



Maintaining Sustainability in the Power Industry *(with an eye on technology)*

Jonathan Sykes – PG&E
2016 EEA Conference
Wellington, New Zealand




Together, Building
a Better California




Who is PG&E?




5.3 million
Electric customer accounts



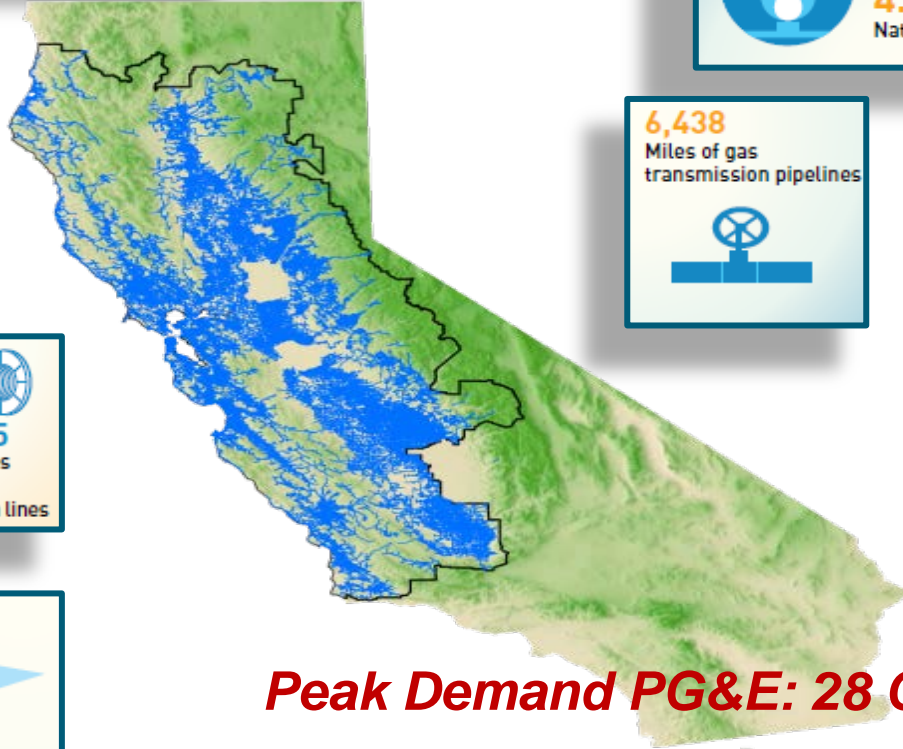
18,616
Circuit miles of electric transmission lines



141,215
Circuit miles of electric distribution lines




67
Hydroelectric powerhouses




4.3 million
Natural gas customer accounts

6,438
Miles of gas transmission pipelines



42,141
Miles of natural gas distribution pipelines



23,000
Employees

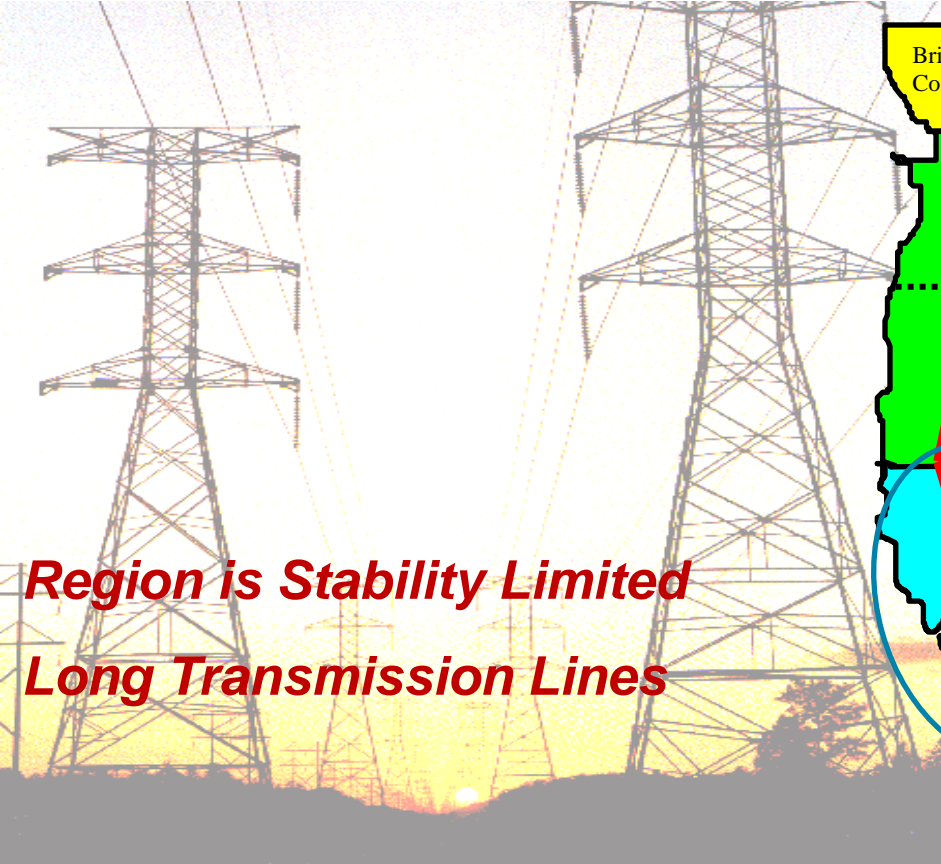


Peak Demand PG&E: 28 GW

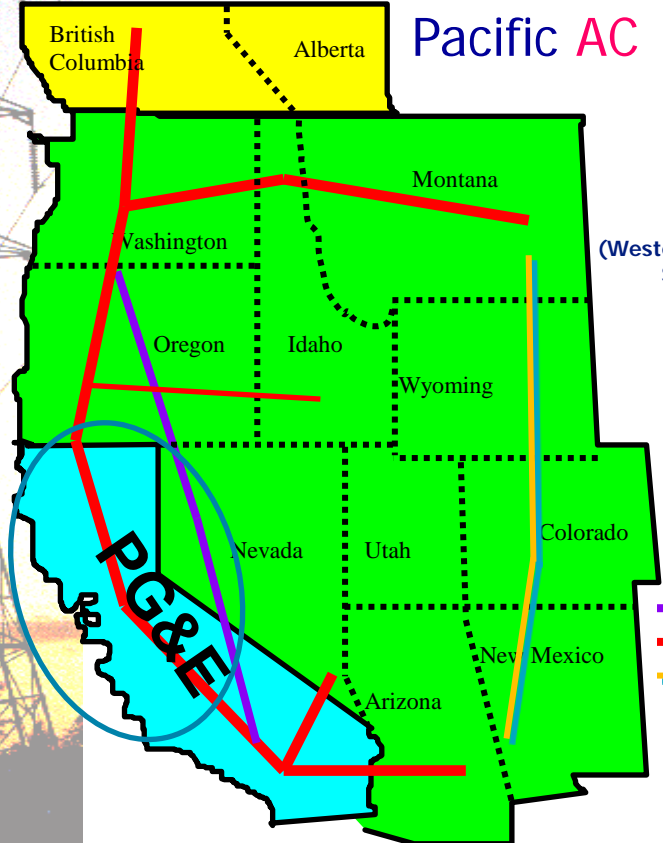
California Control Area: 58 GW



PG&E and Regional Reliability






Region is Stability Limited
Long Transmission Lines



Pacific AC Intertie (PACI)

