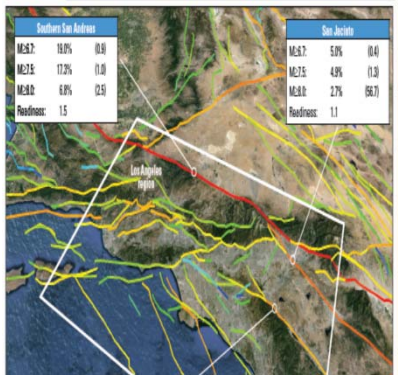
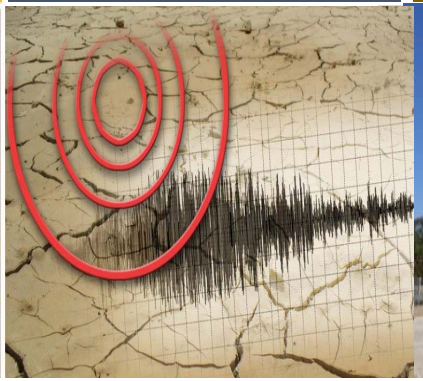
SOUTHERN CALIFORNIA EDISON®
Energy for What's Ahead℠

PEER

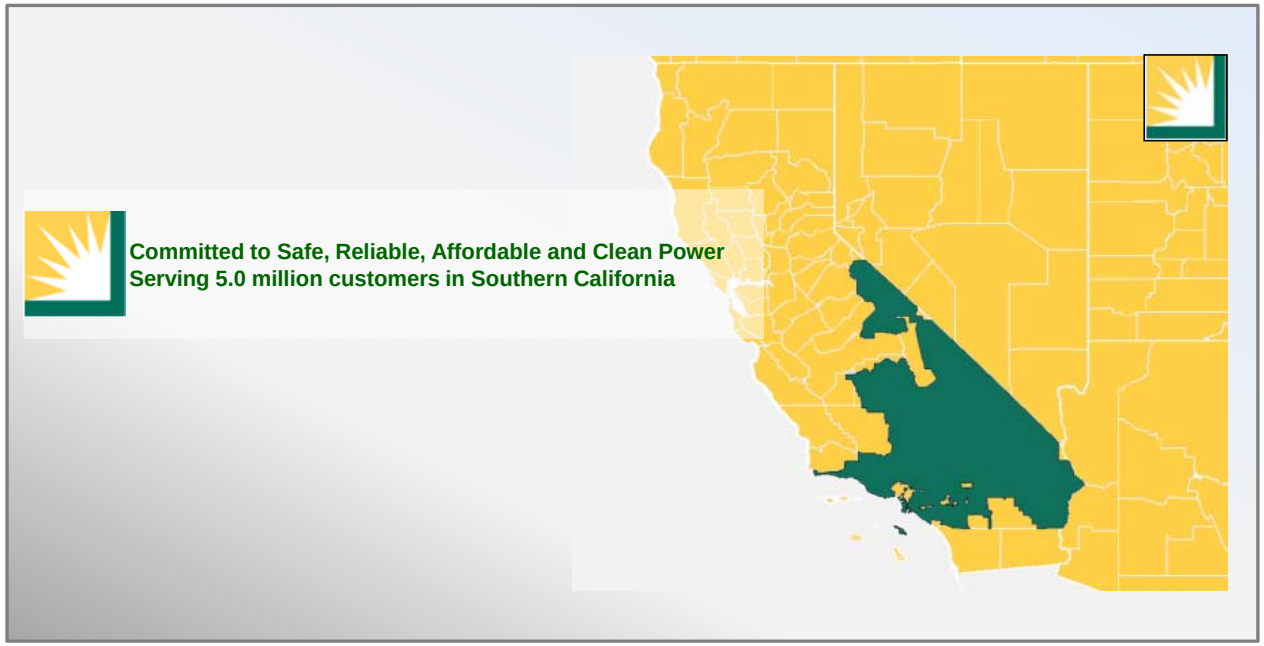
A Pathway to Achieving a Seismic Resilient Electric Infrastructure

"Seismic Resilience 25 Years after Northridge: Accomplishments & Challenges"

