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California Energy Commission
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March 21, 2011

**Hearing on the Japanese Earthquake and Implications for California
California Senate Select Committee on Earthquake Disaster Preparedness,
Response and Recovery**

Thank you, Chairperson Corbett. I am Energy Commissioner Jim Boyd, Commission Vice Chair, appearing today for the California Energy Commission (CEC). I serve as the State Liaison Officer to the U.S. Nuclear Regulatory Commission (NRC), which is the federal agency that regulates the safety of nuclear power plants in the U.S.

As requested, I plan to give you an overview of the Energy Commission's 2008 study of seismic hazard and plant vulnerabilities at Diablo Canyon and San Onofre, summarize the major findings and recommendations from this study, and how seismic issues are being addressed in license renewal reviews for these plants.

Overview of Federal and State Roles:

The primary responsibility for overseeing nuclear power plant safety, including seismic safety, in the U.S. rests with the federal Nuclear Regulatory Commission. State governments retain responsibility for regulating the non-radiological environmental impacts of the plants, such as impacts from plant cooling, and for assessing the role of nuclear power as part of the state's energy supply. The Energy Commission has no jurisdiction over any of the nuclear plants operating in California today. Diablo Canyon and San Onofre were specifically exempted from the Energy Commission's licensing authority and from the California nuclear waste laws enacted in 1976.

However, the Energy Commission does have a number of activities and obligations related to existing and new nuclear power plants in the state:

1. First, under the 1976 nuclear waste laws, no new nuclear plants can be built in California until the Energy Commission determines that a means for the permanent disposal of spent nuclear fuel has been demonstrated and approved by the federal government.
2. In addition, the Energy Commission since the late 1980's has been the Governor's appointee to the Western Interstate Energy Board (WIEB) High-Level Waste Committee and, since the 1990's, the Governor's appointee as the California Liaison Officer to the Nuclear Regulatory Commission and the California representative on the Western Governors' Association Waste Isolation Pilot Plant

(WIPP) Transport Advisory Group. The Energy Commission coordinate's California's official response to federal proposals for spent nuclear fuel transportation, disposal, and reprocessing.

3. As directed by Assembly Bill 1632 (Chapter 722, Statutes of 2006), the Energy Commission in 2007 and 2008 conducted a comprehensive assessment of Diablo Canyon and San Onofre to examine:
 - the vulnerability of the state's nuclear plants to a major disruption from an earthquake or from plant aging;
 - the impacts from such a disruption;
 - the costs and impacts of the accumulation of nuclear waste at these reactors; and
 - The future role of nuclear power plants in California.

Brief History of Seismic Issues for California Plants

California has two in-state operating nuclear power plants: Diablo Canyon Nuclear Power Plant, a 2,160 MW two-unit plant near San Luis Obispo, and the San Onofre Generating Station (SONGS), a 2,200 MW power plant in San Clemente owned by Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E). Diablo Canyon is licensed through 2024 (Unit 1) and 2025 (Unit 2) SONGS Units 2 and 3 are licensed through 2022. In addition, California has four operating research reactors and three permanently shut down commercial power reactors: Rancho Seco, near Sacramento (closed in 1989), SONGS Unit 1 (closed in 1992), and Humboldt Bay 3 (closed in 1976). SONGS 1 and Humboldt Bay had significant seismic issues.

SONGS Units 2 and 3 construction permits were issued in October 1973. The operating license for Unit 2 was issued in February 1982, and for Unit 3 in November 1982 (9 years after construction began). Diablo Canyon Unit 1 construction permit was issued April 1968, its operating license issued November 1984 (16 years), and it began operating May 1985. Diablo Canyon Unit 2 construction permit was issued Dec. 1970, its operating license was issued August 1985, and it began operating in March 1986 (16 years after construction began). PG&E did not conduct offshore fault studies before the Atomic Energy Commission issued construction permits for Diablo Canyon, because this kind of study was not required in 1968. Instead, consultants focused on onshore faulting and considered historic offshore seismicity. After the construction permits were issued, offshore studies by Shell Oil were published in 1971 revealing the Hosgri Fault, which was previously unmapped. The discovery of this fault, the disclosure of major safety-related plant design and construction errors, and other factors resulted in a long, contentious licensing process. California was an intervener in these proceedings.

