

# **After Japan: Nuclear Power Plant Safety in California**

## **OVERVIEW OF NUCLEAR POWER WORLDWIDE**

Nuclear power plants generate roughly 15% of total electricity in the world and more than 40% of global non-fossil fueled electric power generation. The United States, France, and Japan account for nearly 60% of global nuclear power generation. According to the United Nation's International Atomic Energy Agency, 88 nuclear reactors worldwide are situated in seismically active areas; some along coastlines subject to tsunamis.

Globally, there have been four serious nuclear reactor accidents, including Windscale in the United Kingdom (1952), Three Mile Island in the United States (1979), Chernobyl in the former Soviet Union (1986), and most recently, Fukushima Daiichi in Japan (2011). Fukushima Daiichi, which is one of the 25 largest nuclear power plants in the world, was hit by a magnitude 9.0 earthquake, followed by a tsunami, that seriously damaged the plant's cooling systems.

The recent event in Japan has caused countries around the world to pause and take heed. The European Union has made plans to test all 143 nuclear power plants in its 27 countries. Germany temporarily closed seven reactors that went into operation prior to 1980. Switzerland suspended efforts to renew three of the country's five power stations – Switzerland relies on these reactors for 40% of its energy supply. China ceased approvals of new nuclear power plants as it considers additional safety measures and said that it would conduct inspections at existing plants. India and Great Britain also suspended new plant development pending review of Japan's events. In the United States, the U.S. Nuclear Regulatory Commission (NRC) voted to conduct a seismic safety review of all nuclear reactors operating in the country.

## **NUCLEAR POWER AND SPENT FUEL IN THE UNITED STATES**

**Overview:** Nuclear power provides 20% of the nation's electricity. The United States is the largest producer of nuclear power, accounting for about 30% of total global nuclear generation. The United States has 104 operating nuclear reactors at 65 plants in 31 states.

All operating U.S. nuclear power plants are light water reactors that use water to transfer heat generated by the reactor to a turbine generator which produces electricity. There are two types of light water reactors: 1) boiling water reactor, and 2) pressurized water reactor (PWR).

Approximately 70% of U.S. nuclear reactors are PWRs, including the reactors at two nuclear power plants in California—Diablo Canyon Power Plant and San Onofre Nuclear Generating Station (SONGS).

Every one to two years, approximately one-third of the nuclear fuel in an operating reactor needs to be unloaded and replaced with new fuel. Plant operators transfer used fuel rods, which are still hot and radioactive, to a nearby spent fuel pool where they are stored underwater. The water acts as a natural barrier for radiation from the spent fuel as well as keeps the fuel thermally cool while it decays and decreases in radioactivity.

If a spent fuel pool nears capacity, spent fuel rods may be transferred to dry storage casks. Dry storage casks allow spent fuel to be cooled by air. The spent fuel is surrounded by inert gas inside a sealed metal cylinder that is enclosed within a metal and/or concrete outer shell.

At a recent U.S. Senate hearing on nuclear power plant safety, former nuclear engineer, David Lochbaum, with the Union of Concerned Scientists (UCS), testified that “at all U.S. reactors, the spent fuel pool is housed in less robust containment than what surrounds the reactor core. More irradiated fuel that is less well protected and less well defended is an undue hazard.” (Christopher Joyce, “Japan Accident Renews Focus on Spent Fuel in U.S.,” National Public Radio (NPR), April 7, 2011). Spent fuel pools are not generally housed inside concrete containment buildings, as reactors are and are housed in a less protective building. As used fuel accumulates, reactor operators have had to pack the rods closer together in the pools, which requires even more cooling. NRC says the pools and casks are safe. However, transferring fuel rods from pools to the casks requires cycling the rods in the pools and moving them into the casks at the right time which may increase the risk of mishandling the spent fuel.

In California, Diablo Canyon has approximately 1,126 tons of spent fuel located at its facility, while SONGS has an estimated 1,430 tons.

**Federal Nuclear Waste Policy:** Under the provisions of the Nuclear Waste Policy Act, the federal government has the responsibility for managing spent nuclear fuel produced by commercial reactors, and the generators are responsible for bearing the costs of permanent disposal. The Nuclear Waste Policy Act authorizes and requires the U.S. Department of Energy (DOE) to locate and build a permanent repository and an interim storage facility and to develop a system to safely transport spent fuel from nuclear power plants to the repository and interim storage facility. In 1987, Congress designated Yucca Mountain, a complex of underground tunnels in Nevada, as a federal long-term geological repository for nuclear waste. However, the Obama administration has decided not to use the site and has appointed a blue ribbon commission to find a solution for permanent storage. The commission is scheduled to make its preliminary recommendation in July 2011. Several states, including California, have laws that effectively ban the construction of new nuclear plants until a federal long-term waste disposal repository is operating.