Roderick dela Cruz, P.E
Matthew Muto, Ph.D

January 17, 2019



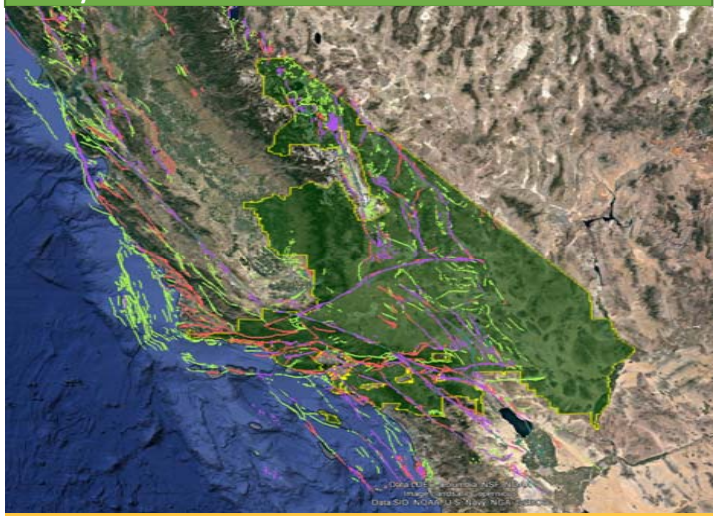
13,000 Miles of Electric Transmission Lines

Over 800 Substations

90,000 miles of Electric Distribution Lines

Over 80+ Dams

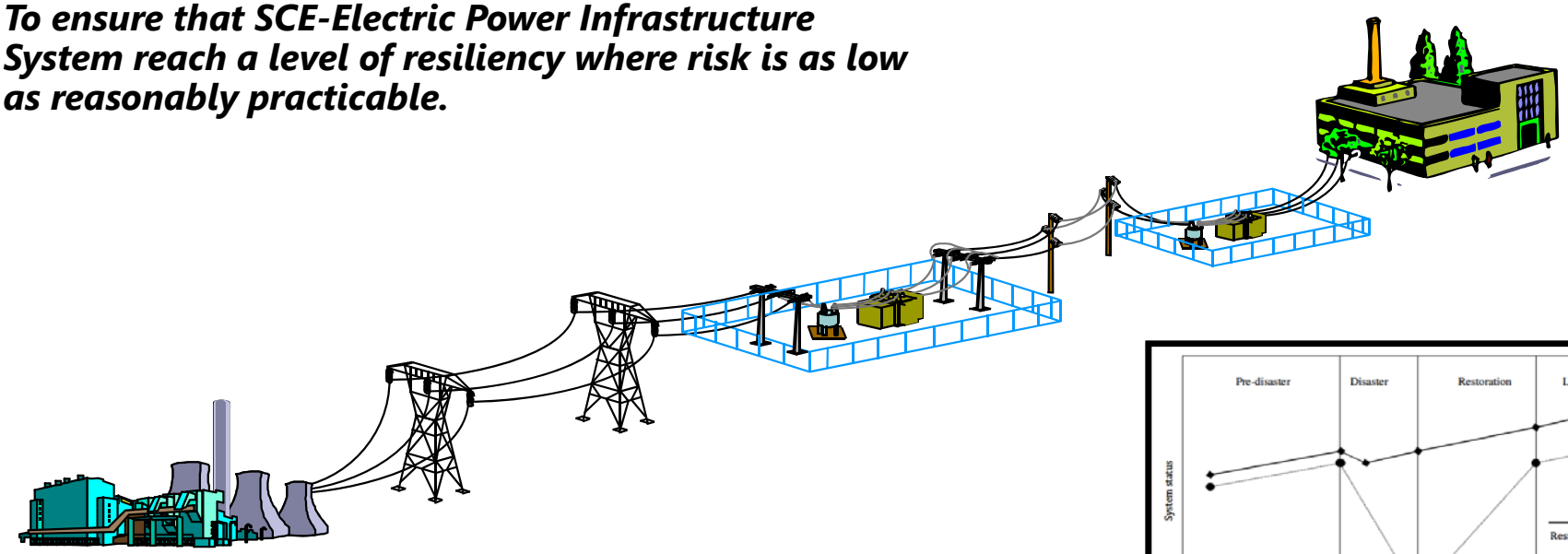
- Southern California Edison owns and operates a transmission and distribution grid that delivers electricity to five million customers in a 50,000 square-mile area of central, coastal and Southern California. 15 million Californians count on us for electricity 24 hours a day, seven days a week.