In January 1976, the USGS concluded that the Hosgri Fault should be considered capable of producing an earthquake with a magnitude 7.0 to 7.5. Diablo Canyon was redesigned and upgraded for a 7.5 magnitude earthquake. Construction costs at Diablo Canyon exceeded the initial \$320 million estimate (1968 dollars) by more than \$5 billion,

in large part due to seismic and other upgrades at the plant. In 1984 the NRC made a condition of Diablo Canyon's operating license that, "PG&E shall develop and implement a state-of-the-art program to revalidate the seismic design bases used for Diablo Canyon." PG&E's Long-Term Seismic Program has extensively explored the seismology and geology of the Diablo Canyon site.

Following the disclosure of serious design and construction errors at Diablo Canyon, in 1982 the California Governor and interveners filed motions with the Atomic Safety and Licensing Appeal Board to reopen the Diablo Canyon record to take evidence on certain quality assurance matters. As part of Diablo's licensing proceeding, the NRC conducted an "Independent Design Verification Program" for design and construction errors associated with the seismic design of the plant to "restore the plant such that its construction satisfies the approved seismic design criteria." PG&E discovered in 1981 that it had built the seismic supports based on a reversed blueprint, thereby requiring another \$2.2 billion in plant retrofits to correct the error.

Recent California Legislation on Seismic Issues at California's Plants

- Chapter 722, Statutes of 2006, Public Resources Code 25303 (AB 1632, Blakeslee) requires the Energy Commission (CEC) to conduct an assessment of existing scientific studies to determine the potential vulnerability to a major disruption due to aging or a major seismic event of large baseload facilities (Diablo Canyon and San Onofre) and requires the Energy Commission to perform subsequent updates as new data or new understanding of potential seismic hazards emerges.
- AB 42 (Blakeslee, 2009) required PG&E to conduct seismic research for Diablo Canyon and the CEC, in consultation with the CA Geologic Survey and the CA Seismic Safety Commission to perform an independent peer review of PG&E's work and include findings in the IEPR. The Governor's veto language mentioned the AB 1632 seismic study and said the bill was not needed in light of CPUC and CEC actions.

AB 1632 Study and Reports

In November 2008, the Energy Commission completed a two-year comprehensive assessment of the Diablo Canyon and San Onofre Plants.¹ This assessment included studies of seismic hazards at Diablo Canyon and SONGS and the seismic vulnerabilities of these plants. Three public workshops were held in 2007 and 2008, detailed data requests were sent to the plants' owners, and a Seismic Vulnerability Advisory Team consisting of California agencies reviewed the study plans and research findings and recommendations. A research team led by MRW & Associates completed a comprehensive study and report entitled, "AB 1632 Assessment of California's

¹ California Energy Commission, *An Assessment of California's Nuclear Power Plants: AB 1632 Report*, November 2008, CEC-100-2008-009-CMF.

Operating Nuclear Plants”.² The Energy Commission in 2008 adopted the study and report entitled “An Assessment of California’s Nuclear Plants: AB 1632 Report (AB 1632 Report) and the Integrated Energy Policy Report (IEPR 2008). This study provided an independent scientific assessment of the seismic hazard at Diablo Canyon and San Onofre and the plant vulnerabilities.

Discovery of the Shoreline Fault

In November 2008, concurrent with adoption of the AB 1632 Report and the 2008 IEPR, PG&E announced that the USGS had discovered a previously unknown significant offshore fault—the Shoreline Fault—less than a mile from Diablo Canyon. This is the second major fault near the plant. PG&E and NRC later concluded that Diablo Canyon’s design would withstand the potential ground motions from this fault. However, the fault’s major characteristics are largely unknown, e.g., its length, proximity to the plant, and relationship to the Hosgri Fault, e.g., whether an earthquake beginning on the Hosgri Fault could continue on the Shoreline Fault or vice versa, causing a larger earthquake than if either fault broke on its own and whether the fault or fault displays could extend beneath the plant.