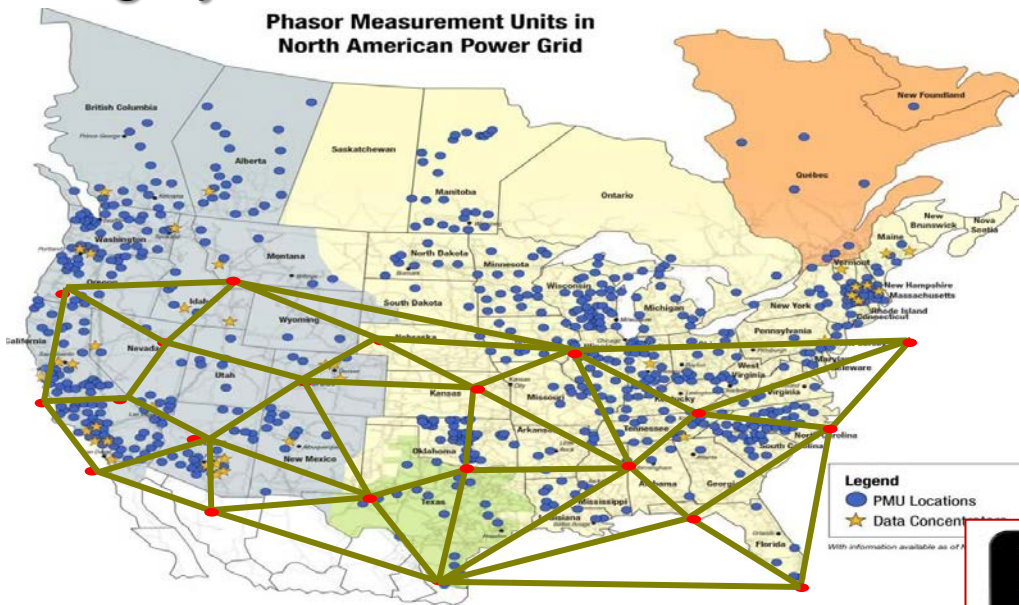
**Major Intertie Corridors
In WECC**
(Western Electricity Coordinating Council)
Serves – 72 Million Population

-  PDCI – DC Link, 1000kV
 -  PACI – AC Corridor, 500kV
 -  PACI – AC NE/SE, 345kV
- NE / SE - North East
SE – South East

Next Generation Monitoring and Control

Highly Instrumented Advanced Sensors & Computing

Phasor Measurement Units in
North American Power Grid



1,700 networked PMUs, funded by SGIG grants and private sector funds

Precise grid measurements (within 1 ms) using GPS signals - Phasor Measurement Units (PMUs)

Dynamic wide-area network view at high speed (e.g., 60 to 120 observations/s) for better indication of grid stress

Source: North American Synchro-Phasor Initiative (NASPI)



Proof of Concept (POC) Facilities

- Risk management : Identifies and remedies product and system integration issues
- A conduit to the industry standards
- Tests have resulted in:
 - Identification of gaps and solutions related to standards
 - Remedied product and system integration issues with potential for serious delays during field installation and commissioning
- Fine tuning applications for functionality and performance
- Transition from development to operation for training future users

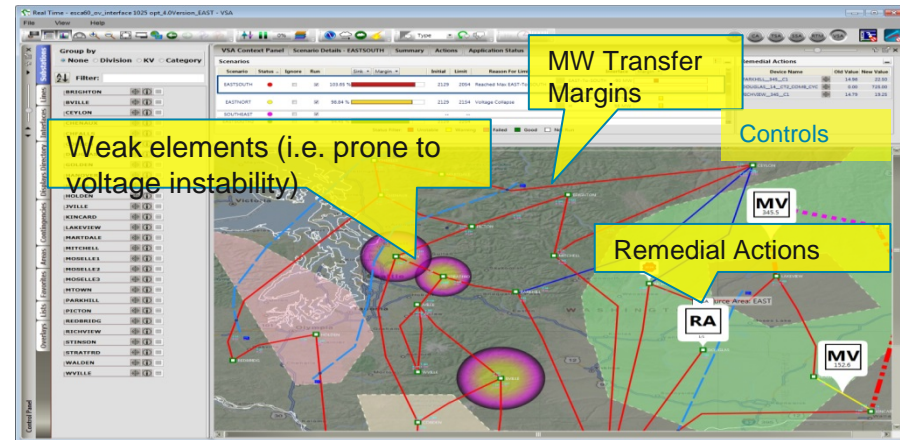
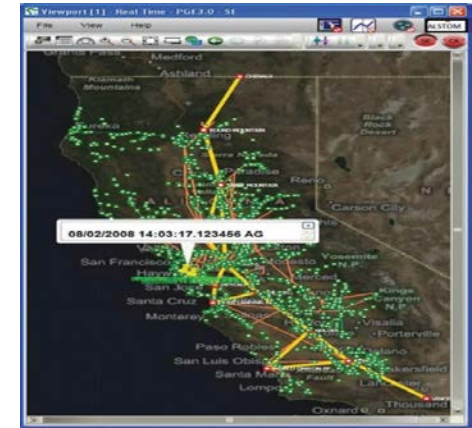


PG&E POC along with other established test facilities have provided the platform for gathering the knowledge to provide the industry with direction and a fast track process for maturing the standards such as the IEEE C37.118.2, C37.238, C37.242, C37.244, and IEC-61850-90-5

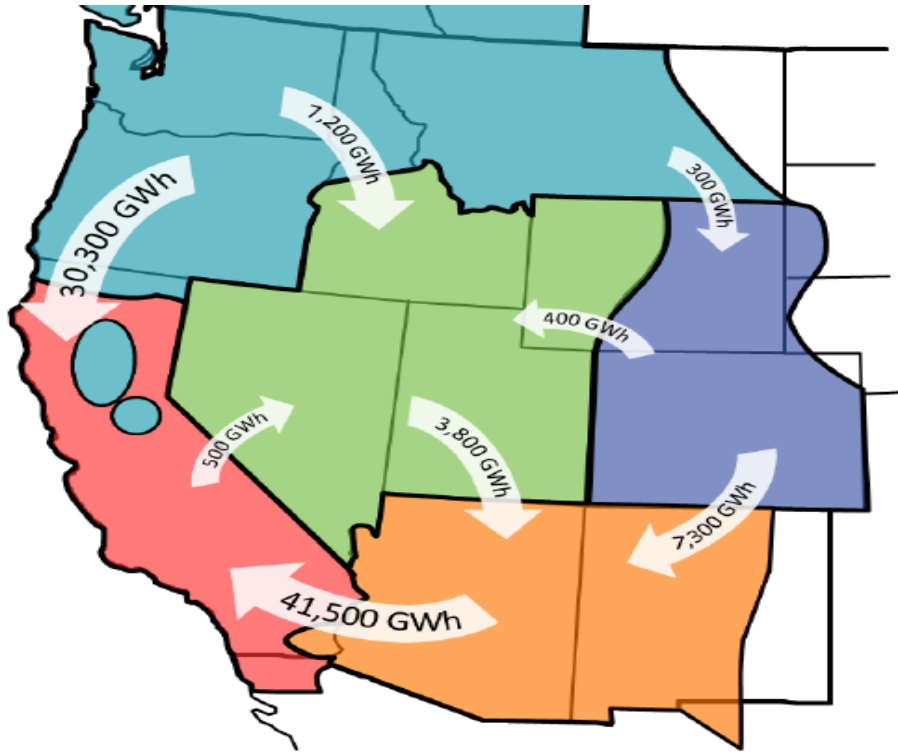


PG&E Applications

- Situational Awareness, Visualization and Alarming (angles and voltages; overloads and oscillations)
- Voltage Stability Management
- Enhanced Energy Management Systems
- System Restoration
- Post-Disturbance Event Analysis, including Fault Location
- Operator and Engineering Training, Dispatch Training Simulator



