

Destructive Restoration – Part 2, Nuclear

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1. Introduction

This is the second in a three-part series on the right way to decommission electric generation plants where it is no longer economical to restore, repurpose, nor continue to use them.

The first part in this series is described and linked below.

Destructive Restoration – Part 1, The Klamath: Every machine made by humans reaches the end of its useful life. This will be the first post in a short series on what should happen to electric generation projects when it is no longer economical to restore, repurpose, nor continue to use them for their intended purpose. This post is partially drawn from my deep past and partially an agreement to restore a natural resource and everything around it through the creative destruction of a series of old hydroelectric projects near the California-Oregon Border.

<https://energycentral.com/c/ec/destructive-restoration-%E2%80%93-part-1-klamath>

Also, since I know that there are large number of people that continue to support nuclear power, because it offers very low carbon generation, I need to make my position clear:

- I support continued operation of existing nuclear power plants as long as this can be done safely and economically.
- I do not support building new Gen III plants, as these have proven to be outrageously expensive compared with other alternatives (for my arguments see “Nukes” linked below).
- I do support building Small Modular Reactors like those from NuScale if these are economically competitive and functionally appropriate for a particular region (for my arguments, see Nukes part 2 and part 3 linked below).

<https://www.energycentral.com/c/cp/nukes>

<https://www.energycentral.com/c/cp/nukes-part-2-little-nukes>

<https://energycentral.com/c/cp/nukes-%E2%80%93-part-3>

Also, I will be the first to admit that politics plays major role in whether a given reactor should be built or decommissioned: it should not be otherwise. Since nuclear power plants have had several major safety incidents and economic disasters, the public in each region should vote through their representatives and utility organizations.

Many nuclear power plants in the U.S. are scheduled to be decommissioned, or they are in the decommissioning process. Thus the primary purpose of this paper is to review this process, and then review the proposed specific process for one of those reactors – PG&E’s Diablo Canyon. Decommissioning a reactor, especially fully decommissioning, without any site restrictions, is neither simple, inexpensive nor fast.

2. Early Provisions

The following text from the Nuclear Regulatory Commission (NRC) is referenced here.¹

DECOMMISSIONING FUNDS

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 there will be sufficient money to pay for the ultimate decommissioning of the facility.

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 NRC regulations. 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. 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. These reports are required annually during decommissioning so the NRC can ensure the funds are being used appropriately.

When a power company decides to close a 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 U.S. Nuclear Regulatory Commission’s rules govern nuclear power plant decommissioning to ensure cleanup of radioactively contaminated plant systems and structures and removal of the radioactive fuel. These requirements protect workers, the public and the environment during the entire decommissioning process and after the license is terminated.

Decommissioning involves active cleanup and decontamination, called DECON for short, or a combination of DECON and deferred dismantling, or SAFSTOR.

Under DECON, 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, a nuclear power plant is maintained and monitored in a condition that allows the radioactivity to decay; afterwards, the plant shifts to DECON as the facility is dismantled and the property decontaminated.

A licensee may combine these two strategies, leaving parts of the facility in SAFSTOR while actively dismantling and decontaminating other parts of the facility. The decision may be based on factors other than radioactive decay, such as the availability of waste disposal sites.

¹ U.S. NRC, “Decommissioning Nuclear Power Plants (NUREG/BR-0521, Revision 1)”, June 2017, <https://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0521/#pub-info>

A third strategy, known as ENTOMB, would encase contaminated facilities in concrete. No U.S. commercial nuclear power plant has chosen this option.

Once DECON is complete and the site meets the NRC's cleanup standards, the NRC will terminate the license and release the property for unrestricted use. A portion of the site may remain under NRC license to store the spent fuel. The licensee is responsible for maintaining and protecting the spent fuel storage facility.

Decommissioning must be completed within 60 years of the plant ceasing operations.

3. Decommissioning – General Case

The following is also from reference 1.

3.1. Initial Activities

When a nuclear power plant licensee shuts down a 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 a reactor vessel. This eliminates the obligation to adhere to certain requirements needed only during reactor operation.

Within 2 years after submitting the certification of permanent closure, the licensee must submit a post-shutdown decommissioning activities report 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...

After receiving the report, the NRC will publish a notice of receipt in the Federal Register, make the report available for public review and comment, and hold a public meeting in the vicinity of the plant to discuss the licensee's intentions.

3.2. Major Decommissioning Activities

Ninety days after the NRC receives the planning report, 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 ensure that the release of the site will allow for possible unrestricted use, result in 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 will become available 90 days after submittal of the planning report unless the NRC staff has raised objections.

