DOCKETED	
Docket Number:	21-ESR-01
Project Title:	Resource Planning and Reliability
TN #:	258248
Document Title:	CEC Staff Report
Description:	Diablo Canyon Power Plant Operations Assessment Report - 2024 Update Senate Bill 846
Filer:	susan fleming
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	7/31/2024 3:50:58 PM
Docketed Date:	7/31/2024

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

STAFF REPORT

Diablo Canyon Power Plant Operations Assessment Report – 2024 Update

Senate Bill 846

July 2024| CEC-700-2024-006

California Energy Commission

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ABSTRACT

The Diablo Canyon Power Plant Operation Assessment report addresses a requirement in Senate Bill 846 (Dodd, Chapter 239, Statutes of 2022) for the California Energy Commission, in coordination with the California Public Utilities Commission and the California Independent System Operator, to publish an assessment of the operation of the Diablo Canyon Power Plant, on or before July 1, 2023, and on July 1 of each year thereafter until 2031. The assessment includes outage information, power plant operational costs, average revenues from electricity sales, worker attrition, and the contribution of the power plant to resource adequacy requirements. This report serves as the July 2024 update.

Keywords: Diablo Canyon, operations assessment, Senate Bill No. 846, outage, refueling, operational costs, worker attrition, resource adequacy

Turner, Michael. 2024. *Diablo Canyon Power Plant Operations Assessment Report, Senate Bill 846, 2024 Update*. California Energy Commission. Publication Number: CEC-700-2024-006.

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EXECUTIVE SUMMARY

The Diablo Canyon Power Plant in San Luis Obispo County is owned and operated by Pacific Gas and Electric Company and, since 2012, is the last operating nuclear power plant in California. The Diablo Canyon Power Plant consists of two nuclear reactors (Units 1 and 2) that began operation in May 1985 and March 1986, respectively. The Diablo Canyon Power Plant produces about 18,000 gigawatt-hours of electricity annually, which is about 9 percent of California's annual in-state electricity generation. The Diablo Canyon Power Plant's original operating licenses issued by the U.S. Nuclear Regulatory Commission expire November 2024 for Unit 1 and August 2025 for Unit 2.

The 100 Percent Clean Energy Act of 2018 (Senate Bill 100, De León, Chapter 312, Statutes of 2018) establishes a target for renewable and zero-carbon resources to supply 100 percent of retail sales and electricity procured to serve all state agencies by 2045. Actions to achieve the goals of SB 100 are resulting in the unprecedented buildout of clean energy resources, primarily solar and energy storage at utility scale. Risks to the timely buildout of these resources at the scale required include supply chain issues and delays in interconnection and permitting.

Due to the Diablo Canyon Power Plant providing roughly 2,280 megawatts of capacity at peak and net-peak times and the potential challenges in developing new clean energy projects, Senate Bill 846 (Dodd, Chapter 239, Statutes of 2022) was passed to provide a path to extend Diablo Canyon Power Plant operations beyond 2025 if it is needed to support grid reliability.

Based on a thorough analysis, the California Energy Commission determined that it is prudent for the state to pursue extension of the Diablo Canyon Power Plant. This determination is driven by the risk that sufficient clean electricity resources may not be built in time to reach the ordered procurement and to address potential grid demands in extreme heat events associated with climate change.

In December 2023, the California Public Utilities Commission (CPUC) voted to conditionally approve (D23-12-036) an extension of the Diablo Canyon Power Plant. This decision directs and authorizes extended operations at Diablo Canyon Power Plant until October 31, 2029 (Unit 1), and October 31, 2030 (Unit 2).

The Nuclear Regulatory Commission is reviewing Pacific Gas and Electric Company's license renewal application, which would grant a 20-year extension to the plant if approved. However, SB 846, as well as the California Public Utilities Commission's recent conditional approval, only provide a path for five-year extensions for Diablo Canyon Power Plant Units 1 and 2.

The Diablo Canyon Power Plant Operation Assessment Report, published by the CEC in July 2023, addressed a requirement in SB 846 for the CEC, in coordination with the CPUC and the California Independent System Operator, to publish an assessment of the operation of the Diablo Canyon Power Plant that includes outage information, power plant operational costs, average revenues from electricity sales, worker attrition, and the contribution of the power plant to resource adequacy requirements.

SB 846 also requires the CEC to publish an update to the original 2023 report on July 1 of each year thereafter until 2031. This report serves as the July 2024 update.

CHAPTER 1: Introduction

The Diablo Canyon Power Plant (DCPP) near San Luis Obispo is owned and operated by Pacific Gas and Electric Company (PG&E). DCPP produces about 18,000 gigawatt-hours (GWh) of electricity annually, which is about 9 percent of California's in-state generation. The two reactor units are licensed by the United States Nuclear Regulatory Commission (NRC) to operate until November 2, 2024 (Unit 1), and August 26, 2025 (Unit 2).[1] The NRC has given permission for Units 1 and 2 to operate past their original termination dates pending evaluation of the relicensing application.

However, due to DCPP providing roughly 2,280 megawatts of capacity at peak and net-peak times and the various challenges in developing new clean energy projects, Senate Bill (SB) 846 (Dodd, Chapter 239, Statutes of 2022) was passed to provide a path to extend DCPP operations beyond 2025 if it is needed to support grid reliability.

Based on a thorough analysis, the California Energy Commission (CEC) determined that it is prudent for the state to pursue extension of DCPP. This determination is driven by the risk that sufficient clean electricity resources may not be built in time to reach the ordered procurement and address potential grid demands in extreme heat events associated with climate change.