Renewable Growth in Region



- Reserves (16.1% min required)
 - WECC 33.8%, 22.2% by 2025
 - NWPP 16.4% by winter 2021
 - SRSR 16.4% by summer 2020
- Renewables Capacity (CA)
 - 21.7GW in service: 8.7PV, 6.0W
 - 21.9GW in development: 18PV, 2.7W
- Energy from Renewables (CA)
 - 24.6% // 62.1 of 252.2 GWh
 - 33% by 2020, 50% by 2030
- Energy Storage (CA)
 - 1325MW by 2024

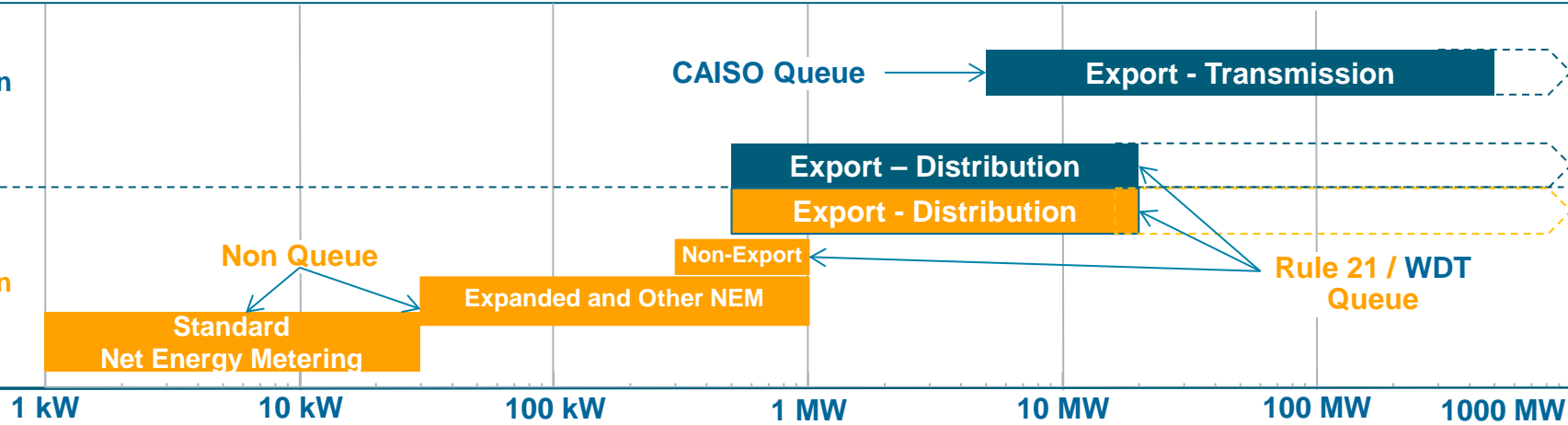
Source: WECC 2015 State of the Interconnection



Electric Generation Interconnection

**FERC
Jurisdiction**
• CAISO
• WDT

**CPUC
Jurisdiction**
• Rule 21



Data as of
12/31/15

S. NEM

Other Rule 21

W. Dist.

W. Trans.

In Service

214,126 sites / 1,141 MW

6,281 sites / 1,513.2 MW

130 sites / 462MW

71 site / 6,266 MW

In Process

997 sites / 5.8 MW

64 sites / 10.8 MW

85 sites / 240 MW

125 sites / 8,988 MW

Monthly

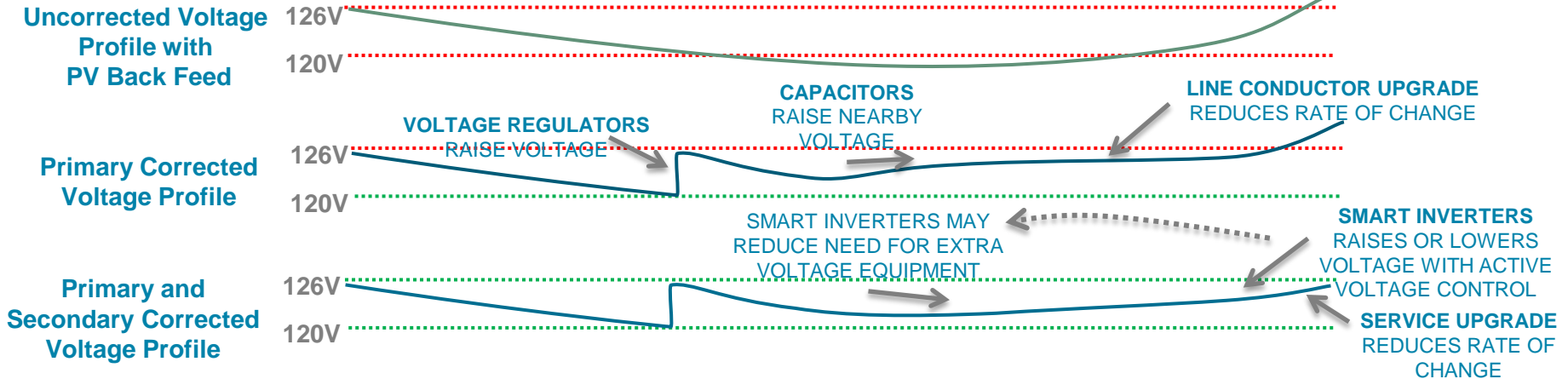
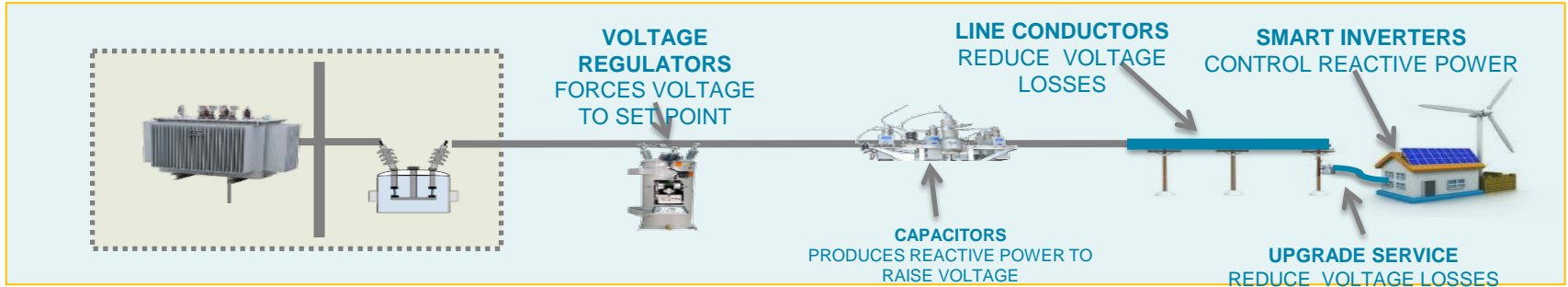
7,285

