“Improving State Wide Electrical Infrastructure’s Safety & Reliability Thru Public/Private Seismic Mitigation Research & Development”

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PIER Mission Statement

"The mission of the Public Interest Energy Research Program is to conduct public interest energy research that seeks to improve the quality of life for California citizens by providing environmentally sound, safe, reliable and affordable energy services and products. Public Interest Energy Research includes the full range of research, development, and demonstration activities that will advance science or technology not adequately provided by competitive and regulated markets."
What are we looking for in PIER Projects?

- It is essential that PIER projects benefit California's electric consumers. PIER projects should:
  - Reduce the cost of electricity and increase the value
  - Increase the reliability of the electric system
  - Reduce the environmental impacts of electricity generation, distribution and use
  - Enhance California's economy
  - Demonstrate a connection to the market
  - Advance science and technology not provided by competitive and regulated markets
Presentation Topics

- CA Overview
  - Mission; Challenges & Outlook
  - Energy is life blood of modern economy

- State’s Role in Assuring Reliability & Protecting Customers

- Why CA supports R&D on Mitigating EQ Impacts to Electric Power Systems

- PEER overview & benefits

- Lessons Learned
  - For Researchers; Government; Utilities
Energy Commission Role

- Energy policy and information advisor to the California governor and legislature

- Major Functions:
  - License power plants
  - Promote energy efficiency
  - Promote advanced energy technologies
  - Assess current and future energy trends

- Diversified Implementation Strategies
  - Analysis & planning
  - Regulatory solutions
  - Incentives
  - R&D
  - Collaborations

**Theme:** A strong energy infrastructure is paramount to California’s future.

**Policy Recommendations**
**Legislative Recommendations**

**Implementers**
- CEC
- CPUC
- CPA
- Cal-ISO
- ARB
- DWR
- EOB
- Caltrans

**Adopters**
- Administration
- Legislature

**Economic Growth**
- Environmental Responsibility
- Stable Energy Prices

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**Policy Recommendations**
- Legislative Recommendations

**Natural Gas & Electricity Assessment**
**Transportation Assessment**
**Public Interest Energy Strat. Assessment**

**Public & Stakeholder Input**
The state’s electricity consumption is the 13th largest in the world (behind USA, China, Japan, Russia, Germany, Canada, India, France, United Kingdom, Brazil, Italy, and South Korea)
California produces some of the energy it uses, but is dependent on other states, Canada and others for supply significant amounts of energy.
Interdependence: WECC Transmission Lines

- Western states, Canadian provinces, Mexico’s Baja are integrated
- The “Doughnut”
- Very weakly connected to rest of NA
Solutions Through Research:
California has Established a $62M/yr Public Interest Energy Research Program (PIER)

California’s Energy Future

**Efficiency:** Affordable Solutions

**Reliable:** Adequate & Available

**Environment:** Protect and Enhance
Consistent with our mission to improve reliability, PIER is a supporter of the Pacific Earthquake Engineering Research Center Lifelines Program.

Partners include:
- PG&E
- USGS
- Caltrans
- CEC/PIER
Pacific Earthquake Engineering Research Center Lifelines Program

A California Partnership for Electric System Seismic Safety and Reliability
Earthquakes represent the greatest natural hazard threat to California’s electric system
FARQUAK AND FIRE: Two San Francisco Gas and Electric Co. employees view the ruins of Station "B," Third and Townsend streets; INSET: Market Street, between Stuart and Second; April 18-23, 1906.
It’s not a matter of “if” an earthquake will happen… it’s a matter of “when”
62% probability
for at least one magnitude
6.7 or greater quake
2003 to 2032
What have we done to prepare for the next catastrophic California earthquake?
PEER Lifelines Program

Providing data, models, and methods needed to improve the earthquake reliability and safety of lifelines systems.

Implementation of Research Results

A key feature of the Lifelines Program is that the research results are implemented rapidly by the sponsors of the research.

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<td>Seismic Inputs Estimate seismic inputs for individual facilities and distributed systems Ground Motion Ground Deformation</td>
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<td>Topic 2</td>
<td>Vulnerability of Components and Facilities Quantify Vulnerability / Evaluate need for retrofits Substation Equipment Gas Pipelines Buildings</td>
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<td>Topic 3</td>
<td>System Performance Evaluate need for retrofits or system changes to meet system performance goals Electric Transmission Gas Transmission Highways and Bridges</td>
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<td>Topic 4</td>
<td>Emergency Response Rapidly Estimate Damage/Performance following an earthquake Bridges Substation Equipment Gas Pipelines Buildings</td>
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http://peer.berkeley.edu/lifelines

PEER is administered under the National Science Foundation’s Engineering Research Centers Program and is headquartered at UC Berkeley. PEER is funded by NSF, the state governments of California and Washington, and private industry and businesses.
PEER Lifeline Project Deliverables

Substation Equipment & Buildings Research Initiatives

• Rigid/ Flexible Bus Interactions
  • Theoretical
  • Experimental
• Input Ground Motions for Simulator Testing

• Seismic Qualification and Testing of 230 / 500 kV Disconnect Switches and 196 and 500 kV Transformer Bushings
• Substation Equipment Database Development
• Seismic Assessment Building Guidelines
• PEER support for IEEE 693 – Recommended Practice for Seismic Design of Substations
Benefits to California rate-payers

• Avoided Costs
  Substation Equipment       $1-2 million/year
  Utility Buildings          $15-20 million/year

• Increased Safety and Reliability
  Reduced damage
  Reduced outage times

• Equipment Qualification
  Improvements to IEEE-693 qualification standards

• Ground Motion Models
  Design of new facilities, upgrade older facilities
Benefits:
230kV disconnect switch performances

- Tests demonstrated the ruggedness of typical switches without special seismic enhancements, when mounted on stiff supports.