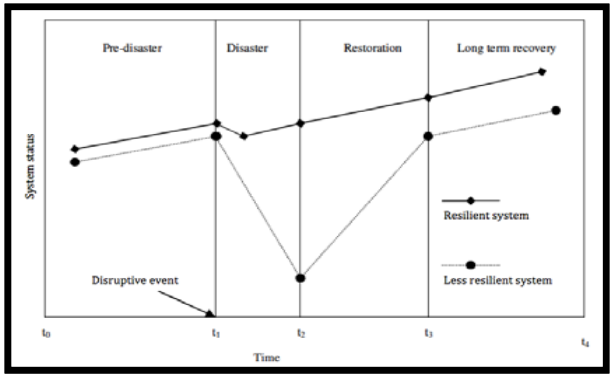


Located in Seismically Active Regions in the U.S

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.***

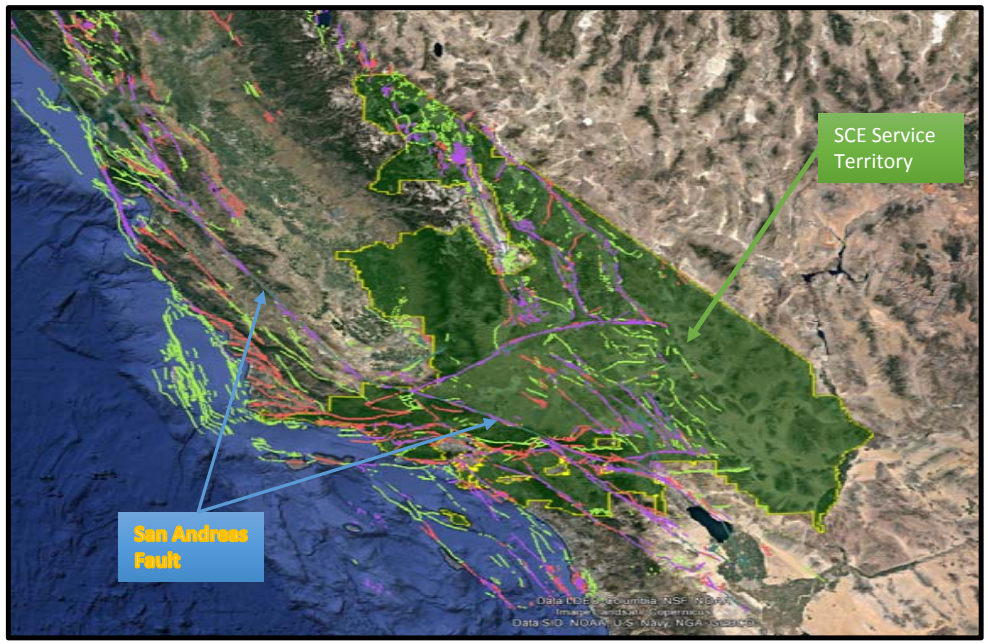


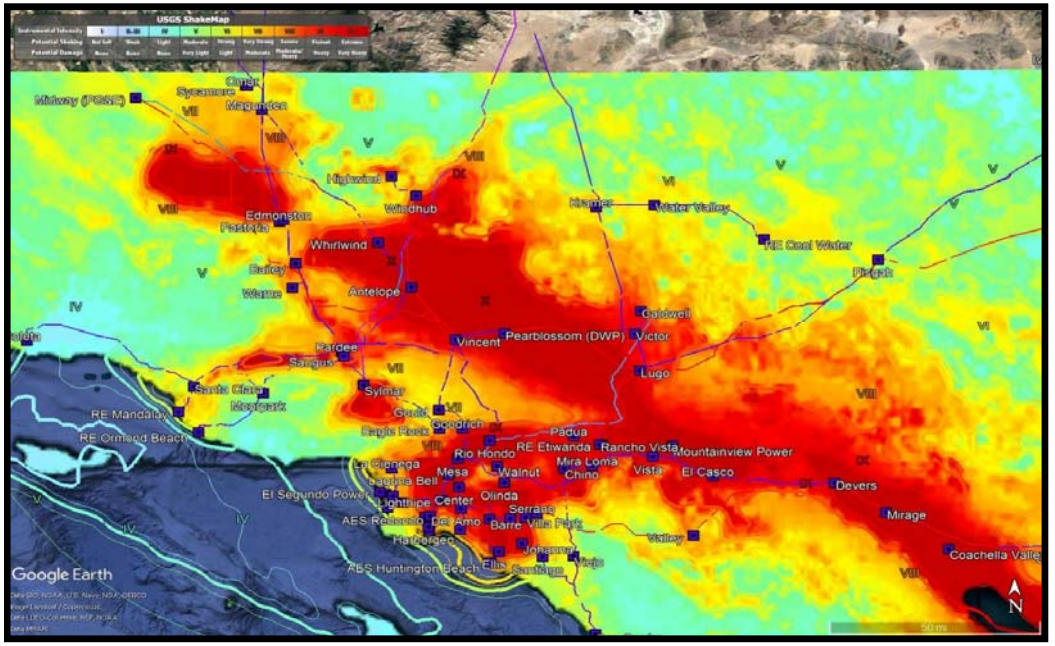


Reduced failure probabilities…
Reduced consequences from failures…
Reduced time to recovery…

