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Subcommittee on Research and Technology

Chairman Buschon, Ranking Member Lipinski, and members of the Subcommittee, thank you for inviting me to testify on earthquake hazards as they relate to lifelines, in particular electric power and other utility systems. Today I am speaking on behalf of the Seismological Society of America, which is the largest and most respected professional society of seismologists and experts in related fields in the world.

During my professional career I have had the opportunity to gain extensive experience and insight into the physical and operational impacts of strong earthquakes on utility operations and facilities. I have had the opportunity to work with the agencies that comprise the National Earthquake Hazards Reduction Program (NEHRP) and see the benefits of strong interagency cooperation and collaboration amongst the community of seismologists. An authorized and appropriated NEHRP is fundamental to an earthquake-resilient nation.

In the following testimony, I'll draw on that experience in briefly covering the following points:

- Managing earthquake risk exposure of electric power systems
- Status of the nation's level of lifeline earthquake preparedness and resiliency
- Recommendations for research and development measures in mitigating earthquake hazards for electric and gas utilities
- Conclusions

1. Managing Earthquake Risk for Electric Power Utilities

I started working in the Geosciences Department at Pacific Gas and Electric Company (PG&E) in February 1986 as the lead seismologist on the Diablo Canyon Long-Term Seismic Program, a Nuclear Regulatory Commission license requirement. In early July of that year, a strong earthquake (magnitude 6.1) occurred very close to a major Southern California Edison (SCE) high-voltage transmission substation near North Palm Springs, CA. The substation equipment (circuit breakers, switches, etc.) was damaged extensively and shut down the Pacific Coast Intertie (the electric transmission system between Southern California and the Pacific Northwest). A senior executive at PG&E, upon being briefed about the North Palm Springs earthquake and its disruptive effect on power transmission in

California, asked the Civil and Electrical Engineering and Geosciences Departments a key question: "Could this happen to PG&E?"

This simple question led to a simple answer, "YES," for many of PG&E's high-voltage substations, particularly those in the San Francisco Bay Area, the heart of PG&E's service territory. My counterpart in the Civil Engineering Department and I joined with a senior electric engineer and developed a map for the greater Bay Area showing locations of active faults and substations that had the same types of high-voltage substation equipment that had failed in the SCE substation. Based on this information, a plan was developed to systematically replace the vulnerable equipment with more expensive, seismically resistant breakers and switches. This "Breaker Replacement Program" was budgeted and began to be implemented over multiple years.

Unfortunately, the next large earthquake to strike California occurred in the southern San Francisco Bay Area, the M6.9 Loma Prieta earthquake of October 17, 1989. Although the Breaker Replacement Program was not yet completed, it was deemed a success, as the substations with replaced breakers could be restored quickly, while the substations with extensive damage had to wait weeks for replacement breakers to be obtained and installed.

PG&E's experience in recovering from a severe urban earthquake provided an opportunity for specialists in transmission reliability from PG&E, SCE and the Los Angeles Department of Water and Power to develop an ongoing discussion of how to manage earthquake risk for our respective utilities. During this period, the next severe California earthquake occurred in Southern California, the January 17, 1994, M 6.7 Northridge earthquake. This event caused extensive damage to the electric transmission and distribution systems in the heart of Southern California and also damaged natural gas transmission lines. The occasional discussions among the West Coast electric utilities prior to the Northridge event self-organized into an ad-hoc "Inter-Utility Seismic Working Group", which I chaired. The Working Group developed gas and electric subgroups, and added Southwest Gas and Southern California Gas, San Diego Gas and Electric companies and Bonneville Power Administration and BC Hydro. We met semi-regularly (either face-to-face or by telephone) to discuss specific issues regarding the seismic performance of electric and gas system components. The open exchange of technical information was welcomed by all the individuals involved. What seemed to facilitate this openness was the lack of substantial involvement by senior management.

California's Seismic Safety Commission identified the California Public Utilities Commission as the lead agency having oversight responsibility for the seismic safety of the regulated utilities. In 1993 the Seismic Safety Commission outlined a seismic safety program to improve the earthquake performance of the electric power and natural gas utilities. They directed the utilities to develop and adopt a comprehensive policy on acceptable levels of earthquake risk with long-term priorities and schedules for the reduction of unacceptable hazards. The Inter-Utility

Working Group took on the responsibility for preparing this policy statement. The version published in 1995[1] is as follows:

Each California gas and electric utility system shall withstand earthquakes to provide reasonable protection of life, to limit damage to property, and to provide for resumption of utility system functions in a reasonable and timely manner. An acceptable level of earthquake risk is the residual risk that remains when this policy has been implemented.

It is the goal of this policy that each utility satisfy its responsibilities to protect the public and to provide reliable customer service in the face of possible earthquake effects. Although compliance with this policy will provide reasonable public safety and customer service, it will not prevent all loss of life, property damage, or loss of utility function.

Each utility is responsible for its own compliance with this policy by preparing and carrying out a long-term seismic safety implementation plan. It should be based on the current understanding of earthquake hazards and risk, and the current technical capabilities and practices of the industry."

PG&E established a formal Seismic Risk Management Program in 1994 in accordance with this policy statement.

2. American Lifelines Alliance

I was involved in the formation of the American Lifelines Alliance, which was established by FEMA in 1998 and was terminated due to lack of funding in 2006.