In December 2023, the California Public Utilities Commission (CPUC) voted to approve an extension of DCPP's license (Decision (D.) 23-12-036).[2] This decision directs and authorizes extended operations at DCPP until October 31, 2029 (Unit 1) and October 31, 2030 (Unit 2). The approval in this decision is subject to the following conditions:

- The NRC authorizes DCPP to continue to operate under its current licenses past their expiration dates.
- The $1.4 billion loan agreement authorized by SB 846 is not terminated.
- CPUC does not make a future determination that DCPP extended operations are imprudent or unreasonable.

The NRC is reviewing PG&E's license renewal application (LRA), which was submitted in November 2023. If approved, the LRA would grant a 20-year extension to the DCPP. In

1 California Energy Commission staff. 2023. *Final Commission Report, Diablo Canyon Power Plant Extension, CEC Analysis of Need to Support Reliability.* Publication Number: CEC-200-2023-004, https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-ESR-01.

2 California Public Utilities Commission. 2023. *Decision Conditionally Approving Extended Operations At Diablo Canyon Nuclear Power Plant Pursuant to Senate Bill 846*, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M521/K424/521424048.pdf

general, NRC aims to complete license renewal reviews within 18 months of receipt of an application; however, longer durations can occur if adjudicatory hearings are necessary.[3]

SB 846 provides a path for only five-year extensions for DCPP Units 1 and 2. An NRC license extension in excess of five years would not alter the authority of SB 846. Therefore, assuming NRC approves PG&E's license renewal application, any operations beyond five years would still require additional authorization from the California Legislature. Moreover and consistent with SB 846, the CPUC's recent conditional authorization of a five-year extension explicitly states that operations are authorized only through October 31, 2029 (Unit 1), and October 31, 2030 (Unit 2).

PG&E's pursuance of a 20-year extension is a cost-saving measure as NRC's standard license extension is 20 years. Requesting a shorter five-year duration would require a special exemption from NRC. Its review system is set up to evaluate license extension applications based on a 20-year time frame, and any deviation from that would likely require the development of updated criteria at additional cost. Thus, pursuing a 20-year extension is less expensive and less complicated than pursuing a 5-year extension and does not relieve PG&E of its obligation under state law to close the plant after just five years.

Operations Assessment Report Update

In 2022, Senate Bill 846 (SB 846, Dodd, Chapter 239, Statutes of 2022)[4] was enacted. SB 846 added Section 25233.2(d) of the Public Resources Code to state:

> On or before July 1, 2023, and on July 1 of each year thereafter until 2031, the commission, in coordination with the Public Utilities Commission [CPUC] and the Independent System Operator [California ISO], shall publish on its internet website in a new report, or as part of another report, an assessment of the operation of the Diablo Canyon powerplant [DCPP]. The report shall include, but not be limited to, outage information, powerplant operational costs, average revenues from electricity sales, worker attrition, and the powerplant's contribution to resource adequacy requirements.

This annual update provides an assessment of DCPP operations occurring since the publication of the first DCPP Operation Assessment Report (CEC-700-2023-005),[5] in July 2023

This annual update includes new information related to:

- Outage information.

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3 United States Nuclear Regulatory Agency staff. 2022. *Backgrounder on Reactor License Renewal,.* https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-reactor-license-renewal.html.

4 Dodd, Bill. 2002. California Senate Bill No. 846, Diablo Canyon Power Plant: Extension of Operations, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB846.

5 California Energy Commission staff. 2023. *Diablo Canyon Power Plant Operations Assessment Report*. Publication Number: CEC-700-2023-005, https://www.energy.ca.gov/publications/2023/diablo-canyon-power-plant-operations-assessment-report.

- Power plant operational costs.
- Revenues from electricity sales.
- Worker attrition.
- Contribution to resource adequacy.

CHAPTER 2:
Diablo Canyon Power Plant Operations Assessment

Outage Information

DCPP schedules outages to permit refueling of the reactors, along with maintenance, inspections, and modifications. However, on occasion, a forced outage (manual maintenance outage) is required when a system is operating outside acceptable limits.

Refueling Outages

Unit 2 recently completed refueling outage 2R23 in October 2022, the results of which were presented at the February 15 and 16, 2023, Diablo Canyon Independent Safety Committee (DCISC) public meeting held in Avila Beach. Refueling outage 1R24 occurred for Unit 1 in October 2023, the results of which were presented at the DCISC public meeting on February 21 and 22, 2024. Unit 2 refueling outage 2R24 started on April 06, 2024.

Maintenance and Forced Outages

Maintenance of the reactor systems are typically planned to occur during refueling outages to minimize the time the reactors are offline. On occasion, a forced outage (manual maintenance outage) is required when a system is operating outside acceptable limits or leaks are detected in various systems. A manual maintenance outage may require a curtailment (reduction) in power production; however, curtailments may also be associated with planned maintenance events.

DCISC's thirty-third annual report[6] for plant operating period July 1, 2022, through June 30, 2023, provides the following information regarding refueling, maintenance, and forced outages.

Table 1: Power Generation-Impacting Events July 2022 –June 2023

6 Diablo Canyon Independent Safety Committee staff. 2023. *Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations*, https://www.dcisc.org/download/library/annual-reports/33rd-annual-report-71.pdf.