122

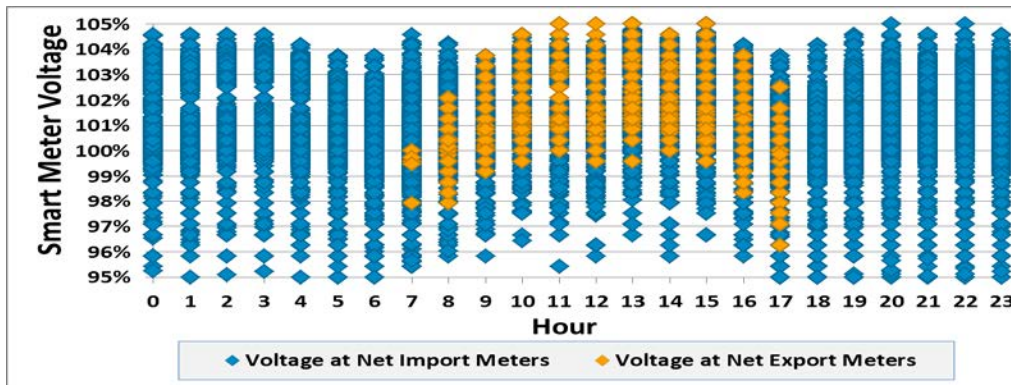
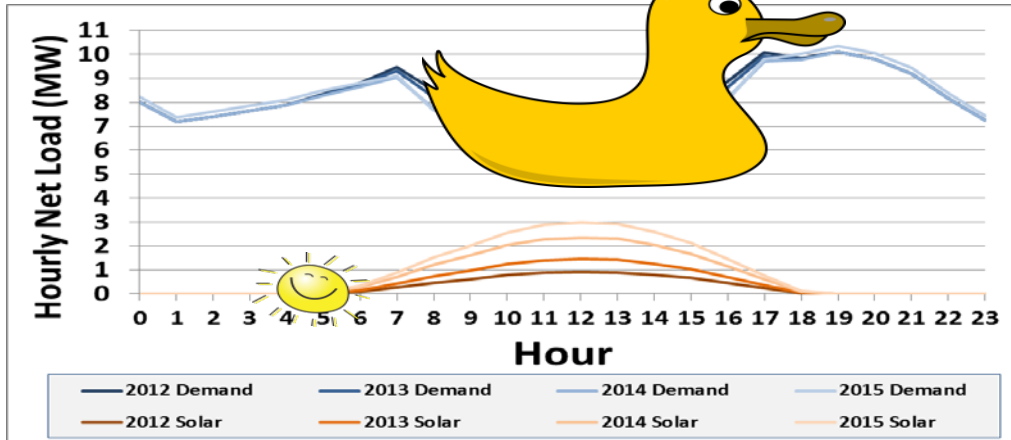
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Strategies on Voltage Control

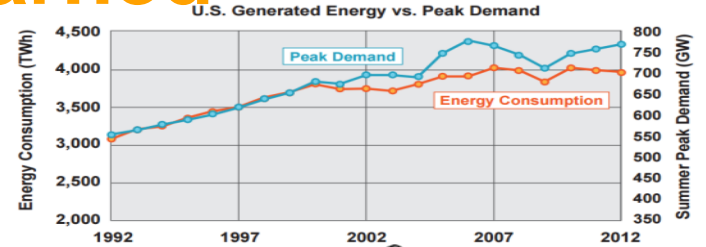


High Penetration Substations

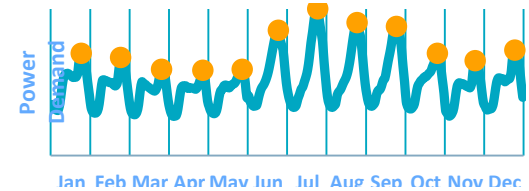
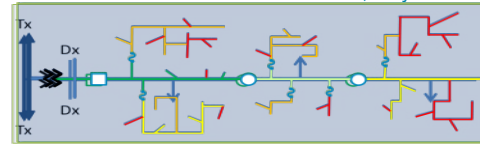


Lessons Learned

- DER will play a much more active role in distribution and system planning and allow for more dynamic flexibility of the system
- Provide engineers with geospatial circuit models for enhanced and accurate simulations
- Determining hourly load profiles are critical for understanding distribution impacts and benefits
- Data analytics and visualization is essential to progress!