AB 1632 Study Findings

1. Diablo Canyon

- The offshore Hosgri Fault zone is the primary seismic hazard at Diablo Canyon.
- PG&E’s Long-Term Seismic Program has extensively explored the seismology and geology of the Diablo Canyon site.
- The geometry of faults bounding the San Luis-Pismo structural block, where Diablo Canyon sits, is not understood sufficiently to rule out a San Simeon-type earthquake directly beneath the plant. Although PG&E has considered such an earthquake in their analyses, PG&E has not assessed the expected ground motions and plant vulnerabilities from such an earthquake.
- Important data on Diablo Canyon’s seismic hazard and plant vulnerabilities are incomplete and three-dimensional geophysical seismic reflection mapping may help resolve questions about the characterization of the Hosgri Fault and might change estimates of the seismic hazard at the plant
- Recent studies have found that ground motion near a fault could be stronger and more variable than previously thought, which could be important at Diablo Canyon, since the offshore Hosgri Fault zone is 4.5 kilometers west of the plant.

² “AB 1632 Assessment of California’s Operating Plants: Final Consultant Report.”, MRW & Associates, Inc. October 2008, CEC-100-2008-005-F.

2. San Onofre

- Data has become available since SONGS was built indicating that the site could experience larger and more frequent earthquakes than was originally anticipated when the plant was designed for a maximum 7.0 earthquake
- A review by the California Coastal Commission stated “there is credible reason to believe that the design basis earthquake approved by U.S. Nuclear Regulatory Commission (NRC) at the time of the licensing of SONGS 2 and 3... may underestimate the seismic risk at the time.”³
- Although new information does not necessarily imply that the facility is unsafe, since the plant was engineered with a large safety margin, the possibility that the safety margin is shrinking does suggest that further study is needed to characterize the seismic hazard at the site, especially since so much less is known about the seismic setting of SONGS than the seismic setting at Diablo Canyon.
- While SCE periodically evaluates the implications of new seismic information for the plant, there is no ongoing program at SONGS similar to PG&E's Long-Term Seismic Program at Diablo Canyon.
- For SONGS, the major uncertainties relate to the earthquake potential of a nearby offshore fault zone (the South Coast Offshore Fault Zone) and the faulting that connects faults in the Los Angeles and San Diego regions.
- Like Diablo Canyon, SONGS is located within 10 kilometers (6.25 miles) of a fault and new research on ground motion near an earthquake rupture is relevant to the seismic hazard of the plant.

3. Japanese Earthquake in 2007

- A strong magnitude 6.5 earthquake in Japan in July 2007 damaged the Kashiwazaki-Kariwa Nuclear Power Plant—the largest nuclear power plant in the world.
- This earthquake resulted in ground motions that exceeded the maximum predicted levels for the site. The plant shut down safely without significant damage to safety-related components. However, nearly four years later, the plant remains in partial shutdown costing billions of dollars in plant repair and power replacement costs.

AB 1632 Report/2008 IEPR Recommendations

- PG&E and SCE should report to the Energy Commission on the overall status and results of their seismic research efforts in future IEPR assessments.
- SCE should develop an active seismic hazards research program for SONGS, similar to PG&E's Long-Term Seismic Program to assess whether there are sufficient design margins at the nuclear power plant to avoid major power disruptions.

³ California Coastal Commission, <http://www.caostal.ca.gov/energy/E-00-014-3mmi.pdf>, page 19.

- SCE's research should include further investigations into the seismic setting at SONGS and assess whether recent or current seismic, geologic, or ground motion research in the vicinity of SONGS has implications for the long-term seismic vulnerability of the plant.
- Both PG&E and SCE should use three-dimensional geophysical seismic reflection mapping and other advanced techniques to supplement ongoing seismic research programs at both Diablo Canyon and San Onofre and report on their progress and the updated seismic assessment in the IEPR.
- PG&E should assess the implications of a San Simeon-type earthquake beneath Diablo Canyon, including expected ground motions and vulnerability assessments for safety- and non safety-related plant systems and components that might be sensitive to long-period motions in the vicinity of an earthquake rupture.
- PG&E and SCE should review the tsunami hazard at their nuclear plants in light of recent research and improved scientific understanding of tsunamis.
- SCE should assess SONGS' tsunami vulnerability after new data from the National Oceanic and Atmospheric Administration for the SONGS site and adjacent coastal areas become available. SCE should also assess the relevance of the University of Southern California second generation tsunami run-up maps for the tsunami hazards at its nuclear plant sites. PG&E and SCE should provide to the Energy Commission the results of the updated Diablo Canyon and SONGS tsunami hazard study as part of future IEPR assessments.
- PG&E and SCE should return the spent fuel pools to open racking arrangements as soon as feasible, while maintaining compliance with NRC requirements and report to the CEC on progress.