3.3. License Termination Activities

The owner is required to submit a license termination plan within 2 years of the expected license termination. The plan addresses each of the following: site characterization,

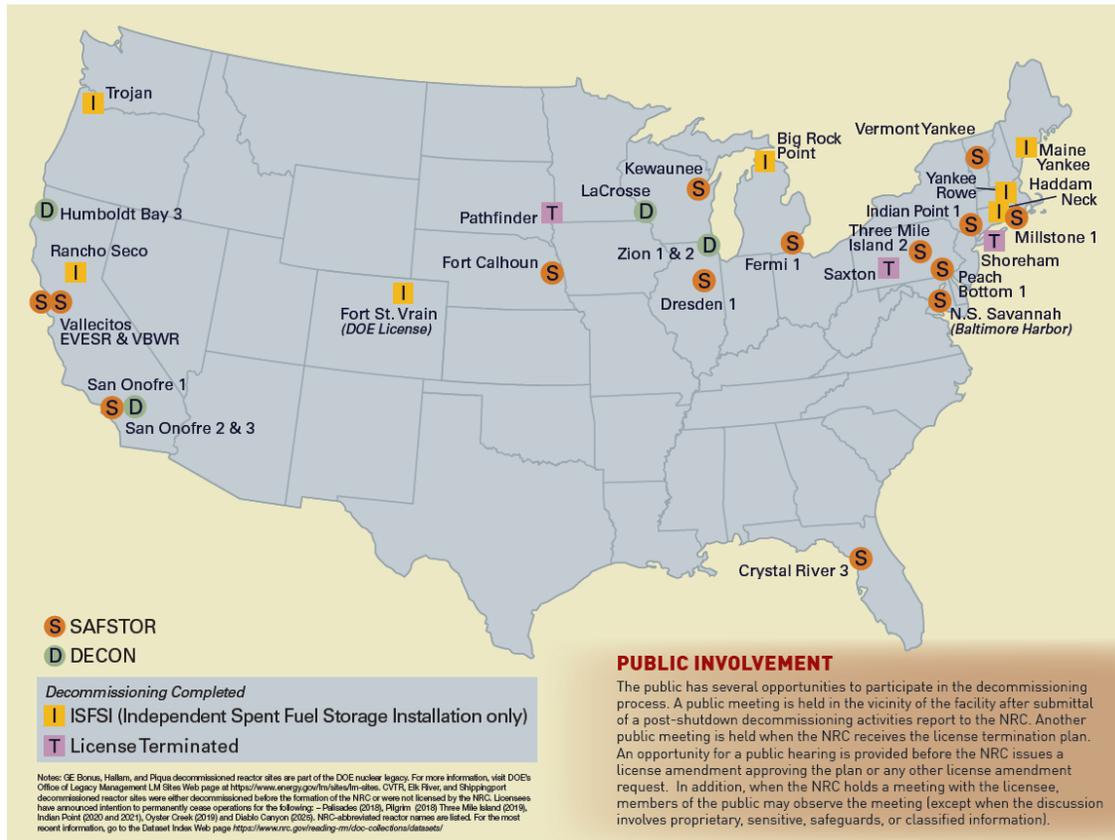
remaining site dismantlement activities, plans for site remediation, detailed plans for final radiation surveys for release of the site, updated estimates of remaining decommissioning costs, and a supplement to the environmental report describing any new information or significant environmental changes associated with the final cleanup. Most plans envision releasing the site to the public for unrestricted use, meaning any residual radiation would be below the NRC's limits of 25 millirem (see Note below) 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, public consultation, institutional controls, and financial assurance needed to comply with the requirements for license termination for restricted release.

On average, Americans receive a radiation dose of about 0.62 rem (620 millirem) each year. This is per the NRC site linked here: <https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html>

The license termination report (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.

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

The following is a map showing the status of reactors undergoing decommissioning and others that have completed decommissioning in the U.S.



4. Decommissioning the Diablo Canyon Power Plant

From Section 2 above: *“Licensees may alternatively determine a site-specific funding estimate, provided that amount is greater than the generic decommissioning estimate.”* The document referenced here² is this estimate by PG&E for Diablo Canyon Power Plant (DCPP).

This document is quite lengthy, but if a reader wants to dig into it he/she can go through the link in the above reference. The following is a summary.

The decommissioning approach that has been selected by PG&E for DCPP is the DECON method...