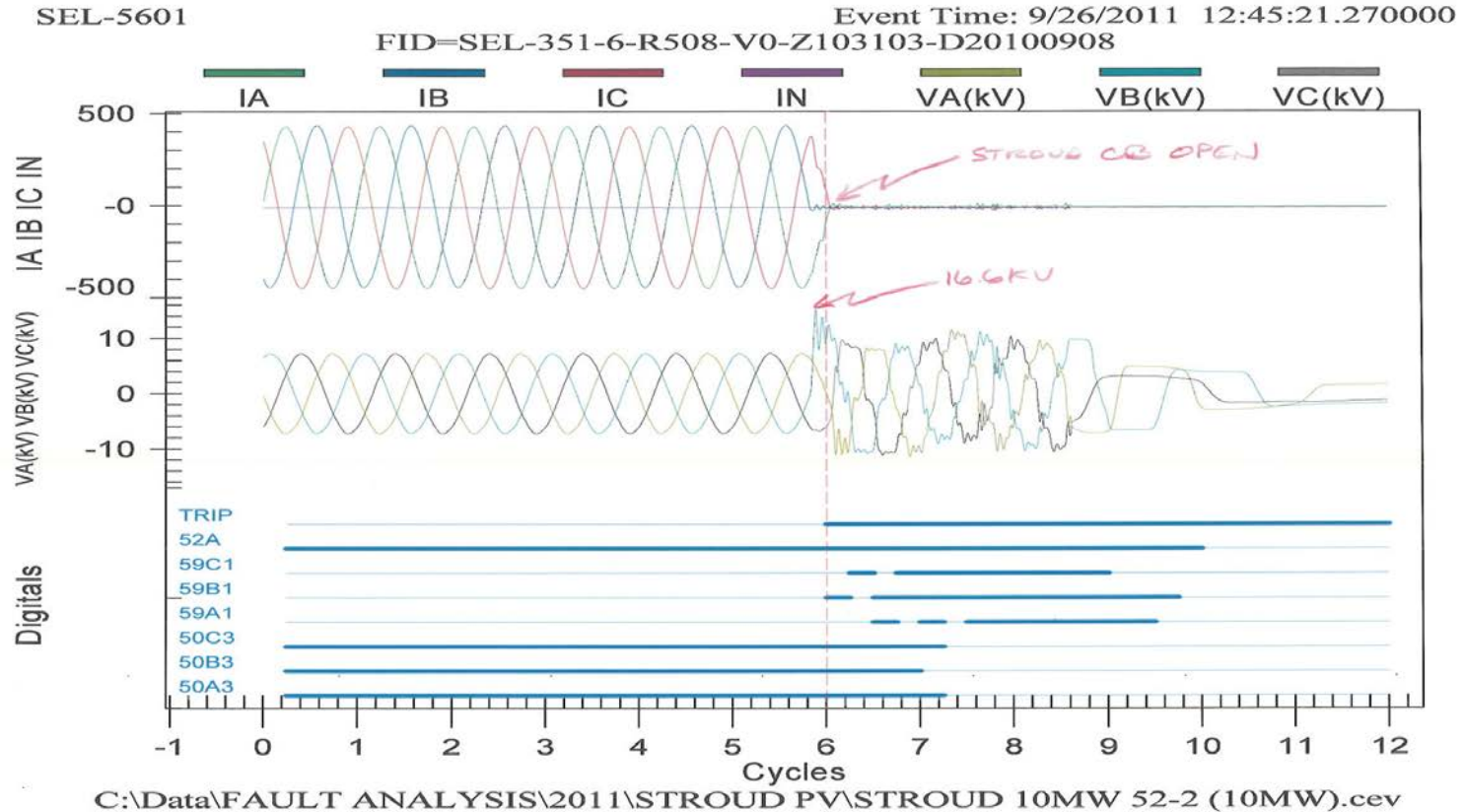


Source: EPRI, July 2015





PV Anti Islanding



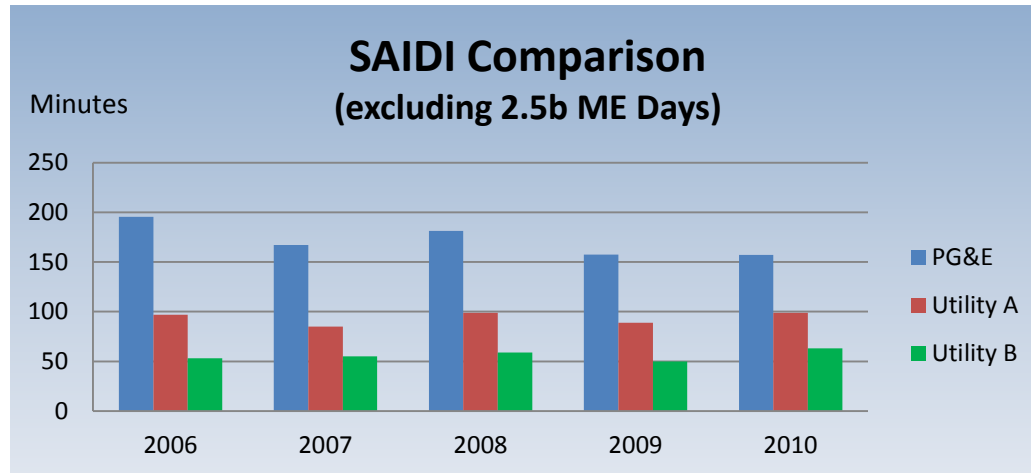


Distribution Modernization

In June 2010, the California Public Utilities Commission (CPUC) approved a program to support improved reliability of PG&E's electric distribution system

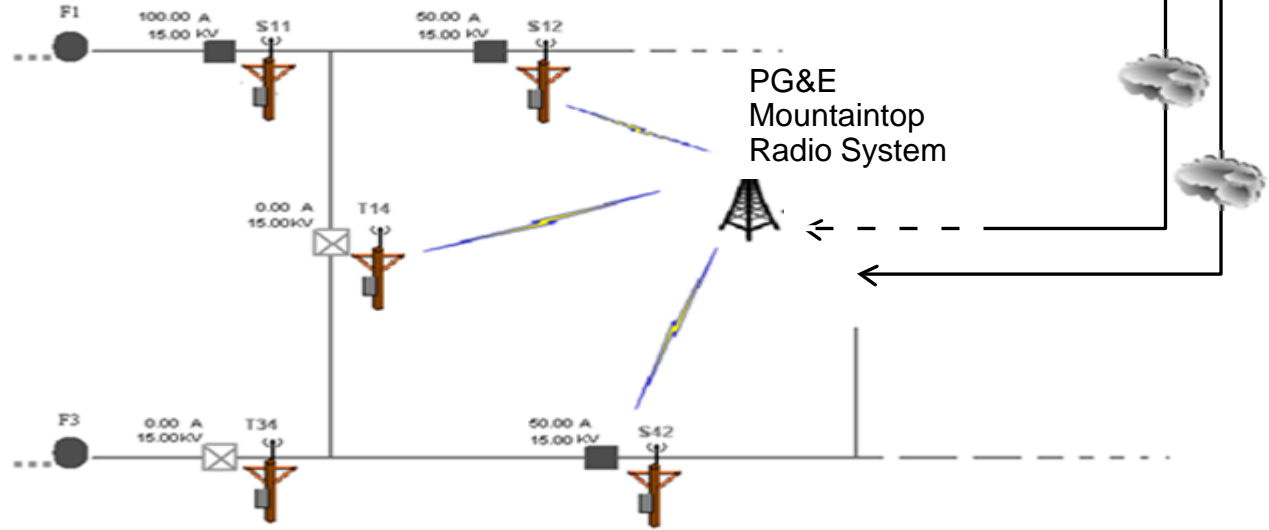
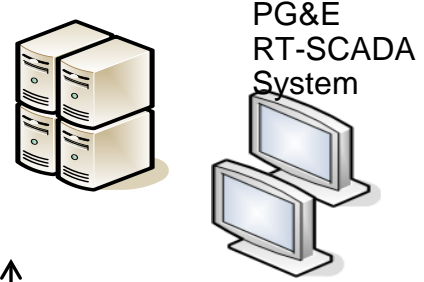
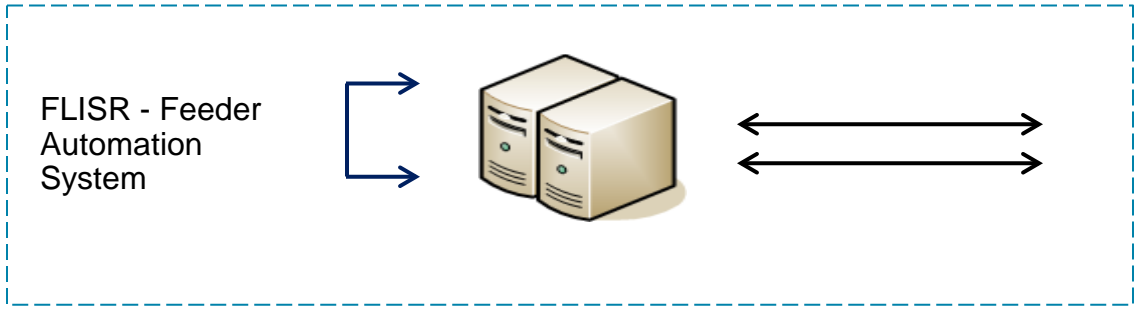
Key Goals:

- Enhance overall reliability
- Improve: System Average Interruption Duration Index (SAIDI)
System Average Interruption Frequency Index (SAIFI)





