, it is dismantled and the property decontaminated.

Under ENTOMB, radioactive contaminants are permanently encased on site in structurally sound material such as concrete and appropriately maintained and monitored until the radioactivity decays to a level permitting restricted release of the property. To date, no NRC-licensed facilities have requested this option.

The licensee may also choose to adopt a combination of the first two choices in which some portions of the facility are dismantled or decontaminated while other parts of the facility are left in SAFSTOR. The decision may be based on factors besides radioactive decay such as availability of waste disposal sites.



Demolition of a Reactor Containment Building

To be acceptable, decommissioning must be completed within 60 years of the plant ceasing operations. A time beyond that would be considered only when necessary to protect public health and safety in accordance with NRC regulations.

Regulations

The requirements for decommissioning a nuclear power plant are set out in NRC regulations (Title 10 of the Code of Federal Regulations, Part 20 Subpart E, and Parts 50.75, 50.82, 51.53, and 51.95). In August 1996, a revised rule went into effect that redefined the decommissioning process and required owners to provide the NRC with early notification of planned decommissioning activities. The rule allows no major decommissioning activities to be undertaken until after certain information has been provided to the NRC and the public.

Decommissioning Funds

Each nuclear power plant licensee must report to the NRC every two years the status of its decommissioning funding for each reactor or share of a reactor that it owns. The report must estimate the minimum amount needed for decommissioning by using the formulas found in 10 CFR 50.75(c). Licensees may alternatively determine a site-specific funding estimate, provided that amount is greater than the generic decommissioning estimate. Although there are many factors that affect reactor decommissioning costs, generally they range from \$300 million to \$400 million. Approximately 70 percent of licensees are authorized to accumulate decommissioning funds over the operating life of their plants. These owners – generally traditional, rate-regulated electric utilities or indirectly regulated generation companies – are not required today to have all of the funds needed for decommissioning. The remaining licensees must provide financial assurance through other methods such as prepaid decommissioning funds and/or a surety method or guarantee. The staff performs an independent analysis of each of these reports to determine whether licensees are providing reasonable “decommissioning funding assurance” for radiological decommissioning of the reactor at the permanent termination of operation.

Before a nuclear power plant begins operations, the licensee must establish or obtain a financial mechanism – such as a trust fund or a guarantee from its parent company – to ensure that there will be sufficient money to pay for the ultimate decommissioning of the facility.

Public Involvement

Several opportunities are provided for public involvement during the decommissioning process. A public meeting is held in the vicinity of the facility after submittal of a post-shutdown decommissioning activities report (PSDAR) to the NRC. Another public meeting is held when NRC receives the license termination plan (LTP). An opportunity for a public hearing is provided prior to issuance of a license amendment approving the LTP or any other license amendment request. In addition, when NRC holds a meeting with the licensee, members of the public may observe the meeting (except when the discussion involves proprietary, sensitive, safeguards, or classified information).



Improving the Decommissioning Program

Several nuclear power plants completed decommissioning in the 1990s without a viable option for disposing of their spent nuclear fuel, because the federal government did not construct a geologic repository as planned. Accordingly, the NRC implemented regulations allowing licensees to sell off part of their land once it meets NRC release criteria, while maintaining a small parcel under license for storing the spent fuel. These stand-alone facilities, called “independent spent fuel storage installations” (ISFSIs), remain under license and NRC regulation. Licensees are responsible for security and for maintaining insurance and funding for eventual decommissioning.

As more facilities complete decommissioning, the NRC is implementing “lessons learned” in order to improve the program and focus on the prevention of future legacy sites. Applications for new reactors must now describe how design and operations will minimize contamination during the plant’s operating life and facilitate eventual decommissioning. New regulations published in 2010 require plant operators to be more vigilant in preventing contamination during operations and to clean up and monitor any contamination that does occur.

Phases of Decommissioning

The requirements for power reactor decommissioning activities may be divided into three phases: (1) initial activities; (2) major decommissioning and storage; and (3) license termination activities.

1) Initial Activities

When a nuclear power plant licensee shuts down the plant permanently, it must submit a written certification of permanent cessation of operations to the NRC within 30 days. When radioactive nuclear fuel is permanently removed from the reactor vessel, the owner must submit another written certification to the NRC, surrendering its authority to operate the reactor or load fuel into the reactor vessel. This eliminates the obligation to adhere to certain requirements needed only during reactor operation.