Unit	Date	Type	Reduced to Power Level	Event
1	1/5/23 – 1/8/23	Curtailment	50%	Main condenser pick and dredge of marine growth due to high sea swells
1	3/12/23 – 3/20/23	Curtailment	50%	Main condenser pick and dredge of marine growth and debris
2	10/15/22 – 11/24/22	Refueling Outage	Off-line	2R23 Refueling Outage
2	11/24/22 – 11/28/22	Power Ascension	Off-line to 28%	Main condenser pick and dredge of marine growth due to high sea swells
2	1/5/23 – 1/7/23	Curtailment	50%	Steam leak on a feedwater heater 1-1A valve
2	3/10/23 – 3/12/23	Curtailment	50%	Maintenance of intake biolab pump liner

Source: DCISC's thirty-third annual report, *Diablo Canyon Independent Safety Committee Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations July 1, 2022—June 30, 2023*

Outage Filings With the NRC

PG&E files outage reports with the NRC. The outage reports include descriptions of violations and associated corrective actions reported and taken by PG&E related to outages. These outage reports include licensee-revealed findings and violations. NRC-identified and self-revealed findings and violations can be found on the *Inspection Reports for Operating Power*

Reactors section of the NRC website.[7] The following definitions are provided from the NRC Inspection Manual, Chapter 0612, Issue Screening, Effective date January 1, 2020:[8]

- Licensee-identified — Licensee-identified findings and violations are (1) identified as a result of deliberate observation by licensee personnel and (2) entered into the licensee corrective action program.
- Self-revealed — Self-revealed findings or violations are those identified as a result of a condition that (1) become apparent through a readily detectable degradation in material condition, capability, or functionality of equipment or plant operations and (2) does not meet the definition of licensee-identified or NRC-identified.
- NRC-identified — NRC-identified findings or violations are found by NRC inspectors, of which the licensee was not previously aware or had not been previously documented in the licensee's corrective action program. NRC-identified findings or violations also include issues initially identified by the licensee to which the inspector has identified inadequacies in the licensee's characterization or evaluation of the issue of concern.

Licensee-identified outage related violations and their associated corrective actions identified during scheduled outages and occurring since the publishing of the initial SB 846 Operations Assessment Report are summarized below.[9]

7 United States Nuclear Regulatory Agency staff. 2024. "Inspection Reports for Operating Power Reactors," https://www.nrc.gov/reactors/operating/oversight/listofrpts-body.html#diab.

8 United States Nuclear Regulatory Agency staff. 2020. *NRC Inspection Manual, Chapter 0612, Issue Screening, Effective data January, 1, 2020*, https://www.nrc.gov/docs/ML1921/ML19214A243.pdf#:~:text=Self-revealed%20findings%20or%20violations%20are%20those%20identified%20as,not%20meet%20the%20definition%20of%20licensee-identified%20or%20NRC-identified.

9 Pacific Gas and Electric Company. 2021. "2021 Energy Resource Recovery Account Compliance Application 22-02-XXX Data Response, Question 25," https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=22-MISC-01.

Table 2: Violations and Corrective Actions

Inspection Report	Violation Description/Summary	Corrective Actions
2023-002	Failure to provide adequate written instructions while routinely swapping bio-lab pumps, to prevent simultaneous two-pump operation. This issue resulted in a failure of the PVC piping associated with the bio-lab system, subsequent flooding of circulating water pump 2-2, and ultimately resulted in Unit 2 reducing power to approximately 50 percent power.	Repaired the broken PVC pipe and implemented a design change for the pump switches. Installed signage with caution on pump operation. Revised applicable procedure to include a precaution note and steps to prevent simultaneous two-pump operation in the bio-lab system. Updated the electronic operator rounds system so if bio-lab pump switches were found in the incorrect position a status message would appear so the operator would be notified to correct the alignment of the pump switches. Revised site procedure to add instructions on PVC installation torque values.

Inspection Report	Violation Description/Summary	Corrective Actions
2023-002	The licensee failed to identify a deficient weld in reactor coolant system (RCS) pressure boundary piping during installation of a vent line in 1994. In October 2022, the licensee identified dry boric acid deposits indicating that this deficient weld had caused RCS pressure boundary leakage in the vent line connected to the Unit 2, loop 1 cold leg.	The weld repair was completed and remaining welds on the pipeline were inspected prior to returning the subject piping line to service. During the next Unit 2 refueling outage in spring 2024, PG&E plans to replace the coupled vent lines with a straight run of piping, thus eliminating the coupling and the repaired weld. Verified this issue is not applicable to Unit 1 through confirmatory inspections. Revised a site procedure to formalize independent workmanship visual inspection. Included this operating experience in plant training.
2023-003	The licensee failed to check continuity on the non-energized side of the vital bus undervoltage relay after performing relay calibrations. This failure resulted in actuation of the bus G undervoltage relay, which resulted in the unnecessary cycling of plant equipment.	Restored plant equipment to pre-event configuration and completed the procedure with additional oversight in the field.

Source: Pacific Gas and Electric Company staff, 2024

Operational Costs

The historical operating costs of the DCPP as percentages of total annual expenses are summarized in the table below. The operational costs subcategories listed below were developed by PG&E and intended to align with those used by the Electric Utility Cost Group (EUGC).

EUCG provides a professional working forum for the electric utility industry to share information to help companies improve their operating, maintenance, and construction performance.

Table 3: Operating Costs as Percentages of Total Expenses

Operational Subcategory	2020	2021	2022	2023
Engineering (%)	11.7	10.3	10.9	7.9
Fuel Management (%)	0.1	0.2	0.2	0.5
Loss Prevention (%)	19.7	18.9	19.0	12.7
Materials and Services (%)	1.2	1.3	1.9	1.3
Operations (%)	17.8	18.6	18.7	12.9
Support Services (%)	20.0	21.1	20.6	34.4
Work Management (%)	26.6	27.2	26.5	26.7
Training — Develop and Conduct (%)	2.9	2.4	2.2	3.6

Source: Pacific Gas and Electric Company staff, 2023 and 2024

Table 4 summarizes operational expenses for 2020 through 2023, as approved by the CPUC in general rate cases (GRC). GRCs are proceedings used to address the costs of operating and maintaining the utility system and the allocation of those costs among customer classes.