The Nuclear Waste Policy Act created the Nuclear Waste Fund as a means to pay for a permanent repository, an interim storage facility, and for the transportation of spent fuel. Since 1982, electricity consumers have paid into the fund a fee of \$0.001 per nuclear-generated kilowatt-hour of electricity consumed, and the funds are collected by DOE from nuclear

generators. NRC estimated that by the end of the last century, customer payments plus interest totaled more than \$16 billion.

Without a centralized repository for spent nuclear fuel, rods are accumulating at reactor sites across the country. In 2009, the United States had over 60,000 tons of nuclear waste at more than 100 temporary sites (primarily nuclear power plants) around the country. At a recent U.S. Senate hearing, NRC chairman, Gregory Jaczko, stated, “Right now, we believe that for at least 100 years that fuel can be stored with very little impact to health and safety.” (Christopher Joyce, “Japan Accident Renews Focus on Spent Fuel in U.S.,” NPR, April 7, 2011).

**Governance of Nuclear Power—Nuclear Regulatory Commission (NRC):** According to NRC, its mission is to protect people and the environment from radiation hazards through regulation of the various commercial and institutional uses of nuclear material, including nuclear power plants in the United States. NRC’s basic functions are as follows:

- Establishment of standards, regulations, and requirements governing licensed activities;
- Licensing of nuclear facilities, and the possession, use, and disposal of nuclear materials; and,
- Inspection of facilities and users to ensure compliance with these requirements.

**NRC’S Reactor Oversight Process (ROP):** According to UCS, when an event occurs at a reactor, or workers or NRC inspectors discover a degraded condition, NRC evaluates whether the chance of damage to the reactor core has risen. If the event or condition has not affected that risk – or if the risk has increased only incrementally – the NRC relies on its ROP to respond. In this process, NRC inspectors continually monitor operations and procedures at nuclear plants, relying primarily on resident inspectors who are stationed at each nuclear facility. The intent is to detect problems before they lead to more serious violations or events.

According to NRC, the regulatory framework for reactor oversight consists of three key strategic performance areas: reactor safety, radiation safety, and safeguards. Plant performance is evaluated by analyzing two distinct inputs: inspection findings resulting from NRC’s inspection program, and performance indicators (PIs) reported by the licensee. Both inspection findings and PIs are evaluated and given a color designation based on their safety significance, classifying violations into five categories – Non-Cited Violations, Green, White, Yellow, and Red (denoting the most serious violation).

A recent NRC Inspector General report notes that nearly 30% of U.S. nuclear power plants fail to report equipment defects that could pose substantial safety risks—this lack in reporting makes it more difficult for regulators to spot problematic trends across the nuclear power industry. In addition, according to UCS’ recent report, “The NRC and Nuclear Power Plant Safety in 2010” (March 2011), NRC reported on 14 significant safety- and security-related events at nuclear reactors which resulted in special inspections last year. Among the findings, UCS states that nuclear power plants continue to have issues with safety-related equipment and worker errors that increase the risk of damage to the reactor core.

**NRC Reactor License:** The Atomic Energy Act and NRC regulations restrict commercial power reactor licenses to an initial 40 years. Upon approval by the commission, a license may be renewed for an additional 20-year term.

## **License Renewal**

*Safety Review:* Pursuant to federal regulations (10 CFR 54.4), a safety review of a nuclear power reactor license renewal application is performed in order to determine if the applicant has sufficiently shown that the effects of aging will not adversely affect the nuclear facility's operation. The focus of the license renewal safety review is on managing the detrimental effects of aging.

*Environmental Review:* Pursuant to the National Environmental Policy Act (NEPA), NRC performs an environmental review of an applicant's license renewal application to determine the effects of operating the nuclear power facility for an additional 20 years. Federal environmental laws, regulations, and Executive Orders apply.

Safety issues are considered outside the scope of the environmental review process. However, they may be included in an environmental review for a relicensing application when they could result in environmental impacts. The site-specific supplement to the generic environmental impact statement on license renewal may consider environmental effects of postulated accidents. For purposes of a NEPA review process, federal, state, tribal, or local agencies having special expertise with respect to an environmental issue or jurisdiction may act as a cooperating agency.