Removal of Contamination on Nuclear Plant Wall

Within two years after submitting the certification of permanent closure, the licensee must submit a post-shutdown decommissioning activities report (PSDAR) to the NRC. This report provides a description of the planned decommissioning activities, a schedule for accomplishing them, and an estimate of the expected costs. The PSDAR must discuss the reasons for concluding that environmental impacts associated with the site-specific decommissioning activities have already been addressed in previous environmental analyses. Otherwise, the licensee must request a license amendment for approval of the activities and submit to the NRC a report on the additional impacts of decommissioning on the environment.

After receiving a PSDAR, the NRC publishes a notice of receipt in the *Federal Register*, makes the report available for public review and comment, and holds a public meeting in the vicinity of the plant to discuss the licensee’s intentions.

2) Major Decommissioning Activities

Ninety days after the NRC receives the PSDAR, the owner can begin major decommissioning activities without specific NRC approval. These include permanent removal of such major components as the reactor vessel, steam generators, large piping systems, pumps, and valves.

However, decommissioning activities conducted without specific prior NRC approval must not prevent release of the site for possible unrestricted use, result in there being no reasonable assurance that adequate funds will be available for decommissioning, or cause any significant environmental impact not previously reviewed. If any decommissioning activity does not meet these terms, the licensee is required to submit a license amendment request, which would provide an opportunity for a public hearing.

Initially, the owner can use up to 3 percent of its set-aside funds for decommissioning planning. The remainder becomes available 90 days after submittal of the PSDAR unless the NRC staff has raised objections.

3) License Termination Activities

The owner is required to submit a LTP within two years of the expected license termination. The plan addresses each of the following: site characterization, identification of remaining site dismantlement activities, plans for site remediation, detailed plans for final radiation surveys for release of the site, method for demonstrating compliance with the radiological criteria for license termination, updated site-specific estimates of remaining decommissioning costs, and a supplement to the environmental report that describes any new information or significant environmental changes associated with the owner's proposed termination activities. Most plans envision releasing the site to the public for *unrestricted use*, meaning any residual radiation would be below NRC's limits of 25 millirem annual exposure and there would be no further regulatory controls by the NRC. Any plan proposing release of a site for *restricted use* must describe the site's end use, documentation on public consultation, institutional controls, and financial assurance needed to comply with the requirements for license termination for restricted release.



**A Steam Generator is Removed
from a Reactor Building**

The LTP requires NRC approval of a license amendment. Before approval can be given, an opportunity for hearing is published and a public meeting is held near the plant site.

The NRC uses a standard review plan (NUREG-1700, "Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans") to ensure high quality and uniformity of LTP reviews. The standard review plan is available to the public so that NRC's review process is understood clearly.

If the remaining dismantlement has been performed in accordance with the approved LTP and the termination survey demonstrates that the facility and site are suitable for release, the NRC issues a letter terminating the operating license.

The following table lists those plants that have been permanently shut down. The section following the table describes work underway at 14 of these plants that are currently in some phase of the decommissioning process.

Decommissioning Status for Shut Down NRC-Licensed Power Reactors

(As of April 2013)

Reactor	Type	Thermal Power	Location	Ceased Operations	Status	Fuel Onsite
Big Rock Point	BWR	67 MW	Charlevoix, MI	08/29/97	ISFSI Only *	Yes
Crystal River 3	PWR	2,609MW	Crystal River, FL	02/20/13	SAFSTOR	Yes
Dresden 1	BWR	700 MW	Morris, IL	10/31/78	SAFSTOR	Yes
Fermi 1	Fast Breeder	200 MW	Monroe Co., MI	09/22/72	SAFSTOR	No
Fort St. Vrain	HTGR	842 MW	Platteville, CO	08/18/89	ISFSI Only	Yes
GE VBWR	BWR	50 MW	Alameda Co., CA	12/09/63	SAFSTOR	No
Haddam Neck	PWR	1825 MW	Haddam Neck, CT	12/09/96	ISFSI Only	Yes
Humboldt Bay 3	BWR	200 MW	Eureka, CA	07/02/76	DECON	Yes
Indian Point 1	PWR	615 MW	Buchanan, NY	10/31/74	SAFSTOR	Yes
LaCrosse	BWR	165 MW	LaCrosse, WI	04/30/87	DECON	Yes
Main Yankee	PWR	2772 MW	Bath, ME	12/06/96	ISFSI Only	Yes
Millstone 1	BWR	2011 MW	Waterford, CT	07/21/88	SAFSTOR	Yes
N.S. Savannah	PWR	80 MW	Norfolk, VA	11/70	SAFSTOR	No
Pathfinder	Superheat BWR	190 MW	Sioux Falls, SD	09/16/67	License Terminated	No
Peach Bottom 1	HTGR	115 MW	York Co., PA	10/31/74	SAFSTOR	No
Rancho Seco	PWR	2772 MW	Sacramento, CA	06/07/89	ISFSI Only**	Yes
San Onofre 1	PWR	1347 MW	San Clemente, CA	11/30/92	SAFSTOR	Yes
Saxton	PWR	28 MW	Saxton, PA	05/01/72	License Terminated	No
Shoreham	BWR	2436 MW	Suffolk Co., NY	06/28/89	License Terminated	No
Three Mile Island 2	PWR	2772 MW	Middletown, PA	03/28/79	SAFSTOR**	No
Trojan	PWR	3411 MW	Portland, OR	11/09/92	ISFSI Only	Yes
Yankee Rowe	PWR	600 MW	Franklin Co., MA	10/01/91	ISFSI Only	Yes
Zion 1 and 2	PWR	3250 MW	Zion, IL	02/21/97 09/19/96	DECON	Yes