CPUC reviews detailed cost data for various areas of utility operations and approves a budget for the first year (test year) of the GRC cycle. For Years 2, 3, and 4 (posttest years), the GRC decision prescribes how to adjust the test year budget for inflation and other factors that may affect costs, such as additional capital projects between test years.[10]

10 California Public Utilities Commission staff. 2023. *What is a General Rate Case (GRC)?* https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-rates/general-rate-case. *Pacific Gas and Electric (PG&E) GRC Proceedings (Phase I).* https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-rates/general-rate-case/pacific-gas-and-electric-grc-proceedings

The GRC does not include nuclear fuel costs. These costs are addressed in an annual Energy Resource Recovery Account proceeding.[11]

Table 4: Operating Expenses

2020	2021	2022	2023
$1,094,915,000	$1,078,665,000	$1,068,689,000	$1,069,191,000

Source: Pacific Gas and Electric Company staff, 2023 and 2024

Revenues From Electricity Sales

DCPP earns revenue from various types of electricity sales. The majority of DCPP's electricity sales revenue comes from sales into organized markets, like the California ISO, and from capacity revenue which comes from sales to residential and commercial retail customers. Sales into organized markets are generally wholesale, and the electricity can be sold to the California ISO or another balancing authority. These two sources, market sales and retail customers, make up 85 to 90 percent of DCPP's electricity sales revenue, depending on the year. The remaining 10 to 15 percent DCPP earns is from allowing spare capacity to be dispatched to meet load demands. Table 5 below summarizes the annual revenues from 2020 through 2023.

Table 5: Annual Revenues from DCPP for 2020–2023

Year	2020	2021	2022	2023
Electricity Sales into Organized Markets	$475,048, 391	$819,754, 590	$1,485,696,233	$980,840,452
$/MWh	$29.16	$49.68	$84.38	$55.29
Capacity Revenues	$125,582, 400	$142,272, 000	$221,889,600	$393,163,200
$/kW-yr	$55.08	$62.40	$97.32	$172.44
Retail Rates or Amounts Collected Through Cost-of-Service Rate Recovery	$1,246,934,873	$1,212,227,360	$1,181,608,028	$1,194,912,000

11 California Public Utilities Commission staff. 2023. *What is an Energy Resource Recovery Account (ERRA) Proceeding?* https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/what-is-an-energy-resource-recovery-account-proceeding#:~:text=Energy%20Resource%20Recovery%20Account%20%28ERRA%29%20proceedings%20are%20used,The%20costs%20are%20forecast%20for%20the%20year%20ahead

Source: Pacific Gas and Electric Company staff, 2023 and 2024

Worker Attrition Through Continued Operation

The employee retention program authorized by CPUC (D.)18-01-022 expired at the end of 2023. However, SB 846 in PUC 712.8(f)(2) directs the CPUC to fund an extended program to support worker retention. The PUC 712.8(f)(2) text is provided below.

> "The commission shall continue to fund the employee retention program approved in Decision 18-11-024 (December 2, 2018) Decision Implementing Senate Bill 1090 and Modifying Decision 18-01-22, as modified to incorporate 2024, 2025, and additional years of extended operations, on an ongoing basis until the end of operations of both units with program costs tracked under subdivision (e) and fully recovered in rates. Any additional funding for the employee retention program beyond what was already approved in commission Decision 18-11-024 shall be submitted by the operator in an application for review by the commission."

As of the publishing of this update, CPUC is reviewing PG&E's application (A.23-10-009) to modify the DCPP employee retention program in accordance with SB 846. In the CPUC proceeding (A.23-10-009), the CPUC issued a scoping ruling January 11, 2024, setting a procedural schedule with a proposed decision in August 2024.

DCPP employee sign-ups for Commitment Period 1 (September 1, 2023, through December 31, 2024) occurred from September 18 to October 30, 2023, for management, International Brotherhood of Electrical Workers (IBEW), and Engineers and Scientists of California (ESC) employees, and from October 16 to November 27, 2023, for Service Employees International Union (SEIU) employees. The employee retention program has been critical at retaining the qualified workforce necessary to operate the plant to the end of DCPP's current licenses.

The Contribution of Diablo Canyon to Resource Adequacy

DCPP is a nuclear power plant that provides about 9 percent of California's in-state energy generation and accounts for 2,280 megawatts (MW) total (1,140 MW per unit) of system resource adequacy (RA). Each unit at DCPP undergoes a planned refueling outage roughly every 18 months. The planned outages for each unit are staggered such that only one unit is in a planned outage at a time.

In addition to refueling, DCPP undergoes planned curtailments to clean the intake tunnels of the plants. During planned refueling and tunnel cleaning outages, PG&E is obligated to ensure that adequate replacement RA resources are available to meet PG&E's RA obligations during the outage period. As planned outage timing and duration are scheduled far in advance, PG&E plans its portfolio so that it continues to meet its RA obligations and appropriately contributes to overall grid reliability during planned outages.