The American Lifelines Alliance (ALA) was a public-private partnership funded by the Federal Emergency Management Agency (FEMA) of the Department of Homeland Security (DHS) and managed by the Multihazard Mitigation Council of the National Institute of Building Sciences (NIBS). The goal of ALA was to reduce risks to lifelines – the essential utility and transportation systems that serve communities across all jurisdictions and locales – from all hazards. To do so, it facilitated the development, dissemination, and implementation of planning, design, construction, rehabilitation and risk-management guidance and encourages use of this information to improve the performance and reliability of new and existing critical infrastructure. The ALA's key stakeholders were lifeline operators and the communities they serve, standards development organizations, and engineering and risk-management professionals. The ALA provided a forum to address current industry and community needs and formed a unique partnership to work across lifelines systems. ALA products were intended to be incorporated in national

[1] Technical Council on Lifeline Earthquake Engineering (TCLEE) Monograph No. 6, Michael J. O'Rourke (editor), *American Society of Civil Engineers*

consensus standards documents as well as disseminated to key industry stakeholders through relevant associations and industry publications.

During its active existence, ALA partners included FEMA, NIBS, the Federal Highway Administration, PG&E, ROHN Industries, USGS, and the Bureau of Reclamation.

The funding support originally planned for ALA by FEMA waned substantially during the organization's life, and ended up severely curtailing its effectiveness. However, one of the last projects that ALA was able to complete was the preparation and publication of guidelines for utility performance assessment. There are four guidelines, covering electric power systems, oil and natural gas pipeline systems, water systems, and wastewater systems. Each guideline consists of a guidelines document and a commentary document. Because of the untimely closure of ALA, it was not possible to carry out full implementations of the guidelines as demonstration projects. Individuals who have expressed an interest in doing performance assessments have obtained copies of the guidelines, but to my knowledge there has not yet been a full implementation of any of the guidelines.

Interested persons may go to the web site AmericanLifelinesAlliance.com (please note: it is a .com site, not .org) to review the assessment guidelines and other ALA products and resources.

3. Status of Current Utility Lifeline Earthquake Preparedness and Resiliency

It's my opinion that, as a nation, we don't actually know how earthquake-prepared or earthquake-vulnerable our lifeline utilities are. The utilities that have suffered relatively recent natural hazard events know, but the ones that do not have recent experience, either directly or vicariously (e.g., to a neighbor utility), probably do not know. They won't know their state of preparation/vulnerability until they do a formal assessment along the lines as prescribed in the ALA documents, or suffer a severe earthquake. Many aspects of vulnerability have to do with the adequacy of anchorage and bracing, falling of adjacent non-critical components, etc. Even a walk-through by an earthquake-savvy utility person who is expert on the modes of earthquake damage and operational failure of electric power systems could provide some useful information.

4. Coordination between federal, state, and local stakeholders for earthquake emergency preparation and mitigation

I am not a particularly good commentator on this subject, as my ongoing involvement in these matters are fairly sub-regional, not national. What I have observed is that the preparation for future earthquakes and management of earthquake risk has not recovered the priority that it had prior to the terrorist attacks in 2001. The ALA project was a struggle for FEMA to sustain, for example. I

think that the more seismically exposed regions (Pacific Northwest and California) in particular have made progress at local levels, but the more moderate-hazard urban areas seem to not have been able to sustain programs given lower ability for cooperation at the national level. For lifelines, I'm pleased to see the current NIST efforts to develop the Community Disaster Resilience Program with efforts to promote such activities rather widely around the country. Particularly with regard to utility lifelines, their internal organizational commitment to safety and reliability can help build wider local and regional support for assessing current levels of preparedness and promoting mitigation. Our nation has a strong track record of pulling together for response and recovery from major natural hazard events, but the better approach is assessing exposure and programmatically improving resilience in advance of the next earthquake.

4. Recommendations for Research and Development Measures in Mitigating Earthquake Hazards for Utilities

PG&E established a successful user-directed research program with the Pacific Earthquake Engineering Research Center (PEER) at UC Berkeley that has lasted 20 years. During the several years that I managed PG&E's side of that program, many useful results were obtained that could be directly and immediately applied by PG&E, such as shake-table testing of various types of high-voltage substation components. In my view, the PEER Lifelines Project has directly benefitted the funding entities (initially PG&E and later including California Department of Transportation) for more than two decades. This applied-research model has an advantage over principle-investigator-directed research in that when users put their own money into research, they legitimately own, and feel motivated to use, the results.

5. Conclusions

The NEHRP agencies have important contributions to make in the arena of utility lifeline earthquake preparedness and resiliency. NIST and NSF both support contributions of new knowledge relevant to lifeline performance in the face of earthquake risks. In particular, USGS has taken extraordinary steps to provide earthquake hazard data that are quite valuable in the real-time assessment of earthquake hazards for emergency response. Their internal research support of USGS experts and their external support of non-USGS earthquake hazard specialists are directly used for the updating of national hazard maps, providing emergency responders with critical data, and providing the basis for earthquake preparedness by all elements of our society.

The ALA project initiated by FEMA was well-envisioned and was managed as well as could be done in a difficult governmental time and setting. Re-establishing a lifelines partnership would provide a setting for engaging lifeline organizations to

promote and conduct rigorous earthquake performance assessments; it is necessary to understand the problem before it can be fixed. We do not have to wait for the next damaging earthquake to identify seismic vulnerabilities and mitigate them.

Thank you again for this opportunity to provide testimony on these important subjects to the Subcommittee members. I hope this information and my perspectives are useful as you proceed with your deliberations.