2009 IEPR Recommendations

- PG&E and SCE should complete and report in a timely manner on all of the AB 1632 Report recommended studies including those that the CPUC identified for completion as part of license renewal review. The utilities should make their findings available for consideration by the Energy Commission and the CPUC and the NRC during their review of the utilities' license renewal applications.
- The utilities should not file license renewal applications with the NRC before completing the following studies and before the CPUC authorizes funds for license renewal:
 1. Updates on their seismic and tsunami hazard studies, including results of 3D seismic imaging studies, and assessing the long-term seismic vulnerability and reliability of the plants;
 2. Assessment of the degree to which non-safety-related plant components comply with current seismic standards
 3. Assessment of the seismic vulnerability implications of evolving seismic standards since Diablo Canyon and SONGS were designed and built;
 4. Evaluation of the implications for California's plants of the 2007 Kashiwazaki-Kariwa earthquake in Japan;

5. Reassess whether plans and access road surrounding the plants, following a major seismic event and/or plant emergency, are adequate for emergency response to protect the public, workers and plant assets and for timely evacuation following such an event.
6. Plans and costs for storing and disposing low-level nuclear waste and spent nuclear fuel through 20-year license extensions and plant decommissioning;
7. Quantifying the reliability, economic and environmental impacts of replacement power options.
8. SCE should report on efforts to improve the safety culture at SONGS.
9. The Diablo Canyon Independent Safety Committee should evaluate reactor pressure vessel integrity at Diablo Canyon over a 20-year license extension and recommend mitigation plans, if needed. This review should consider the reactor vessel surveillance reports for Diablo Canyon in the context of any changes to the predicted seismic hazard at the site.

Other California Agencies' Activities on Seismic Studies and License Renewal

- The CPUC (March 2007), approved \$16.8 million for PG&E to conduct a Diablo Canyon license renewal feasibility study (General Rate Case D077-03-044) and directed PG&E to complete a license renewal feasibility study that incorporates the findings and recommendations of the AB 1632 assessments and submit an application by June 30, 2011 on whether plant license renewal is cost-effective and in the ratepayers' best interest.
- The CPUC (June 2009) directed PG&E and SCE to complete and report on the findings and conclusions from the AB 1632 studies, including updated seismic and tsunami hazard studies, as part of their license renewal feasibility studies for Diablo Canyon and San Onofre. This reinforced the state's expectations that the AB 1632 studies should be completed in a timely manner, so that their findings can be considered during license renewal reviews. The CPUC noted that this information was necessary to thoroughly evaluate the overall economic and environmental costs and benefits of license extension, particularly in light of the plants' location and seismic hazard and vulnerability assessment.
- The California Coastal Commission (CCC) informed PG&E (December 29, 2009) and the NRC (March 12, 2010) that updated seismic information for Diablo Canyon is needed to review PG&E's application for a coastal development permit and the CCC's federal consistency review for the proposed license renewal.
- The CPUC in 2011 approved funding (about \$17.7 million) for advanced PG&E seismic studies, as recommended by the AB 1632 Report, for Diablo Canyon.
- The CPUC is reviewing SCE's request for approximately \$21 million for advanced seismic studies at SONGS as part of SCE's 2012 General Rate Case.