During the period of extended DCPP operations, the RA value for the two DCPP units will be credited to all CPUC load serving entities proportional to their share of coincident peak load. Additionally, the CPUC's Decision 23-12-036 instructed load serving entities to procure future

resources as DCPP doesn't exist for the Integrated Resource Plan process. Beginning with the 2025 RA compliance year, the CPUC is implementing a new slice-of-day framework that requires load-serving entities to demonstrate sufficient capacity has been procured to meet their proportional share of each month's 24-hour peak-load day. Because DCPP is a baseload resource, the contribution of DCPP to the RA program will be greater than resources that may otherwise be energy-limited across the day.

CHAPTER 3: Conclusions

This annual update provides an assessment of DCPP operations occurring since the publishing of the initial *DCPP Operation Assessment Report* (CEC-700-2023-005), in July 2023. This annual update includes new information related to:

- Outage information.
- Power plant operational costs.
- Revenues from electricity sales.
- Worker attrition.
- Contribution to resource adequacy.

CEC staff prepared this operation assessment report update to provide the state Legislature an understanding of the current conditions of operations at DCPP. An operation assessment report update will be submitted to the Legislature on July 1 of each year until 2031 and will include updated analyses and assessments of DCPP operations.

GLOSSARY

CLIMATE CHANGE — Climate change refers to a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean or the variability of the climate properties or both and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Anthropogenic climate change is defined by the human impact on Earth's climate, while natural climate change is the natural climate cycles that have been and continue to occur throughout Earth's history. Anthropogenic climate change is directly linked to the amount of fossil fuels burned, aerosol releases, and land alteration from agriculture and deforestation.

FUEL CYCLE FACILITIES — According to the NRC Commission fuel cycle facilities are licensed by NRC to process and handle special nuclear material, source material, or both. These forms of nuclear material are highly regulated to ensure the safe use and enhanced security. The NRC Division of Fuel Management is responsible for the effective regulation of operational fuel facilities and the licensing of new facilities.

ONCE-THROUGH COOLING — Once-through cooling (OTC) technologies draw ocean water to cool the steam that is used to spin turbines for electricity generation. The technologies allow the steam to be reused, and the ocean water that was used for cooling becomes warmer and is then discharged back into the ocean. The intake and discharge can have negative impacts on marine and estuarine environments.

RESOURCE ADEQUACY — The Resource Adequacy (RA) program ensures that adequate physical generating capacity dedicated to serving all load requirements is available to meet peak demand and planning and operating reserves, at or deliverable to locations and at times as may be necessary to ensure local area reliability and system reliability.

APPENDIX A:
Acronyms and Abbreviations

AEC — Atomic Energy Commission

California ISO — California Independent System Operator

CEC — California Energy Commission

CPUC — California Public Utilities Commission

DCISC — Diablo Canyon Independent Safety Committee

DCPP — Diablo Canyon Power Plant

DOE — U.S. Department of Energy

GW — gigawatt

GWh — gigawatt-hour

HBPP — Humboldt Bay Nuclear Power Plant

ISFSI — Independent Spent Fuel Storage Installation

IPRP - Diablo Canyon Nuclear Power Plant Independent Peer Review Panel

MW – megawatt

MWh – megawatt-hour

NRC — Nuclear Regulatory Commission

PG&E — Pacific Gas and Electric Company

PWR — pressurized water reactor

QA — quality assurance

RA — resource adequacy

SB — Senate bill

SCE — Southern California Edison

SMUD — Sacramento Municipal Utility District

SONGS — San Onofre Nuclear Generating Station

SSC — Alfred E. Alquist Seismic Safety Commission

STEP — California Energy Commission, Siting, Transmission, and Environmental Protection Division

APPENDIX B:
Nuclear Energy in the United States and California

United States

Atomic Energy Commission

Before NRC was created, nuclear regulation was the responsibility of the Atomic Energy Commission (AEC), which Congress established in the Atomic Energy Act of 1946. Eight years later, Congress amended that law with the Atomic Energy Act of 1954, which allowed the development of commercial nuclear power. The act assigned AEC the functions of promoting the use of nuclear power and regulating the safety of nuclear power. AEC sought to ensure public health and safety from the hazards of nuclear power without imposing excessive requirements that would inhibit the growth of the industry. This was a difficult balance to achieve and within a short time AEC stirred considerable controversy. An increasing number of critics during the 1960s charged that AEC regulations were insufficiently rigorous in several important areas, including radiation protection standards, reactor safety, plant siting, and environmental protection. [12]

Nuclear Regulatory Commission

By 1974, AEC's regulatory programs had come under such strong attack that Congress decided to abolish the agency. Supporters and critics of nuclear power agreed that the promotional and regulatory duties of AEC should be assigned to different agencies. The Energy Reorganization Act of 1974 placed AEC's weapons and energy development programs under the jurisdiction of an agency that later became the Department of Energy. Congress created the NRC to regulate the civilian nuclear power industry. NRC began operations January 19, 1975. NRC focused its attention on several broad issues that were essential to protecting public health and safety. These issues included radiation protection, reactor safety, and regulation of nuclear materials.[13]

Radiation Protection

The primary danger of the use of nuclear materials for electrical power production, as well as a variety of industrial, medical, and research applications, is that workers or the public could be exposed to hazardous levels of radiation. AEC and NRC published standards that were intended to provide an ample margin of safety from radiation generated by the activities of its

12 United States Regulatory Commission. 2021. *About the NRC.* https://www.nrc.gov/about-nrc.html

13 Ibid

licensees. These radiation standards were based on available scientific information and the judgment of leading authorities in the field at the time.[14]