- Allows procurement of seismically qualified switches at much lower cost.

- Prior to the test, PG&E paid 30% more to obtain seismically qualified 230kV disconnect switches.

- The result is $250,000/YR cost avoidance.
Benefits Continued

500 kV Disconnect Switch Seismic Performance

- Tests demonstrated performance of low-cost switch
- Lower cost, lower maintenance composite bushing found to outperform porcelain
  - Avoided cost of $25,000/bushing estimated because composite bushing is likely to survive an earthquake
  - System wide maintenance cost savings of $100,000 due to reduced need for cleaning

* Switches procured for Path 15 project in California
* IEEE 693 performance level testing requirements deficiencies identified and revised in draft standard
Electric System Seismic Safety and Reliability Success Story

In California, it is never a matter of “if” an earthquake will happen. It is a matter of “when.” In the event of a major earthquake, first responders are key players in managing emergency situations. Police officers, emergency operators, hospital emergency room personnel, and fire fighters are just a few of the people who are called in to help when the inevitable events occur. But before these and other emergency personnel can even begin to do their jobs properly, there is one thing that each one of them needs - electric power.

Thanks to research sponsored by the California Energy Commission’s Public Interest Energy Research (PIER) Program and Pacific Gas and Electric Company (PG&E), and conducted by the Pacific Earthquake Engineering Research Center at UC Berkeley (PEER), new tools and methods are being developed to make electric power transmission more reliable in the event of a major seismic event in California. When it comes to construction standards, there is no place on earth that can match California in preparing for an earthquake. When it comes to predicting what will happen to the electric grid during the course of an earthquake, energy leaders in California continue to strive to make the system perform the best it possibly can.

Among the areas under study are the substations that receive and distribute electricity to large areas of the state. The major causes of outages during past earthquakes were the catastrophic failures of circuit breakers, transformer bushings and disconnect switches at the substations. Here are some of the ways PIER researchers are currently working to make the system even more reliable:

Substation Porcelain Transformer Bushings

Throughout most of California and the nation, high voltage wires leading into substation transformers are insulated by a porcelain bushing on top of the transformer. This material is very brittle, and researchers are testing new composite materials and anchorage designs for these bushings to help prevent their destruction during future earthquakes. This results in a cost avoidance to PG&E of approximately $100,000/year. Based on these results, PG&E now procures only 500kV composite bushings for new orders. Not only are these bushings more rugged during earthquakes, they require less maintenance as well.

Although the bushings can be replaced after an earthquake, the loss of a 500kV substation could not only affect electricity in California, but possibly disrupt service in surrounding states. Also, the repair of substations could involve a significant amount of time – at the very least, several hours – during the crucial time following a disaster.

Fragility Testing – 500kV and 230kV Disconnect Switches

Like the electric circuits in our homes, substations are equipped with disconnect switches, which are used for routing power to the desired circuit, or shutting down an electrical line for a variety of reasons – whether it be damaged equipment, routine maintenance or a downed power line. Any time work is done on
Benefits: Ensuring the Seismic Performance of Utility Buildings

- Utility buildings should withstand expected earthquakes (protect equipment housed in bldgs and provide for safety of workers).

- PG&E has updated and applied seismic models to several common utility buildings and made retrofit decisions.

- Benefits to PG&E have resulted from:
  - Avoiding retrofits from some buildings by demonstrating that seismic performance is already adequate.
  - Reducing the cost of required retrofits for some buildings.
  - Identifying and retrofitting higher risk buildings first, increasing short-term safety margin.

- Benefits to PG&E estimated to be ~$15-20 million.
Lessons Learned

- Government & Utilities can be effective Partners

- Research Collaboratives are effective to:
  - Pool Resources
  - Leveraging $$
  - Find Complementary Opportunities among Individual Missions (e.g., electric, water, transportation)
Comprehensive Loss Estimation Framework for Electric Power Systems
Govt. Alone Can’t Do What’s Needed: Strategies to Maximize a Partnership

**Researchers**
- Help stretch limited $$$’s
- Look for leverage opportunities
- Seek linkages with other related societal problems and bodies of research (e.g., security, etc)
- Translate research results from science advancements into public benefits
- Be prepared to do outreach (e.g., PEER – IUSWG)

**Government**
- Join collaboratives (even if funding in minimal)
- Seek linkages with other related societal problems and bodies of research (e.g., security, etc)
- Be proactive & long range
- Embrace solutions beyond regulatory actions

**Utilities**
- Join collaboratives
- Seek linkages with other bodies of research
Closing

- It’s vital that we all do our share to maximize the limited resources available to mitigate the real threats posed to society by natural and human threats