The decision to transition to immediate DECON is consistent with the CPUC and stakeholder preference and is also in the best interest of PG&E's customers because the total cost of decommissioning can be reduced by direct transition to decommissioning immediately upon plant shutdown. PG&E determined that immediate transition to decommissioning is more cost-effective than the SAFSTOR strategy based on the following considerations: (1) the operating licenses are terminated earlier; (2) earlier security staff and emergency plan reductions due to security modifications and earlier transfer of spent nuclear fuel (SNF) to the Diablo Canyon independent spent fuel storage installation (DC ISFSI); (3) benchmarking experience of other plants supports more efficient resolution of technical challenges; and (4) availability of experienced, in-house staff.

The cost to decommission the site, safeguard the spent fuel until it can be transferred to the Department of Energy (DOE) for storage at a permanent offsite repository, and restore the impacted area of the site is estimated to be \$5.1 billion in 2019 dollars.

PG&E commented that it did have prior decommissioning experience: *...after 10 years of full-scale decommissioning at Humboldt Bay Power Plant (HBPP) Unit 3 (see the above map).*

Typically, initial planning efforts detailing the decommissioning process can take 18 to 24 months after reactor shutdown before physical decommissioning begins. To support a direct transition to immediate DECON, PG&E plans to leverage the CPUC's early approval of DCPP shutdown in 2024 and 2025 to continue decommissioning planning and permitting activities from 2019 to 2024. The planning would streamline the decommissioning effort, reduce decommissioning costs, and accelerate the schedule by allowing the majority of physical decommissioning of portions of the site to begin shortly after the Unit 2 permanent shut down. This also would shorten the overall decommissioning schedule. Industry experience indicates that early, detailed preparation and planning reduces the duration and cost of decommissioning while enhancing safety and efficiency.

For the schedule, see the table below:

² James M. Welsch, Senior Vice President Generation and Chief Nuclear Officer, Pacific Gas & Electric, “Diablo Canyon Power Plant, Units 1 and 2 - Site-Specific Decommissioning Cost Estimate”, Dec 4, 2019, <https://diablocanyonpanel.org/wp-content/uploads/2019/12/Public-DCL-19-082.pdf>

Table 3-1: Diablo Canyon Power Plant Decommissioning Periods Summary

Period	Period Title	Period Start	Period Finish	General Description
1	Pre-Shutdown Planning	Dec 2010	Oct 2024	Consists of detailed planning, engineering, contracting, licensing, and permitting efforts.
2	Power Block Modifications	Nov 2024	Apr 2027	Transitions the plant to a decommissioning configuration to support safe and efficient decommissioning.
3	Wet Storage	May 2027	Jun 2032	Designates the timeframe where SNF is cooling in the spent fuel pools (SFPs) and/or is being transferred to the DC ISFSI. Concurrently, preparations are being made for major D&D in the next period.
4	Building Demolition	Jul 2032	Apr 2035	Consists of D&D of radiological SSCs. Also includes removal of several ancillary (non-radiological) structures.
5	Site Restoration	May 2035	Dec 2038	Includes demolition of non-radiological structures, conduct of final radiological surveys to support license termination, and restoration of non-ISFSI areas. Period ends with 10 CFR 50 license termination.
6	ISFSI Operations	Jan 2039	Aug 2067	Designates the timeframe after 10 CFR 50 license termination where SNF and GTCC waste are stored only at the DC ISFSI and transferred to the DOE for storage at a permanent offsite repository. This period also includes biological monitoring of the plant site restoration.
7	ISFSI Restoration	Sep 2067	Jan 2076	Consists of removal of ISFSI structures, permitting, conduct of final radiological surveys for ISFSI license termination, restoration of affected areas, and biological monitoring.

Reference 1, Enclosure 3

In the above table, note that D&D is decontaminate and dismantle, SSC is systems, structures, and components, and 10 CFR 50 is a section of the combined federal regulations (CFR).

GTCC is Greater than Class C (nuclear waste). GTCC waste may include transuranic radionuclides (like isotopes of plutonium) that contaminate nuclear fuel cycle waste. See the link below for more information.

<https://www.federalregister.gov/documents/2019/07/22/2019-15434/greater-than-class-c-and-transuranic-waste#:~:text=Greater-than-Class-C%20waste%20may%20include%20transuranic%20radionuclides%20%28%20e.g.%2C,draft%20regulatory%20basis%20and%20to%20facilitate%20public%20comment>

Other abbreviations were defined earlier in this section.

5. Possible Rollback

I spent much time digging into the possibility of the principals needing to delay the decommissioning of Diablo Canyon due to the need for its generation capacity after 2025.