Radiation standards are continually updated as new data emerge. NRC ensures that users of radioactive materials keep radiation exposures within the agency's specified dose limits and as low as reasonably achievable. Users of radioactive materials must obtain a license from NRC and be inspected to ensure that they are following the agency's latest regulations and safety practices. Nuclear power plants emit minute quantities of radioactive gases and liquids to the environment under controlled and monitored conditions during normal plant operations. Because these radioactive discharges can have environmental impacts on humans and the environment, NRC requires licensees to monitor the discharges and analyze nearby environmental samples to ensure that the impacts of plant operations are minimized.[15]

NRC assists States expressing interest in establishing programs to assume NRC regulatory authority under the Atomic Energy Act of 1954, as amended. Section 274 of the Act provides a statutory basis under which NRC relinquishes to the States portions of its regulatory authority to license and regulate byproduct materials (radioisotopes); source materials (uranium and thorium); and certain quantities of special nuclear materials. Additional details About the NRC Agreement State Program can be found on the NRC website.[16] California is an Agreement State with the California Department of Public Health Division of Radiation Safety and Environmental Management serving as the state regulator.

Reactor Safety

The focus of AEC and NRC regulatory programs was to prevent a major reactor accident from occurring that would threaten public health and safety. Both agencies issued a series of requirements designed to ensure that a power reactor would not release a massive amount of radiation. As the number and size of nuclear power plants being built rapidly increased during the late 1960s and early 1970s, reactor safety became a hotly debated and enormously complex public policy issue. Often bitter debates over the reliability of emergency core cooling systems, pressure vessel integrity, quality assurance, the probability of a major accident, and other questions received a great deal of attention from AEC, NRC, Congress, the nuclear industry, environmentalists, and the news media.

On March 28, 1979, the debate over nuclear power safety moved from the hypothetical to reality. An accident at Unit 2 of the Three Mile Island plant in Pennsylvania melted about half of the reactor core and generated fear that widespread radioactive contamination would result. The crisis ended without a major release of radiation or a need to order a general

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14 Ibid

15 United States Regulatory Commission. 2022. https://www.nrc.gov/about-nrc/radiation/protects-you.html

16 United States Regulatory Commission. 2022. *Agreement State Program*. https://www.nrc.gov/about-nrc/state-tribal/agreement-states.html

evacuation, but it underscored that new approaches to nuclear regulation were essential. The accident demonstrated that even a seemingly small equipment failure could lead to a serious nuclear incident and highlighted the importance of operator training, emergency planning, and other "human factors" in ensuring the safe operation of nuclear power plants.[17]

Regulation of Nuclear Materials

NRC devotes substantial resources to a variety of complex questions in nuclear materials safety. One such issue was the protection of nuclear materials from theft or diversion. This issue became a prominent question after the 1970s in response to growing concern that nuclear materials could be obtained by terrorists or nations seeking to build atomic weapons. NRC devotes a great deal of attention to the safety of managing high-level and low-level radioactive waste, which remains a matter of public fear and political controversy today.

Regulatory Activities

NRC's regulatory activities are focused on:

- Inspections.
- Security and safeguards.
- Plant licensing.
- Operator licensing.

Inspections

NRC conducts inspections to ensure that licensees meet NRC's regulatory requirements. These inspections include licensed nuclear power plants, fuel cycle facilities, and radioactive materials activities and operations. There are roughly 1,000 inspections conducted a year that cover areas such as training of personnel who use materials, radiation protection programs, radiation patient dose records, and security of nuclear materials.[18] Inspectors follow guidance in the NRC Inspection Manual,[19] which contains objectives and procedures to use for each type of inspection. If an inspection shows that a licensee is not safely conducting an activity or safely operating a facility, the plant is informed. NRC will continue to inspect that activity or facility until the problems are corrected.

In addition to region-based inspectors, NRC has resident inspectors at each of the nation's operating nuclear plants and fuel cycle facilities to carry out the inspection program on a day-to-day basis. DCPP has two full-time on-site NRC inspectors.

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17 United States Regulatory Commission. 2022. *About the NRC.* https://www.nrc.gov/about-nrc.html

18 United States Regulatory Commission. 2020. *Inspections. https://www.nrc.gov/about-nrc/regulatory/safety-oversight.html*

19 United States Regulatory Commission. 2023. *Inspection Manual.* https://www.nrc.gov/reading-rm/doc-collections/insp-manual/index.html

Security and Safeguards

NRC has instituted programs that protect public health and safety by promoting the common defense and security of the DCPP and guarding against theft and sabotage. NRC reviews and approves licensees' security programs and contingency plans dealing with threats, thefts, and sabotage relating to special nuclear material, high-level radioactive wastes, nuclear facilities, and other radioactive materials and activities. NRC also ensures safeguards and security by regulating licensees' accounting systems for special nuclear and source materials and security programs and contingency plans. NRC security and safeguard responsibilities include:

- Domestic safeguards, which are aimed at ensuring that special nuclear material within the United States is not stolen or otherwise diverted from civilian facilities for possible use in clandestine fissile explosives and does not pose an unreasonable risk owing to radiological sabotage.
- Information security, which is the protection of classified and sensitive unclassified non safeguards information related to U.S. government programs for the physical protection and safeguarding of nuclear materials or facilities against unauthorized disclosure.
- Cybersecurity, which is composed of establishing and maintaining an effective cybersecurity program. Digital systems are increasingly used in nuclear power plants to maximize productivity. In response to the cybersecurity challenges facing nuclear power plants, the NRC has implemented infrastructure changes, enhanced interagency interfaces, performed enhanced inspections, and developed a cybersecurity roadmap.
- Radioactive material security, aimed at regulating the use of radioactive material to protect people and the environment.
- Required reporting for clearance holders, which is oversight of the reporting requirements for NRC employees and NRC contractors, as well as cleared licensee personnel, cleared licensee contractors, and others who hold national security clearances issued by NRC.
- Insider threat program for licensees. Executive Order 13587 required all federal agencies to establish and implement an insider threat program to cover contractors and licensees who have exposure to classified information.
- Licensee criminal history records and firearms background checks.[20]

Plant Licensing

Through the licensing process, NRC authorizes an applicant to conduct any or all of the following activities:

- Construct, operate, and decommission commercial reactors and fuel cycle facilities.
- Possess, use, process, export and import nuclear materials and waste, and handle certain aspects of their transportation.
- Site, design, construct, operate, and close waste disposal sites.

