Application No.: 04-01-009
Exhibit No.: ___________
Date: August 3, 2004
Witness: Jay Namson

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of Pacific Gas and Electric Company (U 39 E) for Authority to Increase Revenue Requirements to Recover the Costs to Replace Steam Generators in Units 1 and 2 of the Diablo Canyon Power Plant.	Application 04-01-009 (Filed January 9, 2004)

TESTIMONY OF JAY NAMSON ON BEHALF OF THE SAN LUIS OBISPO MOTHERS FOR PEACE, SIERRA CLUB, PUBLIC CITIZEN, GREENPEACE AND ENVIRONMENT CALIFORNIA

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August 3, 2004

TESTIMONY OF JAY NAMSON

Q. Please state your name, address, and professional affiliation.

A. Jay Steven Namson, 12715 Byron Ave. Granada Hills, CA, 91344. I am a partner in Davis & Namson Consulting Geologists.

Q. Please summarize your educational and professional background.

A. I received a B.S. in Geology in 1977 from California State University, Humboldt, and a Ph.D. in Geology in 1982 from Princeton University. I was a Senior Research Geologist for ARCO Oil & Gas Company from 1982-1988. In 1988, I received a grant from the U.S. Geological Survey to study faults in the Santa Maria, California geographical area. Since 1988, I have been a partner in Davis & Namson Consulting Geologists. A copy of my curriculum vitae is set forth in Attachment A.

Q. What is the purpose of your testimony today?

A. The purpose of my testimony is to discuss an area of potential future costs for the Diablo Canyon Nuclear Power Plant (DCNPP) that Pacific Gas and Electric Company's (PG&E) Application in this case ignores. My testimony focuses on seismic issues, mitigation measures, and potential costs. As I explain below, seismology is an evolving science that has evolved significantly since the design and installation of DCNPP's existing seismic mitigation measures. More specifically, DCNPP's underlying seismology is significantly different than was assumed by PG&E when it designed and installed the plant's seismic mitigation measures and that as a consequence public health and safety risks may well be significantly greater than previously assumed. Installation of additional seismic mitigation measures, at a significant cost, may therefore be required in order to achieve the degree of seismic protection that was thought to have been achieved by the seismic mitigation measures that are presently in place at DCNPP.

Q. How does this relate to the decisions this Commission will be making in this case?

A. It is my understanding that the Commission will be deciding whether to approve PG&E's application to replace DCNPP's existing steam generators. PG&E claims that such replacement would significantly extend DCNPP's operating lifetime and that it is substantially less expensive than other options.

My testimony demonstrates, however, that there is existing scientific evidence that additional seismic measures may be required. PG&E has not taken the risk and cost of such additional protection into account in its cost-benefit analysis in this case. PG&E's May 27, 2004 Revised Testimony (Testimony) does not include any capital costs associated with seismic upgrades. In fact PG&E assumes that after 2015, capital expenditures will continue at the "base" level of about $30 million per year, but does not include any specific major capital improvements.[1] This assumption ignores the possibility of any additional significant costs due to increased seismic protection measures.

Q. What information have you based your testimony on?

A. In 1988 I conducted an in-depth study, which was published in 1990, of the Santa Maria area faults, which includes the area surrounding Diablo Canyon. The study conclusions were that the entire western Coast Ranges are an actively deforming fold and thrust belt, composed of broad anticlines caused by active thrust faults at depth. An anticline is a fold in the earth's crust that forms above thrust faults. The DCNPP

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[1] Testimony at 5A-5:6-13.

is located above the Point San Luis anticline, which is caused by the associated Point San Luis thrust located directly below the DCNPP.

In addition to this report, I am familiar with the more than three decades of geological and seismological investigation in the vicinity of Diablo Canyon, including PG&E's December, 2001 Diablo Canyon, Independent Spent Fuel Storage Installation (ISFSI) Safety Analysis Report (SAR). A representative list of studies that describe the fault character and tectonic style of the region is set forth in Attachment B to this testimony. These investigations have yielded ample data to show the character and locations of the major active fault systems that pose serious earthquake threats to the DCNPP.

Q. What is the current understanding of seismic conditions in area of the DCNPP?

A. DCNPP is located above the Point San Luis anticline and near the Hosgri fault zone. The south-central California coastal zone is an area dominated by oblique-shortening. A combination of right-slip, as expressed by the San Andreas fault system, in concert with northeast-directed compression, has controlled the earthquake and geologic deformation of the region for the past 3 to 6 million years.[2] This compressive deformation is expressed in the regional geology by the widespread thrust and reverse faulting as well as the major geologic folding.[3] Most likely the parallel trends of faults and fold axes are directly related to the oblique character of this deformation, which is due to the combined interaction of the strike-slip associated with the Pacific-North America transform fault plate boundary and the northeast-directed compression. Geologists use the word transpression to describe this tectonic style.