There was one suggestion by some that I rejected pretty quickly – the possibility of someone buying this facility. Any group wanting to buy this plant would need to have very deep pockets, and prior experience in operating a nuclear power plant in order to satisfy all of the principals involved. A large majority of really large private firms would be too financially conservative to take on this risk. There are only a few large energy generation firms that own multiple existing nuclear plants:³

Dominion Resources owns three plants

Duke owns three plants and is planning to build a fourth plant

Southern Company owns three plants

UniStar Nuclear Energy (a joint venture of EdF and Constellation) owns four plants, and the principals own a fifth through another JV.

All of the above except UniStar are large southeastern regional utilities that probably don't want to have anything to do with California and our politics.

Speaking of politics, I have lived in California since 1975, and know that the chances that our political leaders will accept any agreement that would keep Diablo Canyon open for much more than five more years would be highly unlikely. This makes this plant a very unlikely acquisition target.

However, there is a distinct possibility that Diablo Canyon might get a reprieve. In a very well-written analysis of this possibility by the source referenced here⁴ is summarized below.

An assortment of entities have sought to intervene in a complaint alleging that the California Independent System Operator (CAISO) and California state agencies violated bulk power system reliability standards when they approved retirement of the 2,240-MW Diablo Canyon Power Plant (DCPP) by 2025.

Before the comment deadline on Nov. 16, at least 15 entities sought intervention in the Oct. 26 complaint filed with the Federal Energy Regulatory Commission (FERC) by nonprofit nuclear advocacy group, Californians for Green Nuclear Power Inc. (CGNP) over regulatory approvals of Pacific Gas & Electric Co. (PG&E's) voluntary plan to permanently shutter the nuclear plant near Avila Beach, California. Intervenors include nuclear advocacy organizations, trade groups, power companies, and environmental and citizen groups...

The utility reached the decision after reaching a "joint proposal" with labor and environmental groups that sought to increase investment in energy efficiency, energy storage, and renewables beyond the state's 2015 mandates to source 50% of its power from renewables, while also phasing out nuclear power in California by 2025. While the CPUC approved PG&E's application to shutter the plant in January 2018, an initiative to replace the plant's power with zero-carbon options was enshrined in state law by California's former Gov. Jerry Brown in September 2018...

³ Wikipedia article on "List of companies in the nuclear sector", https://en.wikipedia.org/wiki/List_of_companies_in_the_nuclear_sector

⁴ Sonal Patel, Power Magazine, "Battle Brewing About California's Role in Diablo Canyon Nuclear Plant Retirement", Nov 19, 2020, <https://www.powermag.com/battle-brewing-about-californias-role-in-diablo-canyon-nuclear-plant-retirement/>

The complaint also alleges NERC and the Western Electricity Coordinating Council (WECC) “failed to conduct proper oversight or enforced NERC’s reliability standards,” which “will be violated” by removing Diablo Canyon’s 2,240 MW from California’s grid. “Recent events, including the August 2020 blackouts that affected millions of California utility customers, point to the underlying reliability issue facing California’s electric grid, even with DCPD continuing to operate,” it says. “The premature closure of DCPD will only exacerbate current reliability issues, and is inconsistent with federal law.” ...

CAISO, notably, cited the extreme weather and elevated load shedding risks when it requested an intervention by the Department of Energy in September. The agency responded with a rare but drastic emergency order under Federal Power Act Section 202(c) that authorized the maximum operation of three natural gas-fired facilities on CAISO’s grid whose full capability had been stranded by federal air quality and other permits.

California’s goal today is to procure 60% of its electricity from renewable resources by 2030, and source 100% clean energy by 2045. Currently, the state has 13.3 GW of installed large-scale solar and 6.98 GW of wind generation, which are “non-firm renewable generation resource,” the complaint notes.

Although the above action, at best, would only delay Diablo’s closure, I would suggest that this is something that should be considered. However the following points should be noted.

The “August 2020 blackouts...” noted above were caused by an extremely rare weather event / sequence. I posted a brief write-up on this at that time (described and linked below).

New Role for Regional Grid Managers: Last weekend there was a major lightning storm in and around the San Francisco Bay Area. This post contains the whole story, and a new role that grid managers should perform to evaluate the future likelihood of similar perfect storms.

<https://energycentral.com/c/gr/new-role-regional-grid-mangers>

Although it is possible that climate change may make similar events more common, this has yet to be determined.

California has an extremely aggressive schedule to achieve ...60% of its electricity from renewable resources by 2030, and source 100% clean energy by 2045. I believe they will achieve this, mainly by adding increasingly cost-effective large Battery Energy Storage Systems .However it is reasonable to question this.