Self Healing System





Distribution Installation

498 monitored circuits

A total of 1,800 SCADA devices on 400 urban circuits

712 Reclosers and 377 switches

27 servers installed at 13 locations

Steps for Success

Engage key stakeholders early

Identify IT upgrades

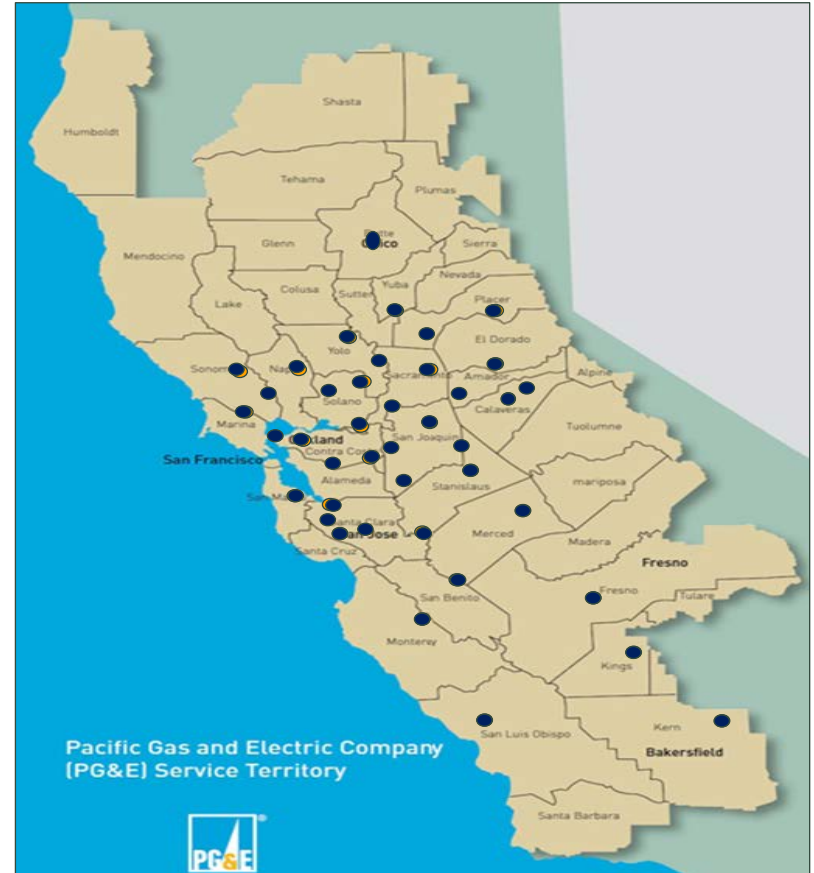
Create design guidelines

Design schemes on targeted circuit

Develop deployment plan

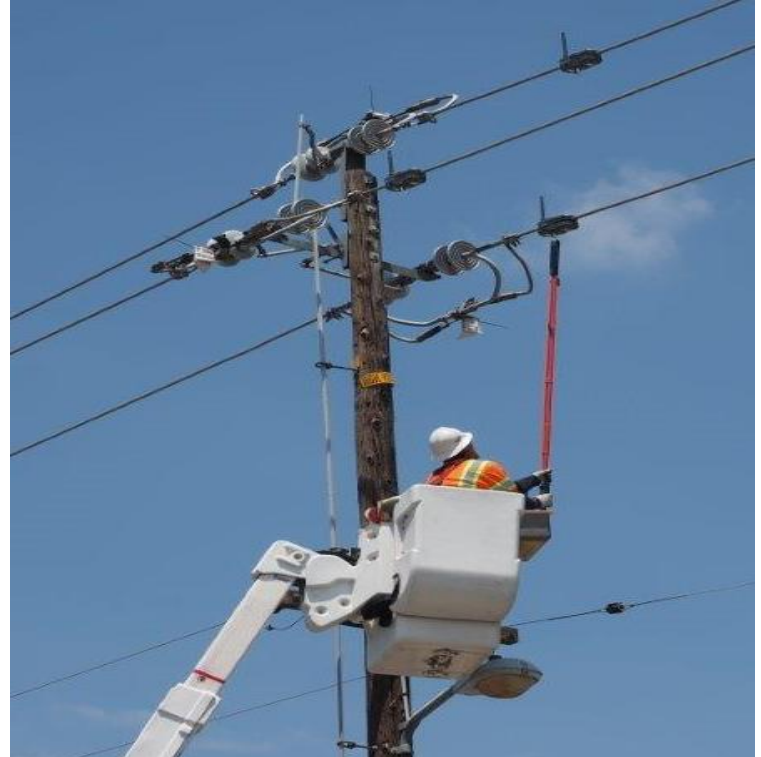
Training

Deployment Process

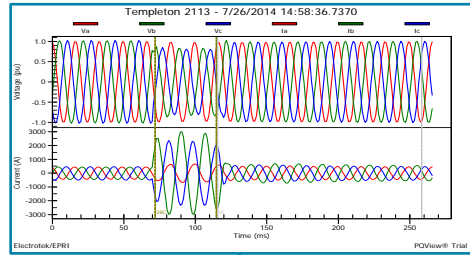


Overview

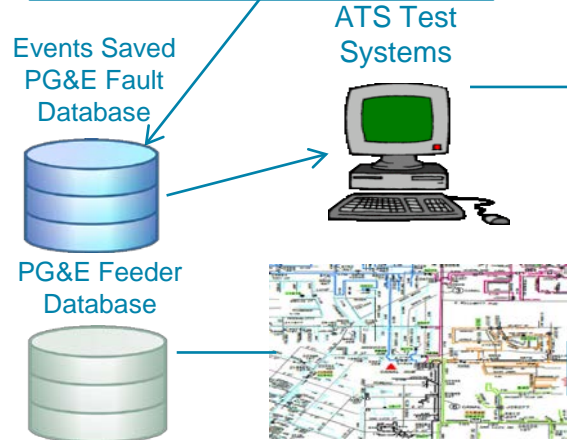
- Line Sensor devices are connected directly to distribution lines, communicating wirelessly to PG&E
- Augments FDL by reducing the number of possible fault location areas
- Delivers RT loading and fault information to distribution operators and engineers
- Faster fault location by reducing the patrol needed to find electric faults
- Prioritizes resources on large outages (i.e. largest number of customers first).



Distribution Fault Sensors System



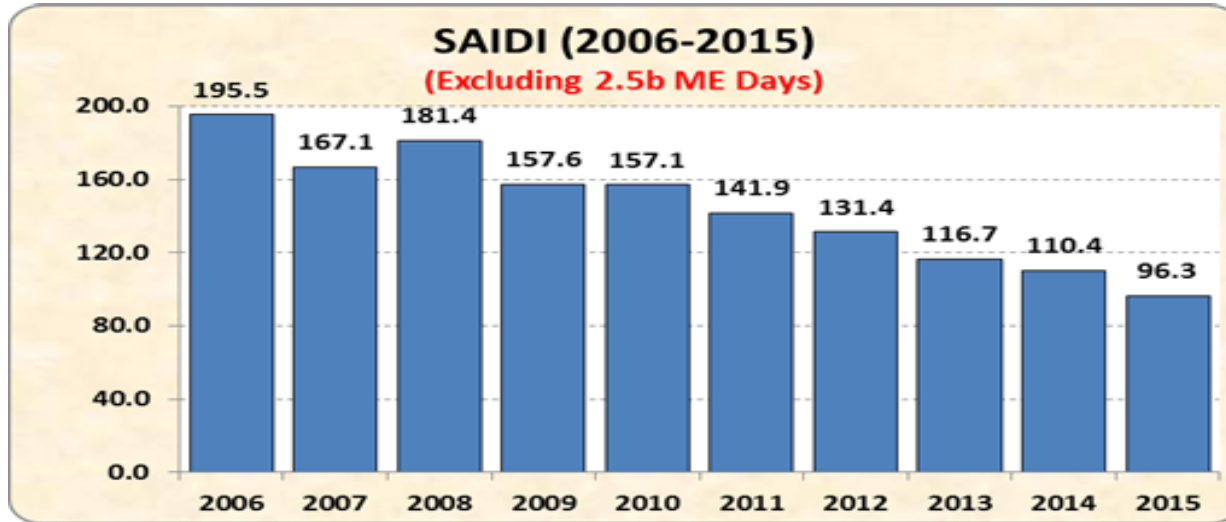
Testing included capturing events and comparing data to actual locations.