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[2] Page, 1981; Nicholson and Crouch, 1989; Sorlien, 1994.

[3] Crouch et al., 1986; Namson and Davis, 1990; Clark et al., 1991; Nicholson et al., 1992.

Seismic reflection profiles in the area as well as proprietary petroleum exploration industry data show numerous east-dipping reverse or thrust faults in the region, including faults within the mapped Hosgri fault zone.[4] The Hosgri fault is listric in character, going from a steep fault at the surface into a shallow east-dipping thrust fault, known as a detachment fault.[5]

Q. Do you have any concerns about the seismic safety of the DCNPP?

A. Yes. The seismic hazards at the DCNPP include a potential for large oblique-reverse earthquake ruptures in close proximity or directly beneath the plant site. The credibility of the large oblique-reverse earthquake scenario is amply demonstrated in the existing geological and seismological data acquired over the past decades of research in the south-central California coastal region. First, the overall transpressional character (combination of strike-slip and compression) of the region has been described in numerous published and unpublished technical papers. The DCNPP sits above one of the major fold trends of the region that was formed by a thrust fault directly below the fold and therefore directly below DCNPP. The earthquake history and active seismicity show that this transpressional character in the focal mechanisms and the broad distribution of microseismicity, without well-defined vertical fault planes over much of the region, are consistent with the complex patterns of faulting expected in such a transpressional environment.[6]

Q. Has PG&E addressed this potential for large oblique-reverse earthquake ruptures?

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[4] Ewing and Talwani, 1991; Clark, et al. 1991; Meltzer and Levander, 1991; McIntosh, et al. 1991; Trehu, 1991; Crouch et al., 1986; Namson and Davis, 1990.
[5] Crouch and others, 1986; Namson and Davis, 1990.
[6] SAR, Figs. 2.6-40, 41.

A. Not to my knowledge. In its SAR, PG&E failed to consider the threat posed by large reverse or thrust fault earthquakes in the vicinity of the Diablo Canyon site. While PG&E correctly considers the Hosgri fault zone to constitute the constraining seismic source for the facility, PG&E incorrectly assumes that it is a purely strike-slip fault.[7] PG&E also assumes that the fault is a vertical fault, rather than east dipping.[8] As a consequence of these non-conservative assumptions, PG&E incorrectly describes the location and type of quake that may occur on the fault.

Q. Does PG&E's application in this case address this potential risk and potential cost impacts?

A. No. PG&E assumes that there is no need for any further seismic retrofitting of DCNPP, even if plant operating life is extended significantly as a result of the steam generation replacement. Its Testimony reflects this assumption. Failure to account for this realistic fault rupture scenario in the DCNPP vicinity represents a serious misunderstanding of the seismic hazard at the plant site. Not only may this represent a serious threat to the public and the environment from the DCNPP but, for this application, omits consideration of potentially very significant future costs in its cost/benefit analysis.

Q. What is the significance of PG&E's assumption that the Hosgri fault is a strike-slip fault rather than an oblique-reverse or thrust fault?

A. PG&E's assumption that strike-slip faulting on a vertical Hosgri fault represents the most severe seismic threat to the Diablo Canyon site understates the DCNPP seismic hazards.

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[7] Id., at p.2.6-33.
[8] Id. at p. 2.6-30.

Q. What is the significance of PG&E's assumption that the fault is vertical rather than east to northeast?

A. PG&E's assumption leads it to incorrectly assume that the DCNPP is further away from the fault surface and the potential epicenter of an earthquake. PG&E has assumed in its ground motion evaluations that the closest distance of the fault surface to the DCNPP is 4.5 kilometers (km).[9] With an east to northeast dip, the closest distance of the fault surface to the DCNPP is significantly closer than PG&E assumes and the epicenter of such an earthquake could lie directly beneath the DCNPP.