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

Seismic Resilience Program: Infrastructure Work streams





Building & Facilities

- Administrative and operational buildings
- Warehouses
- Garages

Electric Infrastructure

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

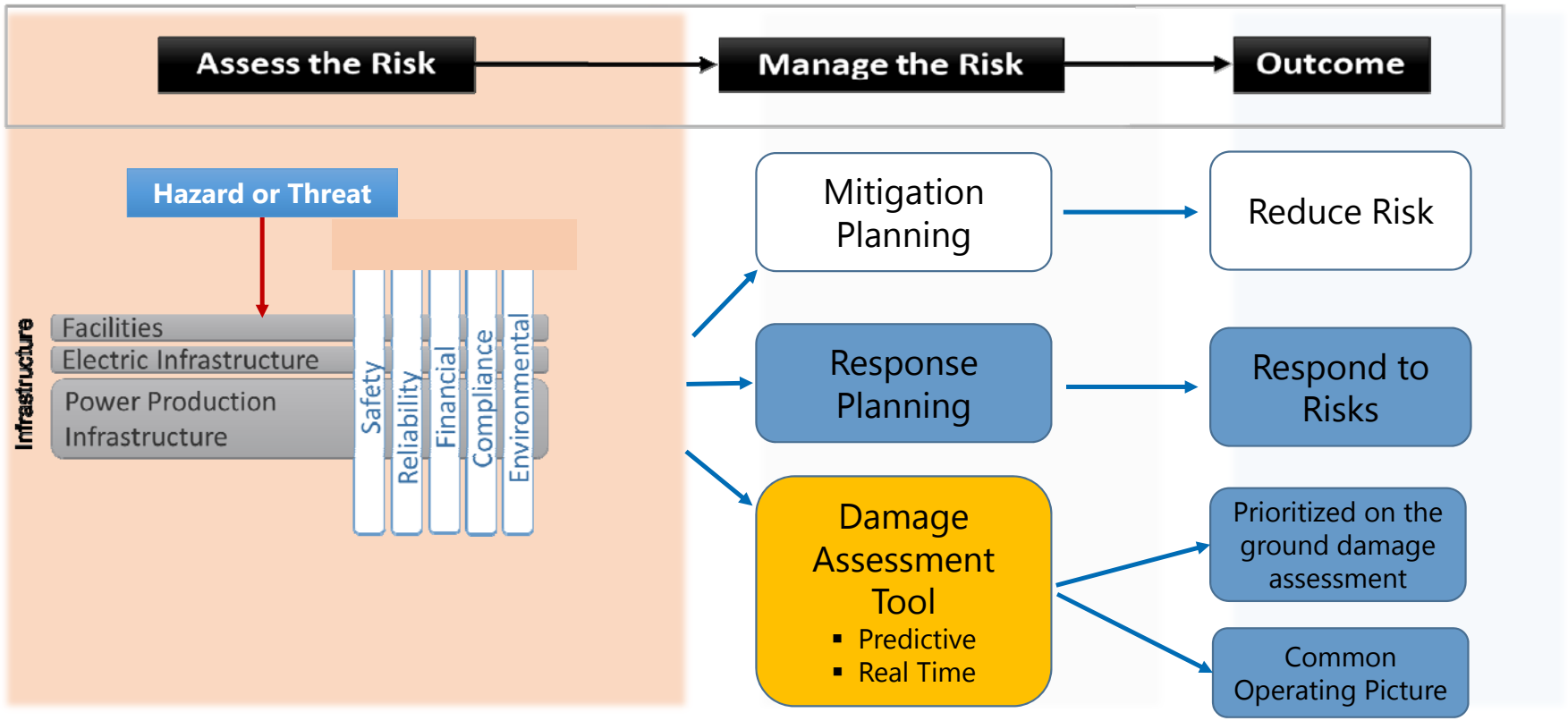
Generation Infrastructure

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

IT/Telcomm

- Antenna towers
- Telecommunications sites
- IT data centers

Path to Achieving a Seismic Resilient Electric Infrastructure

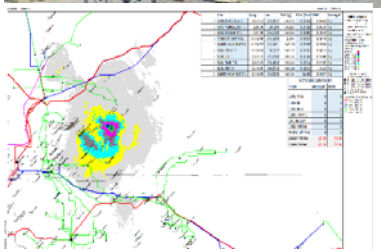


Achieving Seismic Resiliency of Electric Infrastructure

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