License Renewal Review Process

The U.S. Nuclear Regulatory Commission reviews the utilities' applications for 20-year extensions of the plants' operating licenses in the U.S. Operating licenses are issued for 40 years. The NRC's license renewal process focuses on plant aging issues and

plant hardware, such as metal fatigue, and evaluates the environmental impacts from an additional 20 years of plant operation. The NRC has excluded from its proceedings issues that states and public interest groups have raised that are not directly related to plant aging or deficiencies in the environmental assessment. For example, during license renewal reviews for the Indian Point Power Plant in New York, the NRC dismissed from the proceeding most of the State of New York's contentions, including seismic vulnerability, plant vulnerability to terrorist attack, risk of spent fuel pool fires, and the inadequacy of emergency evacuation plans for the plant.

Significant relicensing activities with respect to Diablo Canyon and SONGS include:

- PG&E submitted to the NRC a license renewal application for Diablo Canyon in November 2009.
- SCE has not yet submitted an application to the NRC for SONGS' license renewal.
- The California Energy Commission (March 22, 2010) has requested that the CPUC require that the AB 1632/2008 IEPR studies be completed, independently peer reviewed, and made part of PG&E's license renewal feasibility studies for Diablo Canyon before further action is taken on license renewal.
- The California Energy Commission (April 12, 2010) in a letter to the NRC requested that they include several issues in their evaluations of PG&E's relicensing application for Diablo Canyon including: seismic risks, accumulation of spent nuclear fuel, safeguards and security, aging plant issues, emergency response planning, safety culture at the plant, evaluation of energy alternatives, and once-through plant cooling.
- NRC's license renewal schedule for Diablo Canyon shows NRC issuing a Final Supplemental Environmental Impact Statement January 2012 and a license renewal decision "To Be Determined" "pending the outcome of adjudicatory hearings and Coastal Zone Management Act consistency certification."

Status of Diablo and San Onofre Seismic Studies

- SCE provided their initial report on updated earthquake and tsunami risks to the CPUC and the Energy Commission on Feb. 2, 2011, but they have not yet begun the three-dimensional and other advanced seismic analyses that the CEC and the CPUC requested that they complete.
- PG&E completed a Shoreline Fault Report for the NRC in January 2011. PG&E plans to complete their advanced seismic studies in 2014.

Conclusions

The Energy Commission's comprehensive study in 2008 of seismic hazards and plant vulnerabilities at Diablo Canyon and SONGS recommended that the utilities complete certain advanced seismic studies using three-dimensional seismic mapping and other advanced techniques. The Energy Commission subsequently recommended that these studies be independently peer reviewed and their results included as part of the CPUC's

and the NRC's reviews of license renewal for these plants. Events in Japan from the March 11, 2011, earthquake and tsunami and severe damage to the Fukushima Daiichi nuclear power plant have greatly increased the urgency for the completion of these studies, as well as completing the analyses that President Obama has directed the NRC to conduct on all 104 U.S. nuclear reactors to see if they are susceptible to conditions and events similar to those that occurred at the Fukushima Daiichi plant. In particular, we believe that updated analyses will be important on seismic/tsunami hazards, the vulnerabilities and consequences of spent fuel pool loss of water or loss of active cooling, recommendations to reduce the likelihood of such an event, and analyses of the risk of "station blackouts" (loss of offsite power and onsite emergency power) lasting longer than plant design assumptions.

There are uncertainties and gaps in the understanding of the seismic/tsunami hazard and plant vulnerabilities at both Diablo Canyon and San Onofre. Although the Diablo Canyon seismic setting has been and continues to be extensively studied, the studies called for in the AB 1632 Report using advanced technologies could help resolve questions about the characteristics of the Hosgri and Shoreline Faults and might change conclusions about the seismic hazard at the plant. Similar advanced studies, using three-dimensional reflection data at strategically chosen locations, may also help resolve some of the remaining uncertainties for San Onofre and might change estimates of seismic hazard for this plant as well. Both Diablo Canyon and SONGS are located within 10 kilometers (6.25 miles) from a fault.

Like the Japanese plants, our California plants are older coastal plants, with significant inventories of spent nuclear fuel and located near major earthquake faults. It is essential that studies be completed in a timely manner on the vulnerability of U.S. reactors to events similar to those that occurred in Japan, as well as completion of the advanced seismic/tsunami studies of Diablo Canyon and San Onofre that were recommended by the California Energy Commission in 2008 and 2009.

That completes my prepared remarks. I would be happy to answer any questions.