*State Responsibilities:* In addition to the state's involvement in the NEPA review, two state agencies are involved in other aspects of the license renewal process. First, a license renewal is subject to federal consistency review by the California Coastal Commission (CCC). The Coastal Zone Management Act requires that federally licensed or permitted activities be consistent with state coastal management policies. CCC's jurisdiction includes earthquake safety of buildings near the shore, focusing on structural stability. The applicant must provide a certification of consistency to the NRC stating that the license renewal complies with the California Coastal Management Act. NRC cannot approve a license renewal until CCC completes its review and concurs or waives its authority to concur. Second, the California Public Utilities Commission (CPUC) has a strong influence in license renewal process through its authority over rates charged by the operators. In California, the owner of a nuclear power plant must seek approval by CPUC before charging customers to recoup expenses for activities such as applying for a license renewal.

**Options to License Renewal:** The only alternative to renewing a license is to not renew it. Not renewing the license would result in a nuclear power facility ceasing operation and commencing the decommissioning process when the license expires. The electricity generation lost due to the expiration of the license would create a need to find replacement power.

## **NUCLEAR POWER IN CALIFORNIA**

**Overview:** Nuclear power makes up nearly 15% of California's overall energy portfolio. There are four nuclear power plants in California, two of which have been decommissioned. PG&E's

Humboldt Bay Nuclear Power Plant, located near Eureka, was closed in 1976 due to seismic issues. The Sacramento Municipal Utility District's Rancho Seco Nuclear Generating Station was shuttered in 1989 by a vote of its customers.

The remaining operating nuclear power plants in California are Diablo Canyon Power Plant and the San Onofre Nuclear Generating Station (SONGS).

PG&E's Diablo Canyon is located at Avila Beach in the County of San Luis Obispo. The plant consists of two nuclear reactors. Unit 1 is a 1,073 megawatt (MW) PWR, which began commercial operation in May 1985. Unit 2 is a 1,087 MW PWR, which began commercial operation in March 1986. Licenses for the two reactors expire in 2024 and 2025 respectively. Diablo Canyon can supply approximately three million homes with electricity. About 424,000 people live within 50 miles of the Diablo Canyon plant.

SONGS is located within the boundaries of the U.S. Marine Corps Base Camp Pendleton, on property leased from the federal government, south of the City of San Clemente, and in the County of San Diego. SONGS is jointly owned by Southern California Edison (SCE) (78.21%), San Diego Gas and Electric Company (20%), and the city of Riverside (1.29%). SONGS consists of two operating units. Unit 2 is a 1,080 MW PWR, which began operation in August 1983. Unit 3 is a 1,080 MW PWR, which began commercial operation in April 1984. Both units' operating licenses expires in 2022. The reactors at SONGS can generate enough electricity to supply 1.4 million average homes at a point in time. Approximately 7.4 million people live within 50 miles of SONGS.

**AB 1632 Report:** AB 1632 (Blakeslee) (Chapter 722, Statutes of 2006), required for the California Energy Commission (CEC) to use existing scientific studies to assess the potential vulnerability of California baseload plants, Diablo Canyon and SONGS, to a considerable interruption due to a major seismic event or plant aging. In November 2008, CEC issued the study, "An Assessment of California's Nuclear Power Plants: AB 1632 Report." Among the report's findings:

- Critical data on Diablo Canyon's seismic hazard and plant vulnerabilities are incomplete and three-dimensional geophysical seismic reflection mapping could change estimates of the seismic hazard of the plant.
- Seismologic and geologic data that have become available since SONGS was built indicate that SONGS site could experience larger and more frequent earthquakes than had been anticipated when the plant was designed.
- There is less certainty regarding the tsunami hazards at the sites because currently available tsunami studies for both plants are at least 10 years old and do not take advantage of modern tools that could improve the quality of the assessments.

Among AB 1632 Report recommendations:

- PG&E and SCE should use three-dimensional seismic reflection mapping and other advanced techniques at both plants.
- PG&E and SCE should review the tsunami hazard at their nuclear plants in light of recent research and improved scientific understanding of tsunamis.

**Seismic and Secondary Seismic Risks to Nuclear Plants in California:** Within the next 30 years, California has a 99.7% chance of being hit by an earthquake with a magnitude 6.7 or greater, most likely in areas along the Hayward fault in the Bay Area and the San Andreas fault in southern California, according to Richard Allen, associate director of the Seismological Laboratory at the University of California, Berkeley. Modeling of the San Andreas has demonstrated the potential of an earthquake reaching a magnitude of 7.8 along that fault.