Seismic Assessments & Mitigation: Substations

DAMAGES



FUNCTIONALITY

Seismic Assessment

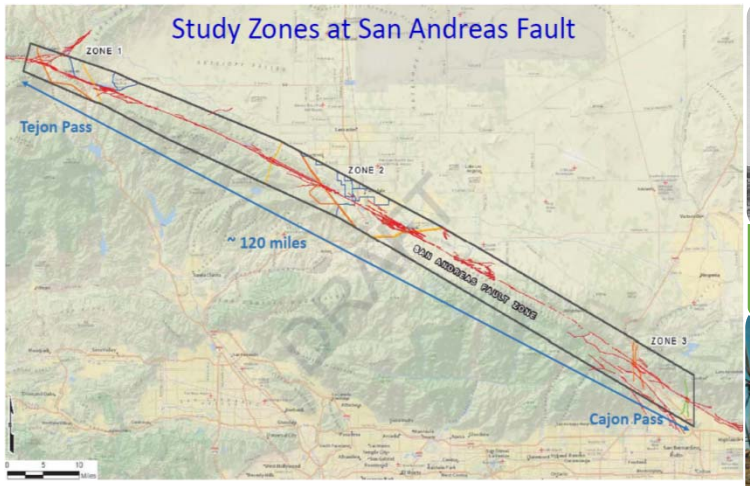
FRAGILITIES

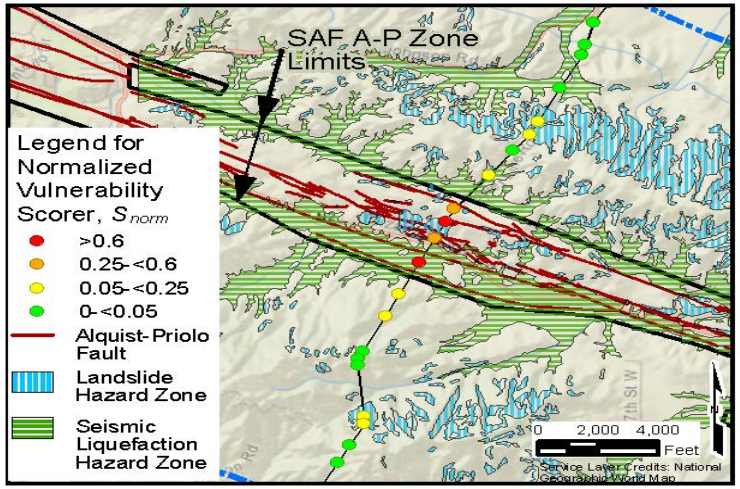
COST

HAZARDS

EQ	Scenario Earthquake	Magnitude
1	San Andreas	8.2
2	San Andreas - Palm Springs	5.7
3	San Jacinto	7.7
4	Compton	6.9
5	Palo Verdes	7.2
6	Cucamonga	7.0
7	Elsinore (Chino)	7.0
8	Elsinore (Whittier)	7.0
9	Elsinore (Whittier + Glen Ivy)	7.2
10	Peralta Hills	6.4
11	Puente Hills	7.3
12	Newport Inglewood	7.4
13	San Jose	6.7
14	Northridge	6.7
15	Sierra Madre connected	7.2

Seismic Assessments & Mitigation: Transmission Towers





Structure Color Code Scores Based on Vulnerability Analysis

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.