This is significant for the analysis of the seismic risks at DCNPP, because strong ground motion (shaking) from moderate to large reverse or thrust earthquakes tends to be greater at a specified source-to-site distance and source magnitude than for pure strike-slip earthquakes.[10] The 1999 Izmit earthquake in Turkey showed the relatively lower shaking amplitudes for a large (Magnitude=7.6) strike-slip earthquake[11] compared to shaking values in the near source of the moderate (Magnitude=6.7) 1994 Northridge blind-thrust earthquake.[12] For an east to northeast-dipping, oblique-reverse, Hosgri fault earthquake source, reverse fault character creates an additional increase in expected ground motions because of the hanging wall effect *i.e.*, seismic energy trapped between the fault and ground surface (in the hanging wall) further amplifies the shaking levels. Therefore I believe that PG&E has underestimated the seismic risks to the DCNPP by assuming a strike-slip earthquake as most probable,

[9] SAR, at p. 2.6-32.
[10] Abrahamson and Silva, 1997; Boore, et al., 1997.
[11] Anderson, et al., 2001.
[12] Darragh, et al., 1995.

instead of a thrust earthquake, and by assuming a minimum distance of 4.5 km between the fault surface and the site rather than the assumption that the fault lies directly below the DCNPP. In other words, PG&E has used the least conservative assumptions in determining the earthquake hazards at DCNPP.

Q. What is the significance of PG&E's conclusions regarding the location of the fault?

A. PG&E locates the active fault plane used to determine the design ground motions along the western side of the 3-5 km (2-3 miles) wide zone recognized as the Hosgri fault zone in this area.[13] By using a vertical fault plane and placing this plane on the more distant side of the fault zone, PG&E maximizes the effective distance of the potential earthquake fault rupture source from DCNPP. As a result, PG&E underestimates the level of ground motion of potential large earthquakes.

Q. Does recent seismic activity in Central and Southern California tend to support PG&E's analysis?

A. No. The December 2003 San Simeon earthquake, which was located about 50 miles to the north of the DCNPP, was a pure thrust earthquake on a previously unknown fault. The strongest earthquakes in recent years, including the 1983 Coalinga, 1987 Whittier-Narrows, and 1994 Northridge earthquakes, have been "blind thrust" earthquakes. An excellent example of a blind-thrust earthquake associated with a well-known right-slip (assumed vertical strike-slip) fault is the 1989 Loma Prieta earthquake along the Santa Cruz Mountains segment of the San Andreas fault. Thus, it is reasonable and prudent to consider thrust earthquake sources along the Hosgri fault zone in proximity to the Diablo Canyon plant site.

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[13] SAR, Fig. 2.6-4; p. 2.6-32.

Q. Do you believe that thrust earthquakes on a blind thrust fault near DCNPP are possible?

A. Yes. The DCNPP is built above one of the most important and extensive fold trends in the region. All of these folds are caused by thrust faults at depth. PG&E has argued that tectonic uplift is still active at the DCNPP but that folding and blind thrust faulting is not active. I believe the active uplift and the existence of the regional fold shows that indeed folding is still active and is being caused by an active blind thrust fault at depth. PG&E's own study shows numerous reverse, thrust and oblique-reverse earthquake focal mechanisms in addition to the right-slip earthquakes typical of the San Andreas fault system.[14] This data demonstrates that such thrust earthquakes are not only possible, but likely in the region.

Indeed, the largest historical earthquake in the region, the 1927 Lompoc earthquake (Magnitude=7.3), had a reverse or thrust mechanism. PG&E consultants relocated the epicenter of that event as farther offshore[15] than other studies of this earthquake.[16] Measured coastal strain in the area of Point Arguello and the observed tsunami demonstrate the dip-slip character of this important earthquake.

Q. How does this distinction between slip-strike faults and thrust faults impact seismic design and retro-fitting of buildings?

A. First, I am not a structural engineer and I cannot testify on specifics of plant design. However, generally speaking, the nature of the faults in the area of a facility, including fault rupture, character, magnitude and geometry, define all the other

[14] SAR, Fig. 2.6-42.

[15] Helmberger, et al., 1992.

[16] Gawthrop, 1978; Hanks, 1979.

relevant seismic issues that inform the safe design and operation of the facilities. These are what are known as "design earthquake parameters."

The question for DCNPP is: has the DCNPP been designed to withstand a thrust-related earthquake directly below the site? We know that PG&E studies have erroneously considered a thrust earthquake below the DCNPP as unlikely. It is also my understanding that the 1980's retrofit of DCNPP was designed to withstand a strike-slip fault earthquake, rather than a thrust fault quake located in close proximity to DCNPP. I understand that the retrofit was required by the NRC in order to correct deficiencies in the original seismic design of DCNPP that resulted from PG&E's failure to design the plant to withstand an earthquake on the Hosgri fault.[17]

Q. What items at DCNPP would need to be evaluated to determine if there is adequate protection from an oblique-reverse earthquake?