☐ Decommissioning completed

* An independent spent fuel storage installation (ISFSI) is a stand-alone facility within the plant boundary constructed for the interim storage of spent nuclear fuel. ISFSI Only means the plant license has been reduced to include only the spent fuel storage facility.

** Rancho Seco has a low-level waste storage facility in addition to its ISFSI.

*** Post-defueling monitored storage (PDMS).

Power Reactors in the Decommissioning Process

Current updates of all power reactor sites undergoing decommissioning are available at:

<http://www.nrc.gov/info-finder/decommissioning/power-reactor/>.

Crystal River Unit 3

Crystal River 3, in Crystal River, Fla., entered an extended shutdown in 2009 when cracks were discovered in the wall of its containment structure. In February 2013, Duke Energy decided not to attempt costly repairs and certified to the NRC that the plant had permanently ceased operations and that the fuel had been permanently removed from the reactor.

Dresden Unit 1

The plant, near Morris, Ill., shut down in October 1978 and is currently in SAFSTOR. The decommissioning plan (DP) was approved in September 1993. No significant dismantlement activities are underway. Isolation of Unit 1 from Units 2 and 3 is complete. All spent fuel from Unit 1 that was previously stored in the Unit 1 spent fuel pool (SFP), the Unit 1 fuel transfer pool, and the Unit 2 SFP has now been transferred to the on-site independent spent fuel storage installation (ISFSI). Currently, 108 spent fuel assemblies and one fuel rod basket from Unit 1 are stored in the Dresden Unit 3 SFP. The licensee plans to have decontamination and dismantlement of Unit 1 take place from 2029 through 2031 when Units 2 and 3 are nearing the end of their life. Following decontamination and dismantlement of Units 2 and 3, site restoration will be conducted in 2035 and 2036, with final site surveys to be performed in late 2036.

Fermi Unit 1

The plant, in Monroe County, Mich., was shut down in September 1972 and is currently in SAFSTOR. The spent fuel, reactor vessel, piping, bulk sodium and liquid waste tanks have been removed from the site. The licensee is performing occupational safety enhancement activities, concentrating in non-radioactive areas, such as asbestos removal. The PSDAR public meeting was held on April 22, 1998.

Ge- Vbwr (Vallecitos Boiling Water Reactor)

The plant, in Alameda County, Calif., was shut down in December 1963 and issued a possession-only license in 1965. The plant is in SAFSTOR and plans to remain in SAFSTOR until ongoing nuclear activities at the site are terminated and the entire site can be decommissioned. All nuclear fuel has been removed from the site.

Humboldt Bay - Unit 3

The plant, near Eureka, Calif., was shut down in July 1976. A Decommissioning Plan (DP) was approved in July 1988 – currently called a Defueled Safety Analysis Report, it is updated every two years. A post-shutdown activities report (PSDAR) was issued by the licensee in February 1998. The transfer of spent

fuel from the fuel storage pool to the ISFSI was completed in December 2008 and limited decontamination and dismantlement of HBPP Unit 3 decommissioning commenced. In 2010, the construction of a new fossil-fueled generation station on site was completed. The licensee has completed demolition of the non-nuclear Unit 1 and Unit 2. A license termination plan was submitted in May 2013.

Indian Point - Unit 1

The plant, in Buchanan, N.Y., was shut down in October 1974. Currently, there is no significant dismantlement underway. The owner plans to decommission Unit 1 concurrently with Unit 2, which remains in operation. The PSDAR public meeting was held on Jan. 20, 1999.