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

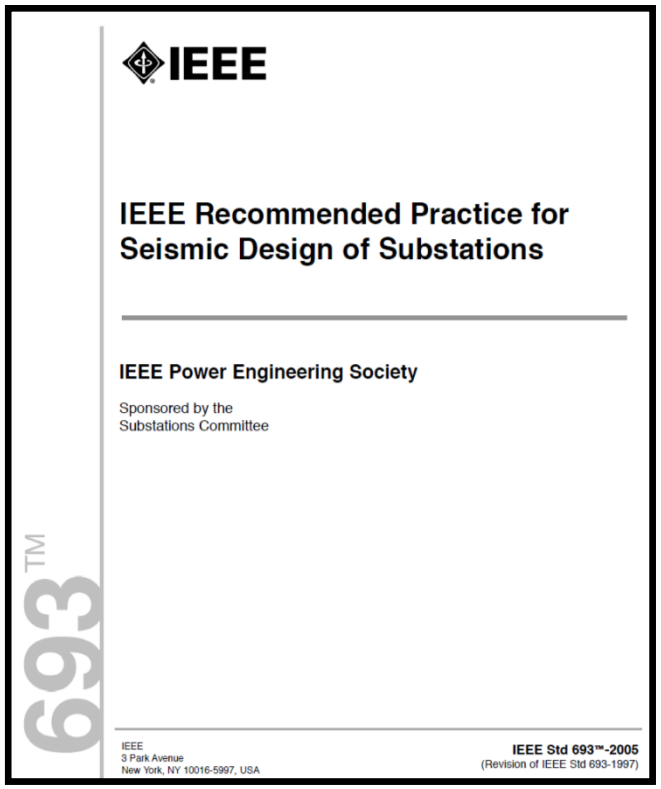
How's is the building going to perform during earthquake

What are potential deficiencies?

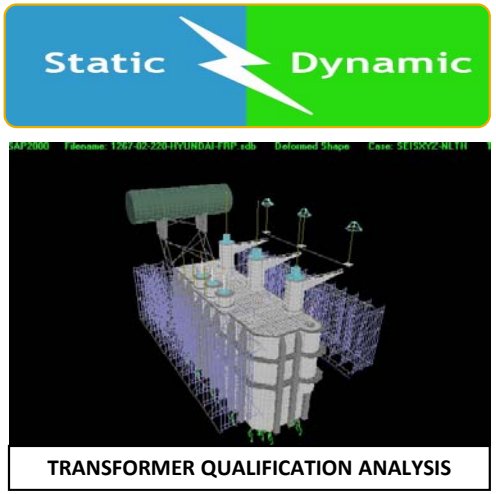
Need Retrofit?

Seismic Assessment-Buildings

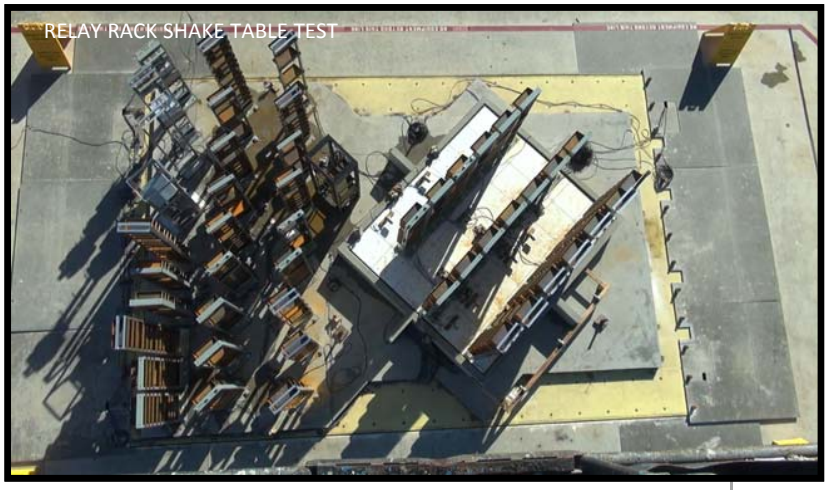
Seismic Resilience: Standards, Testing and Qualifications



- **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.**



TRANSFORMER QUALIFICATION ANALYSIS



Seismic Resilience through Benchmarking & Collaboration

Inter Utilities Working Group (IUWG)