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20 United States Regulatory Commission. 2021. *Security.* https://www.nrc.gov/security.html

To become licensed for any of these activities (or to amend, renew, or transfer an existing license), an entity or individual applies to NRC. NRC staff reviews the submission, using standard review plans, to ensure that the applicant's assumptions are technically correct and that the proposed activities will not adversely impact the environment.[21]

Operator Licensing

NRC regulations in 10 CFR Part 55 require personnel who operate a reactor to have either a reactor operator or a senior operator license issued by NRC. Reactor operators are licensed to operate the reactor under most routine conditions without supervision, such as start-up and shutdown of the reactor, along with monitoring reactor parameters. However, a senior operator must be present to supervise operation of the reactor during some nonroutine plant conditions such as performing fuel movement, making reactor core alterations within the reactor vessel, and overseeing plant operations during emergencies.

To ensure that these operators have the required knowledge, skills, and abilities to control the reactor during routine processes and emergencies, NRC staff prepares and administers a comprehensive written examination and a hands-on operating test to all candidates for a new reactor operator or senior operator license. These examinations, developed from NRC regulations, are designed to measure the candidate's qualifications to operate the reactor. NRC licenses are valid for six years.

Once licensed, operators and senior operators are required to maintain their expertise. Each facility is required to maintain an operator training and requalification program, covering refresher training (material covered during initial licensing) and training on recently changed systems. The operator training and requalification program must be submitted to NRC for approval. The training program is divided into two-year cycles and requires a comprehensive written examination and an annual operating test. These examinations are administered by the facility staff. At the end of the six-year period, operators and senior operators are required to submit a renewal application to renew their licenses. As part of the application, the applicant must certify satisfactory participation in the Operator Training and Requalification Program.[22]

California

As of mid-2012, California has one operating nuclear power plant, DCPP, owned by PG&E. DCPP consists of two units. Unit 1 was originally estimated as a nominal 1,073-MW pressurized water reactor (PWR), which began commercial operation in May 1985, while Unit 2 was originally estimated as a nominal 1,087-MW PWR, which began commercial operation in March

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21 United States Regulatory Commission. 2021. *Licensing.* *https://www.nrc.gov/about-nrc/regulatory/licensing.html*

22 United States Regulatory Commission. 2022. *Licensing Process for Operators.* https://www.nrc.gov/reactors/operator-licensing/licensing-process.html

1986.[23] Today, the two reactors each produce about 1,140 MW and combined produce about 18,000 GWh of electricity annually, which is about 9 percent of California's in-state generation.[24]

DCPP has two Westinghouse-designed four-loop PWRs. The once-through cooling system of the facility draws water from the Pacific Ocean to condense steam that is used to drive the turbine systems.

On June 21, 2016, PG&E announced a joint proposal with labor and environmental organizations to increase investment in energy efficiency, renewables, and storage, while phasing out nuclear power. The proposal indicated that the operating licenses for Diablo Canyon Units 1 and 2 would not be renewed when they were to expire November 2, 2024, and August 26, 2025. PG&E's application to close DCPP was approved by the CPUC in January 2018. In February 2018, PG&E withdrew its application from NRC for a 20-year licensing extension beyond 2024 and 2025.

On September 2, 2022, the Governor approved SB 846, which authorized the extension of operating DCPP beyond the current expiration dates, up to five additional years (no later than 2029 and 2030, respectively), under specified conditions.[25]

Power Reactor Decommissioning

California hosts three commercial nuclear power reactor facilities in various stages of decommissioning or are decommissioned: the Humboldt Bay Nuclear Power Plant near Eureka, the Rancho Seco Nuclear Power Plant near Sacramento, and the San Onofre Nuclear Generating Station south of San Clemente.

Under all NRC operating licenses, once a nuclear plant ceases reactor operations, it must be decommissioned. Decommissioning is defined by federal regulation (10 CFR 50.2) as the safe removal of a facility from service along with the reduction of residual radioactivity to a level that permits termination of NRC operating license. In preparation for the eventual decommissioning of a plant, nuclear plant owners must maintain trust funds while the plants are in operation to ensure sufficient funding will be available to decommission their facilities and manage the spent nuclear fuel.

In general, spent fuel can be either reprocessed to recover usable uranium and plutonium or managed as a waste for long-term ultimate disposal. Since fuel reprocessing is not

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23 California Energy Commission Staff. 2020. *Nuclear Power Reactors in California*. https://www.energy.ca.gov/sites/default/files/2020-03/Nuclear_Power_Reactors_in_California_ada.pdf

24 California Energy Commission Staff. 2023. *Final Commission Report, Diablo Canyon Power Plant Extension, CEC Analysis of Need to Support Reliability*. https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-ESR-01

25 Dodd, Bill. 2002. *California Senate Bill No. 846, Diablo Canyon Power Plant: Extension of Operations*. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB846

commercially available in the United States, spent fuel is held in temporary storage at reactor sites until a permanent long-term waste disposal option becomes available.