- Results measured & quantified
- Benefits evaluated



Reliability Improvements



1. Fewer Customers Experiencing a Sustained Outage
2. Shorter Outage Durations
3. Improved Customer Satisfaction for Reliability

Energy Storage Applications



Market Services

- Energy arbitrage
- Spin/non-spin reserve
- Frequency regulation
- Voltage support
- Black start



Utility Services

- Resource adequacy
- Transmission congestion relief
- Transmission deferral
- Distribution deferral



Customer Services

- Backup power
- Increased PV self-consumption
- Demand charge reduction
- Time-of-use bill management



California Energy Storage Mandate

Regulatory

- AB 2514 (Storage procurement targets)
- AB 327 (Distributed Resources Plan)
- SB 861 (SGIP extension to 2021)
- State EV goals

Market

- Increasing number of players and projects deployed
- Economic case for storage developing

Technology

- Variety of technologies at various levels of maturity
- Synergistic supply chains for li-ion technologies

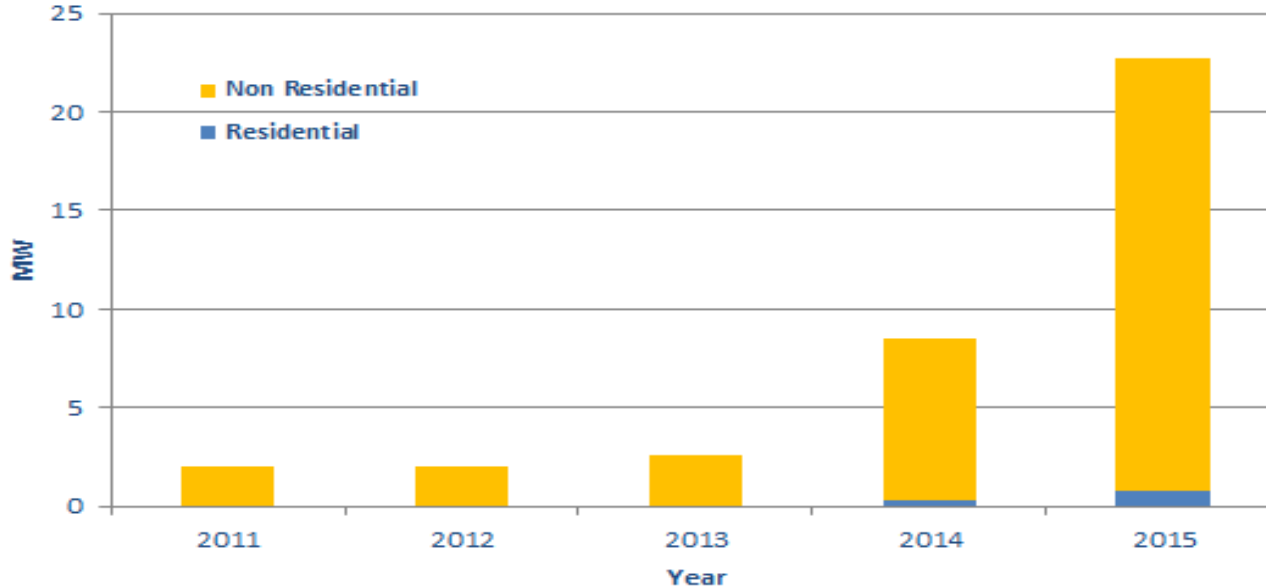
Decision 13-40-040 the “Energy Storage Mandate”

- Approved by CPUC October 2013
 - Stemmed from AB 2514
- **IOUs can own up to 50% of targets**
- Flexibility in targets:
 - Between T/D/customer buckets
 - Between years
- Utilities to host biennial solicitations through 2020



Energy Storage Statistics

Cumulative Customer-Side Storage Capacity



Energy storage interconnections have significantly increased year over year.