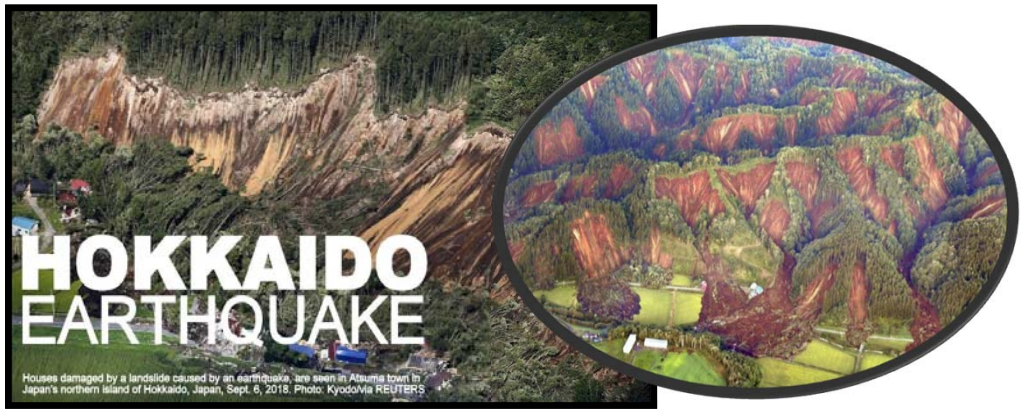
Our E&TS Substation Structural Engineering Group pioneered the Inter Utilities Working Group (IUWG) which is a joint effort among utility companies within the Western region. Since 2011, the IUWG has been the medium in:

- 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

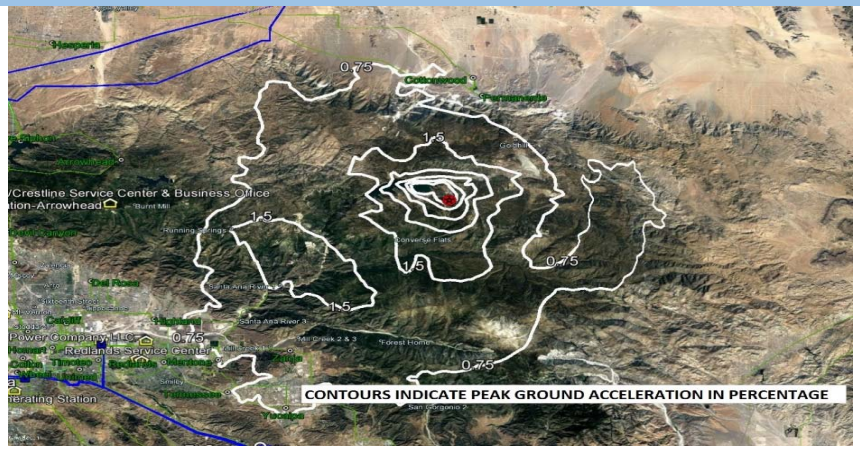
"Together We Build The Future"

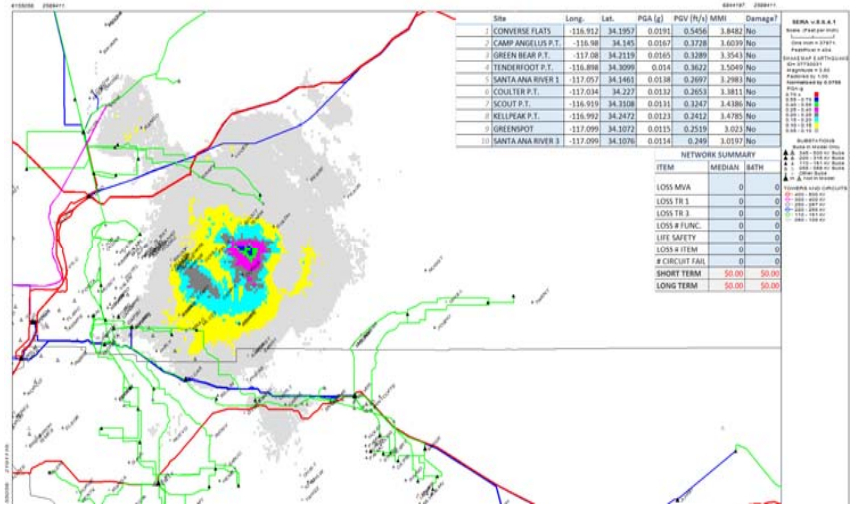
Los Angeles Department of Water & Power
Bonneville Power Administration
Southern California Edison, An Edison International Company
PG&E
SDGE, A Sempra Energy utility
IUWG
PacifiCorp