Because of the lack of permanent long-term waste disposal options in the United States, in 1976 the California placed a moratorium (Chapters 194 and 196, Statutes of 1976) on the construction and licensing of new nuclear reactors until the CEC determines that the federal government has identified and approved a demonstrated technology for:

- The construction and operation of nuclear fuel rod reprocessing plants.
- The permanent disposal of high-level nuclear waste.

In effect, these two conditions halted the construction of new nuclear power plants in California. Accordingly, no new nuclear power plants have been constructed in California since 1976.

The three commercial nuclear power reactor facilities in various stages of decommissioning or are decommissioned are discussed below.

Humboldt Bay Nuclear Power Plant

Humboldt Bay Nuclear Power Plant (HBPP), Unit 3, was a roughly 65 MW boiling water nuclear reactor, owned by PG&E that operated from August 1963 to July 1976. HBPP Units 1 and 2 were fossil fuel steam plants built in 1956 and 1958, respectively. Unit 3 was shut down in 1976 for refueling and seismic upgrades. Repairs subsequently extended the planned shutdown period, and in that interval, significant regulatory changes were made for reactor operation and design. As such, PG&E decided to not restart Unit 3.[26]

In 1983, PG&E announced plans to close the plant permanently and in 1988 placed the plant in SAFSTOR inactive status. SAFSTOR is an NRC facility decommissioning program considered "deferred dismantling," where a nuclear facility is maintained and monitored in a condition that allows the radioactivity to decay; afterward, the plant is dismantled, and the property decontaminated. The other available NRC decommissioning program is called DECON and is considered "immediate dismantling" where 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 the release of the property and termination of the NRC license.[27]

In 2003, PG&E formally submitted a license application to NRC for approval of a dry-cask Independent Spent Fuel Storage Installation (ISFSI) at the Humboldt Bay site. A license and safety evaluation for the Humboldt Bay ISFSI were issued on November 17, 2005. The transfer

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26 Pacific Gas and Electric. 2023. *Humboldt Bay Power Plant.* https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/buildings-and-operations/humboldt-bay-power-plant.page

27 California Energy Commission staff. 2020. *Nuclear Reactors in California.* https://www.energy.ca.gov/sites/default/files/2020-03/Nuclear_Power_Reactors_in_California_ada.pdf

of spent fuel from the fuel storage pool to the ISFSI was completed in December 2008 and decontamination and dismantlement of HBPP decommissioning commenced.[28]

NRC has granted Part 50 termination of the HBPP, Unit 3 apart from the ISFSI on November 18, 2021, and is considered decommissioned.[29]

Rancho Seco Nuclear Power Plant

The Rancho Seco Nuclear Power Plant, located about 25 miles south of Sacramento, is owned by the Sacramento Municipal Utility District (SMUD). The unit approximately 913 MW PWR, was operational from April 1975 to June 1989. It was closed by public referendum.

In 1996, NRC approved the decommissioning plan for the Rancho Seco Nuclear Power Plant. The spent fuel produced during operation remains onsite in protective dry storage.

All power-generating equipment has been removed from the plant except the now-empty cooling towers. In October 2009, NRC released most of the site for unrestricted public use.[30]

San Onofre Nuclear Generating Station

The San Onofre Nuclear Generating Station (SONGS), operated by majority owner Southern California Edison (SCE), is midway between Los Angeles and San Diego and contained three units. The first unit, Unit 1, was in operation from 1968 to 1992, when it was shut down and placed in SAFSTOR inactive status. Unit 1 was a Westinghouse three-loop about 450-megawatts equivalent (Mwe) PWR.[31]

Units 2 and 3 were Combustion Engineering two-loop roughly 1,110-MWe PWRs. Unit 2 began operation in 1983, and Unit 3 began operation in 1984.

Unit 2 was shut down in early January 2012 for routine refueling and replacement of the reactor vessel head. On January 31, 2012, Unit 3 suffered a radioactive leak largely inside the containment shell, with a release to the environment below allowable limits, and the reactor was shut down per standard procedure. On investigation, the replacement steam generators from 2011 in both units were found to show premature wear on over 3,000 tubes, in 15,000 places. In March 2012, NRC forbade the plant to be reopened until the causes of equipment problems were thoroughly understood and fixed. Subsequently, plant owners announced in

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28 Pacific Gas and Electric. 2023. *Humboldt Bay Power Plant.* https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/buildings-and-operations/humboldt-bay-power-plant.page

29 Ibid

30 California Energy Commission staff. 2020. *Nuclear Reactors in California.* https://www.energy.ca.gov/sites/default/files/2020-03/Nuclear_Power_Reactors_in_California_ada.pdf

31 United States Nuclear Regulatory Commission staff. 2023. *San Onofre.* https://www.nrc.gov/info-finder/decommissioning/power-reactor/san-onofre-unit-1.html

June 2013 that the remaining Units 2 and 3 would be permanently retired and would enter decommissioning.[32]

32 California Energy Commission staff. 2020. *Nuclear Reactors in California.* https://www.energy.ca.gov/sites/default/files/2020-03/Nuclear_Power_Reactors_in_California_ada.pdf

General Routing Log		Approval (Date & Initials)
Primary Author	Michael Turner	MT 3/1/2024
Legal	Tanner Kelsey	MP 03/21/2024
Media and Public Communications	Carol Robinson	CER 03/26/2024
Supervisor	Brett Fooks	BF 04/04/24
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