A. In order to provide adequate protection, there would need to be a re-evaluation of all the subsequent, secondary hazard issues, including earthquake-induced slope failure, liquefaction or lurching (surficial ground failures due to extreme shaking), tsunami, and possible secondary faulting in the hanging wall of the active fault surface beneath the coastline.

Q. Can you offer an opinion as to what sort of DCNPP retrofit redesign might be needed to protect against a close-proximity thrust fault?

A. No, I cannot. In order to develop an expert opinion on appropriate retrofit redesign, a team of seismologists and specialized seismic engineers would need to work closely

[17] According to CPUC staff, the first retrofit increased the construction cost of DCNPP from $1 billion to $2.4 billion. A second retrofit was required to correct additional design deficiencies, increasing the total cost to $5.518 billion. Prehearing Brief of the Public Utilities Commission Division of Ratepayer Advocates (A.84-06-014), June 20, 1988, at 5.

together on the relevant conditions at and around DCNPP. This analysis would be an extensive undertaking, and something that I have not personally undertaken.

Q. Given that the requisite analyses and studies for a retrofit redesign have not been undertaken, how do you recommend that the Commission take account of the risks and potential costs associated with close-proximity thrust quakes at DCNPP?

A. I recommend that the Commission direct PG&E to undertake the necessary analyses and studies regarding potential costs associated with mitigating the risks of a close-proximity thrust earthquake at DCNPP prior to reaching a decision on PG&E's application. In order to fully evaluate the costs associated with DCNPP, the Commission should give serious consideration to the question of whether PG&E has erroneously excluded consideration of a potentially significant capital cost. The history of DCNPP itself demonstrates that drastic and very costly action in response to erroneous assumptions regarding earthquake hazards can and do occur.

ATTACHMENT A

JAY STEVEN NAMSON, Ph.D.

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EDUCATION: **Princeton University**, September, 1977 to June, 1982. Ph.D. in Geology June, 1982; M.A. in Geology January, 1979.
Ph.D. Dissertation: Studies of the structure, stratigraphic record of plate interaction and role of pore-fluid pressure in the active fold and thrust belt of Taiwan.
Awards: Phelps Dodge fellowship, Princeton University, 1979.
Middlebury College, Summer 1978, Intensive Chinese Language Program, first year Chinese.
California State University, Humboldt, September, 1973 to June, 1977; B.S. in Geology June, 1977, cum laude.
Thesis Topic: Origin of manganese deposits in the Franciscan Assemblage, northern California.
Awards: N.A.G.T. Field Camp Scholarship, 1976.

EXPERIENCE:

4/88-present **Davis & Namson Consulting Geologists.** Structural geology and exploration consultant for oil companies and foreign governments in California, Alaska, Oklahoma, Colombia, Venezuela, Mexico, Indonesia, Pakistan, China, and Bolivia. Teach seminars on structural geology and balanced cross section construction for oil industry and AAPG Continuing Education Program. Teach field seminars on structure tectonics and basin evolution of southern California. Hydrocarbon evaluation and prospect generation in fold and thrust belts for international and domestic projects. Structural analysis in southern California for the U.S.G.S. National Earthquake Hazard Reduction Program. Associate editor AAPG Bulletin 1995-2001.

6/82-4/88 **Senior Research Geologist, ARCO Exploration Research.** Major research area is in structural geology and regional tectonics concentrating on the general problem of the relationship between fold and fault geometries in compressional tectonic settings. Completed projects in the Coast Ranges, Transverse Ranges and San Joaquin Valley, California, the Brooks Range, Alaska and in the Ouachita Mountains, Oklahoma, Turkey, Pakistan and Papua New Guinea. The research approach includes balanced cross section construction, detailed and regional field mapping, analysis of seismic reflection profiles, earthquake

seismicity, and subsurface well information. Taught structural geology courses and led field trips for ARCO.
Awards: ARCO Outstanding Technical Achievement Award, June, 1985.
ARCO Exceptional Achievement Award, October, 1984.

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ATTACHMENT B

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CERTIFICATE OF SERVICE

I, Jack McGowan, certify that I have, on this date, caused the foregoing TESTIMONY OF JAY NAMSON ON BEHALF OF THE SAN LUIS OBISPO MOTHERS FOR PEACE, SIERRA CLUB, PUBLIC CITIZEN, GREENPEACE AND ENVIRONMENT CALIFORNIA to be served by electronic mail on the parties listed on the Service List, and by U.S. Mail for those who have not provided an electronic address, for the proceeding in California Public Utilities Commission Docket No. A.04-01-009.

I declare under penalty of perjury, pursuant to the laws of the State of California, that the foregoing is true and correct.

Executed on August 3, 2004, 2004 in San Francisco, California.