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



Seismic Resilience through Emergency Management

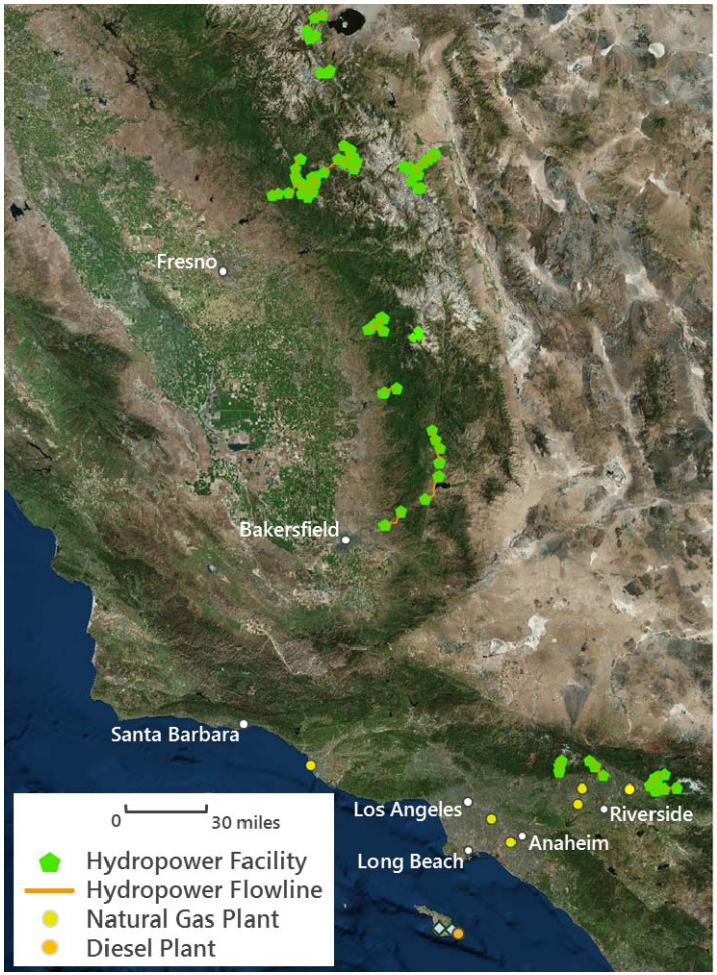




- Develop tools to enhance situational awareness capability and effective emergency response.
- Collaboration among business units and internal/external stakeholders on emergency drills/exercises, vulnerability assessments and emergency management plan development.

Seismic Resilience: Generation Infrastructure

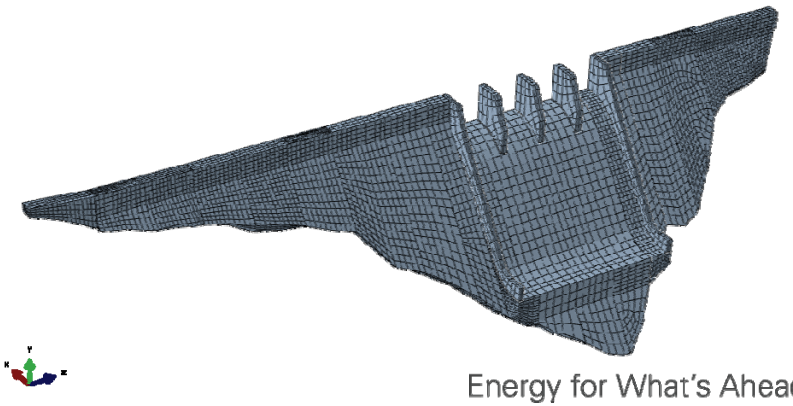
- SCE Generation manages 2,459 MW of generating capacity
  - 33 Hydropower Plants
  - 6 Natural Gas Plants
  - 1 Diesel Plant
- High Hazard Dams are periodically assessed for safety under seismic loading, as required by law
- Assessment of the seismic resilience of generating plants in progress to identify and prioritize potential improvements to seismic resilience



Seismic Resilience: Generation Infrastructure

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 Resilience: Generation Infrastructure

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!