La Crosse

The plant, in La Crosse, Wis., was shut down on April 30, 1987. The SAFSTOR DP was approved Aug. 7, 1991. The DP is considered the PSDAR. The PSDAR public meeting was held on May 13, 1998. The licensee has been conducting limited dismantlement and decommissioning activities and completed transferring spent fuel to an ISFSI in September 2012.

Millstone - Unit 1

Unit 1, near Waterford, Conn., was shut down Nov. 4, 1995, and transfer of the spent fuel to the SFP was completed Nov. 19, 1995. On July 21, 1998, the licensee certified to the NRC that, as of July 17, 1998, Millstone Unit 1 had permanently ceased operations and that fuel had been permanently removed from the reactor vessel. The owner's current plan is to leave the plant in SAFSTOR until the Unit 2 license expires, which is currently scheduled for July 31, 2015. The owner submitted its required PSDAR on June 14, 1999, and has chosen a combination of the DECON and SAFSTOR options.

Safety-related structures, systems, and components (SSCs) remaining at Millstone Unit 1 are associated with the SFP "island" where the Millstone Unit 1 spent fuel is stored. Other than non-essential systems supporting the balance of plant facilities, the remaining plant equipment has been disabled and abandoned in place or removed from the unit and can no longer be used for power generation.

NS Savannah

The ship was removed from service in 1970 and its fuel removed in October 1971. The reactor is currently in SAFSTOR. The Nuclear Ship (NS) Savannah was removed from the Maritime Administration Reserve Fleet in the James River, Va. In May 2008, the NS Savannah was relocated from the Hampton Roads area of Virginia to Baltimore, Md. The Department of Transportation plans to complete decommissioning and terminate the license by 2031.

Peach Bottom - Unit 1

The plant, in York County, Pa., was shut down in October 1974 and is in SAFSTOR with no significant dismantlement underway. Active decommissioning of Unit 1 is not expected until 2034, when Units 2 and 3 are

scheduled to shut down. The PSDAR public meeting was held on June 29, 1998. The spent fuel has been removed from the site and is stored at the Idaho National Laboratory.

San Onofre - Unit 1

Southern California Edison (SCE) shut down the reactor, located near San Clemente, in November 1992 and placed it in SAFSTOR until the planned shutdown of Units 2 and 3 in 2022. In 1998, following a change in NRC decommissioning regulations, SCE submitted a PSDAR for San Onofre Unit 1 to commence DECON in 2000. Since that time, the fuel has been placed in an ISFSI. SCE has removed all structures down to the -8' building level. In late 2008, the licensee completed Phase 2 of the planned ISFSI expansion by locating it on the former containment building site. In 2010, NRC approved SCE's request for a partial site release of the off-shore cooling pipes. The Part 50 license remaining is for the reactor pressure vessel in storage and the ISFSI.

Three Mile Island - Unit 2

The operating accident at this reactor, near Middletown, Pa., occurred in March 1979. Plant de-fueling was completed in April 1990. Post de-fueling monitored storage was approved in 1993. There is no significant dismantlement underway. The plant shares equipment with the other operating unit, which was sold to Amergen (now Exelon) in 1999. GPU Nuclear, which is owned by FirstEnergy, retains the license for Three Mile Island Unit 2 and contracts to Exelon for maintenance and surveillance activities. Both units are currently expected to be decommissioned together when Unit 1 ceases operation. The U.S. Department of Energy has taken title and possession of the spent fuel (except for some debris in the primary systems), which is currently in storage at the Idaho National Laboratory.

Zion - Units 1 And 2

Zion Units 1 and 2, near Zion, Ill., were permanently shut down on Feb.13, 1998. The fuel was transferred to the spent fuel pool, and the owner submitted the certification of fuel transfer on March 9, 1998. The licensee is maintaining the turbine-generators as synchronous condensers to support grid stability and has isolated the spent fuel pool within a fuel building "nuclear island." The owner submitted the PSDAR, site-specific cost estimate, and fuel management plan on Feb. 14, 2000. On Sept. 1, 2010, the facility license was transferred from Exelon to ZionSolutions for the express purpose of expediting decommissioning. ZionSolutions intends to use a "rip and ship" process that will reduce the labor-intensive separation of contaminated materials and transport the materials in bulk to the EnergySolutions disposal site in Utah. Completion of the spent fuel transfer to the ISFSI is scheduled for 2014. Submittal of the LTP is scheduled for 2015 and license termination in 2020.

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