A Pathway to Achieving a Seismic Resilient Electric Infrastructure

“Seismic Resilience 25 Years after Northridge: Accomplishments & Challenges”

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Southern California Edison owns and operates a transmission and distribution grid that delivers electricity to five million customers in a 50,000 square-mile area of central, coastal and Southern California. 15 million Californians count on us for electricity 24 hours a day, seven days a week.

Committed to Safe, Reliable, Affordable and Clean Power
Serving 5.0 million customers in Southern California

- 13,000 Miles of Electric Transmission Lines
- Over 800 Substations
- 90,000 miles of Electric Distribution Lines
- Over 80+ Dams

Located in Seismically Active Regions in the U.S

Energy for What’s Ahead™
Electric Seismic Resiliency Program

• To ensure that SCE-Electric Power Infrastructure System reach a level of resiliency where risk is as low as reasonably practicable.

Reduced failure probabilities...
Reduced consequences from failures...
Reduced time to recovery...

"ability to anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to continue to provide services."

Energy for What’s Ahead”
Seismic Resilience Program: Infrastructure Work streams

- Building & Facilities
  - Administrative and operational buildings
  - Warehouses
  - Garages

- Electric Infrastructure
  - Distribution systems
  - Transmission system
  - Transmissions, distribution and substations

- Generation Infrastructure
  - Dams, Hydro facilities
  - Peakers
  - Powerhouses
  - Mountainview Generating Station

- IT/Telcomm
  - Antenna towers
  - Telecommunications sites
  - IT data centers

Energy for What’s Ahead™
Path to Achieving a Seismic Resilient Electric Infrastructure

- **Assess the Risk**
  - Hazard or Threat
  - Infrastructure: Facilities, Electric Infrastructure, Power Production Infrastructure

- **Manage the Risk**
  - Mitigation Planning
  - Damage Assessment Tool: Predictive, Real Time

- **Outcome**
  - Reduce Risk
  - Respond to Risks
  - Common Operating Picture
  - Prioritized on the ground damage assessment
Achieving Seismic Resiliency of Electric Infrastructure

- Corporate Business Resiliency Program
- Substation Seismic Assessments and Mitigation
- Distribution Systems Assessment and Mitigation
- Control Building Assessment & Mitigation
- Transmission Assessments and Mitigation

Energy for What’s Ahead™
Seismic Assessments & Mitigation: Substations
Seismic Assessments & Mitigation: Transmission Towers

Study Zones at San Andreas Fault

Surface Faulting: Towers are more vulnerable than poles in terms of PGDs.

Landslides: Mountainous terrain and saturated soil conditions generate larger PGDs and are more susceptible to landslides.

Liquefaction: Areas near lakes, waterfronts, and stream channels are more susceptible to liquefaction.

Site Verification

Bucket Auger Drilling for Downhole Logging for Landslide Evaluation

Mitigation—Soil Nailing

Structure Color Code Scores Based on Vulnerability Analysis

Legend for Normalized Vulnerability Scorer, $S_{NOM}$
- $>0.6$
- $0.25-0.6$
- $0.05-0.25$
- $0-0.05$

Alquist-Priolo Fault
Landslide Hazard Zone
Seismic Liquefaction Hazard Zone

Energy for What’s Ahead™
Seismic Assessments & Mitigation: MEER and Control Bldg

- Performed Screening Level Assessments- Occupied Buildings
- Determined estimated performance levels and developed prioritization for further assessments
- Perform ASCE 41 Tier Assessments of Selected Control Buildings
- Engineering and Seismic Mitigation

How’s is the building going to perform during earthquake?
What are potential deficiencies?

Need Retrofit?

Energy for What’s Ahead™
Seismic Resilience: Standards, Testing and Qualifications

- Seismic design recommendations for substations, including qualification of each equipment type.
- Design recommendations consist of seismic criteria, qualification methods and levels, structural capacities, performance requirements for equipment operation, installation methods, and documentation.
Seismic Resilience through Benchmarking & Collaboration

Inter Utilities Working Group (IUWG)

Our E&TS Substation Structural Engineering Group pioneered the Inter Utilities Working Group (IUWG) which is a joint effort among utility companies within the Western region. Since 2011, the IUWG has been the medium in:

- Sharing engineering knowledge
- Discussing and solving common issues pertaining to structures and equipment
- Working toward standardization of electrical utility practices such as the development of a new AISC 113 Substation Structure Design Guide

"Together We Build The Future"

- Risk Management
- Shake Table Testing
- Research & Development
- Standards update & Improvements
- Emergency Management
- Post-Earthquake reconnaissance survey

HOKKAIDO EARTHQUAKE

Energy for What’s Ahead™
Seismic Resilience through Emergency Management

- Develop tools to enhance situational awareness capability and effective emergency response.
- Collaboration among business units and internal/external stakeholders on emergency drills/exercises, vulnerability assessments and emergency management plan development.
Seismic Resilience: Generation Infrastructure

• SCE Generation manages 2,459 MW of generating capacity
  • 33 Hydropower Plants
  • 6 Natural Gas Plants
  • 1 Diesel Plant

• High Hazard Dams are periodically assessed for safety under seismic loading, as required by law

• Assessment of the seismic resilience of generating plants in progress to identify and prioritize potential improvements to seismic resilience
High Hazard Dam Assessments

• SCE owns 83 dams, 28 of which are designated as high hazard by state and/or federal regulators

• Current regulations require deterministic analysis, with some adjustment of ground motions based on fault activity (slip rate)

• Models range from 2-D linear to 3-D nonlinear

• Validation of models using field data enhances confidence in results

• Focus on prevention of life-threatening Uncontrolled Rapid Release of Water
Seismic Resilience: Generation Infrastructure

Generating Plant Assessments

• Identify potential vulnerabilities
  • Structural (building, enclosure, etc.)
  • Equipment (turbines, transformers, etc.)
  • Geologic (liquefaction, rockfall, etc.)

• Gather relevant information
  • Drawings, equipment lists, design documents, operating procedures
  • Facility walk-downs and operator interviews
  • Facilitated risk assessment workshop for geologic hazards

• Analysis focused on ability of plant to rapidly resume operations following earthquake
  • Fragilities developed for each element
  • Logic model developed for plant operation
  • Fragilities and logic model are combined to obtain a plant fragility function
Seismic Mitigation

- High Hazard Dams
  - If deficiencies are identified, potential risk reduction measures include retrofit, reservoir restrictions, and enhanced preparedness (e.g. surveillance cameras, warning sirens, community outreach).
  - Recent recognition that smaller earthquakes do not pose safety risk, but could potentially impact operations. Current practice is to flag potential vulnerabilities for post-earthquake inspections.

- Generating Plants
  - Identify “quick wins” - mitigations with low-cost, fast implementation, and consistent with good practice (e.g. addressing unanchored equipment, securing control room monitors).
  - Evaluate costs and benefits of larger-scale mitigations (e.g. structural retrofits) and prioritize appropriately.
  - Need to better understand resiliency of dependent systems, such as the electric and gas delivery systems.
Together... we can build a resilient Electric Power System Infrastructure!