Diablo Canyon is designed to withstand a magnitude 7.5 earthquake. The Hosgri fault is 50 miles west of the plant and is believed to have a maximum magnitude of 7.1. The San Andreas fault is east of the plant and has had magnitude 7.8 quakes in the past but is also farther away than the Hosgri fault. The distance between these faults and the plant may absorb enough of the energy from a quake to avoid reaching Diablo Canyon's maximum stress level of magnitude 7.5.

In 2008, a previously unknown fault, the Shoreline fault, was discovered less than a half mile offshore from Diablo Canyon and is predicted to reach a magnitude 6.5 quake. PG&E contends that geological studies place the maximum seismic strength of an earthquake near the plant at 6.1 to 6.5. Dr. Jeanne Hardebeck, geophysicist with the U.S. Geological Survey, helped to discover the Shoreline fault. She states that the network of faults in the area appears to be connected and that a rupture at one may compound into a larger earthquake. Lloyd Cluff, director of PG&E's Earthquake Risk Management Program, contends, "There could be [other faults]. But if there are other faults out there, in my judgment they would be low slip-rate faults. So, they're not critical." (Jim Acosta and Evan Glass, "Fears Mounting Over U.S. Nuclear Plants," CNN, March 15, 2011).

SONGS is designed to withstand a magnitude 7.0 earthquake. As mentioned above, the AB 1632 report found that more recent information after the plant was built suggested that the SONGS site could experience larger ground motions from earthquakes than originally anticipated.

SONGS is located five miles away from the Rose Canyon fault, which is part of the Newport-Inglewood fault system. According to San Diego County emergency planning documents, the Rose Canyon Fault has the potential to reach a magnitude 6.9 to 7.2 earthquake.

According to the AB 1632 report, the SONGS facility is 50 feet above sea level, with 30-foot high seawalls, which is about three feet higher than the maximum wave height predicted by tsunami models when the plant was built. The report also noted that more recent findings by scientists show that submarine landslides can generate large local tsunamis.

The AB 1632 report raised concern about how well regulators and plant operators comprehend the seismic risks facing Diablo Canyon and SONGS. The study pointed out that plant operators had not updated their models to reflect the latest seismic research and recommended that earthquake vulnerability of the plants be reevaluated using new technology.

**SONGS—Plant Safety Issues:** In recent years, NRC has cited SONGS dozens of times for safety violations. Among the violations for which SONGS has been cited: failed diesel generators in 2007 as well as in 2009; in January 2008, NRC found that SONGS employees had

willfully falsified fire records for five years; in December 2008, inspectors found that battery used to power emergency systems at the plant had been incorrectly connected and perhaps inoperable for four years.

NRC has cited problems with the culture of safety at the plant, specifically noting that workers have said they are afraid of retaliation for raising safety concerns. In March 2011, NRC issued its annual review of SONGS. On the matter of human performance, NRC pointed out that “corrective actions to date have not resulted in sustained and measurable improvement.” (Ken Bensinger and David Sarno, “Calls Heat Up for Review of California Nuclear Plants,” *Los Angeles Times*, March 21, 2011). In addition, a former manager at SONGS recently filed a whistleblower lawsuit against SCE, claiming that he was fired in October 2010 for reporting safety concerns to NRC inspectors and that his superiors ignored worker complaints. SONGS chief nuclear officer, Pete Dietrich, has acknowledged that the plant has had issues with safety in the past but that the problems have been corrected and stated that Edison was “working very diligently to make sure we have an environment where people feel free to discuss these issues.” (Ibid.)

### CONCLUSION

The recent tragedy at Fukushima Daiichi in Japan has heightened concerns around the world about the level of safety at nuclear power plants from seismic and secondary seismic risks. Although PG&E has already commenced the license renewal process for Diablo Canyon, PG&E recently requested NRC to delay final processing on its license renewal application until the PG&E’s seismic studies are completed. SCE has yet to decide whether it will apply to renew the license for the nuclear reactors at SONGS but has stated that it would like to conduct a \$21 million seismic study. Both studies would require approval from CPUC to allow the operators to recover costs of the studies from its ratepayers, as well as require various permits to be obtained in order to conduct the studies. If operating licenses for either Diablo Canyon or SONGS are not renewed, the operators will have to proceed with decommissioning and find other sources of power to replace the baseload electricity generated at these plants.