Battery Energy Storage at PG&E

Vaca Dixon

2 MW / 14 MWh NAS Battery

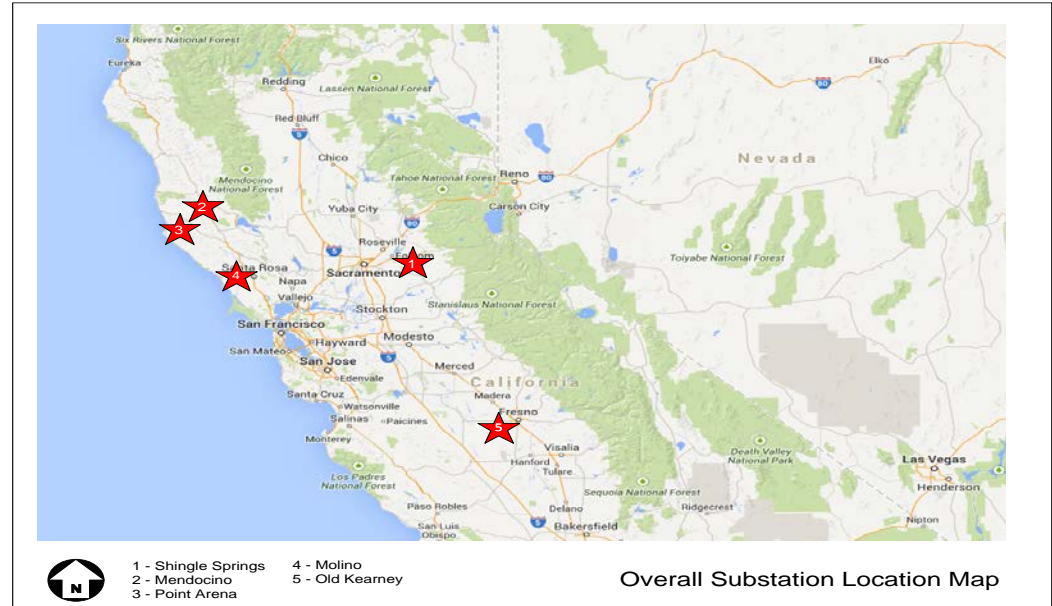


Yerba Buena

4 MW / 28 MWh NAS Battery



Future Sites



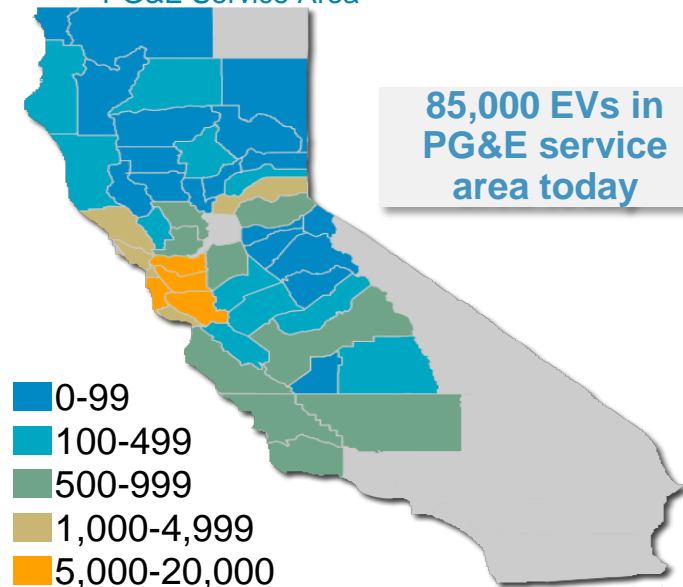


Electric Vehicles



Cumulative EV Sales by County

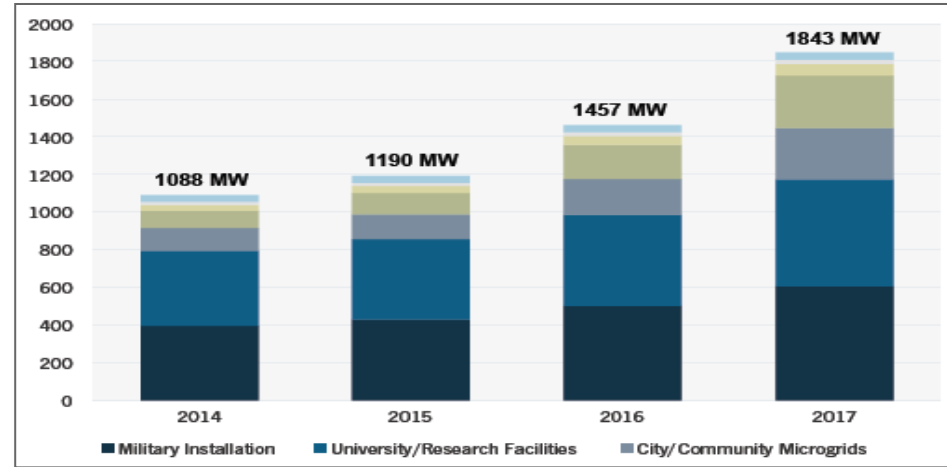
PG&E Service Area



Over 2,200 new EVs added each month

Optimized Hybrid Microgrids

- Utility grid and microgrids must work synergistically to fulfill all the needs - serving all the load all the time
- Assessing costs should include efficiency, reliability, safety, optimizing life-cycle costs, and system resilience
- New tools and Standards, e.g. IEEE 1547 Series, Microgrid Controller
 - Frequency regulation
 - Voltage control



Physical Attack on Substations

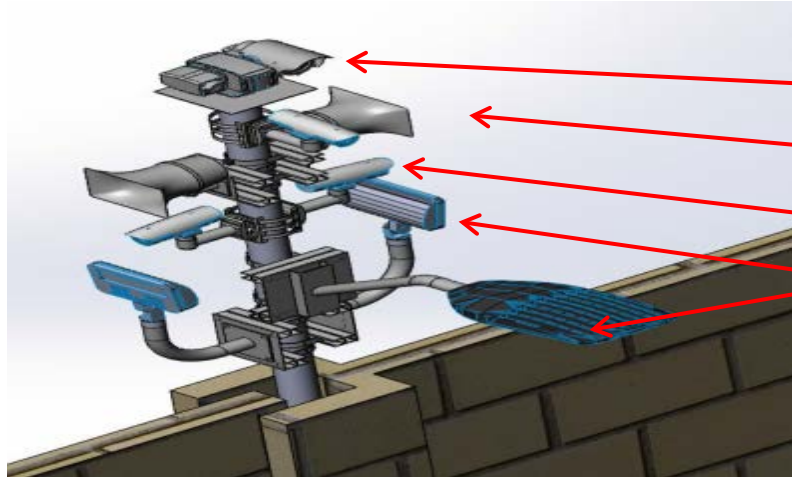


Substation Physical Security

Physical Scope	Technology Scope
Pre-cast concrete walls	Cameras
Fences with privacy slats	Lighting
Gates	Gunshot detection
Shielding/Barriers (protection of key infrastructure)	Public Address

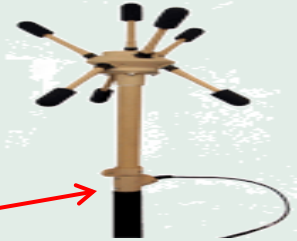


Substation Physical Security



Technology security components for Tier 1 Sites

- Strobe Lights
- Public address system
- Thermal Cameras
- Lighting
- Communication vault security
- Gunshot detection
- Onsite security monitoring station





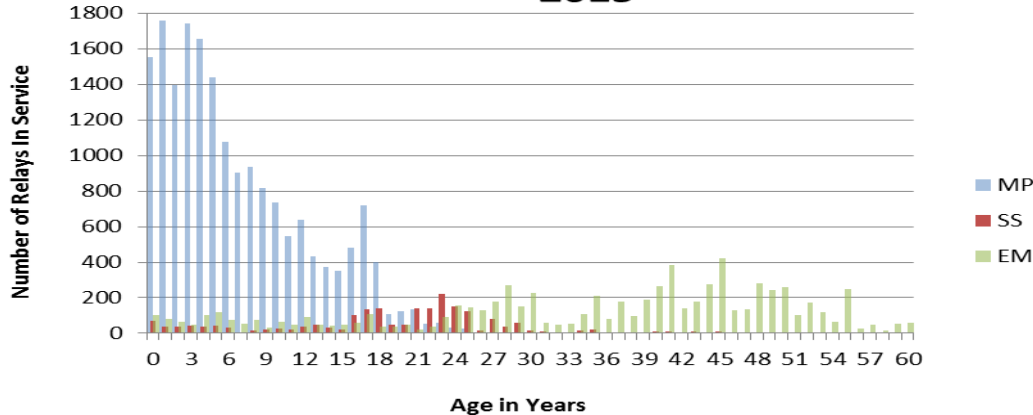
Asset Enumeration

RELAY ASSET 2015 YEAR END	Number In Service	Average Age	Median Age	Standard Deviation
Microprocessor	19,379	7.5	5	6
Solid State	2,935	20	20.5	9
Electromechanical	12,763	41	41	18
TOTAL	35,077			

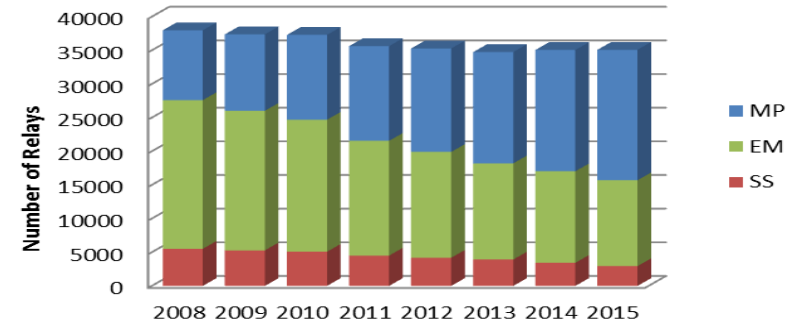
2015 PG&E Relay Inventory by Relay Class



MP, SS, EM Relay Asset Counts - Histogram 2015



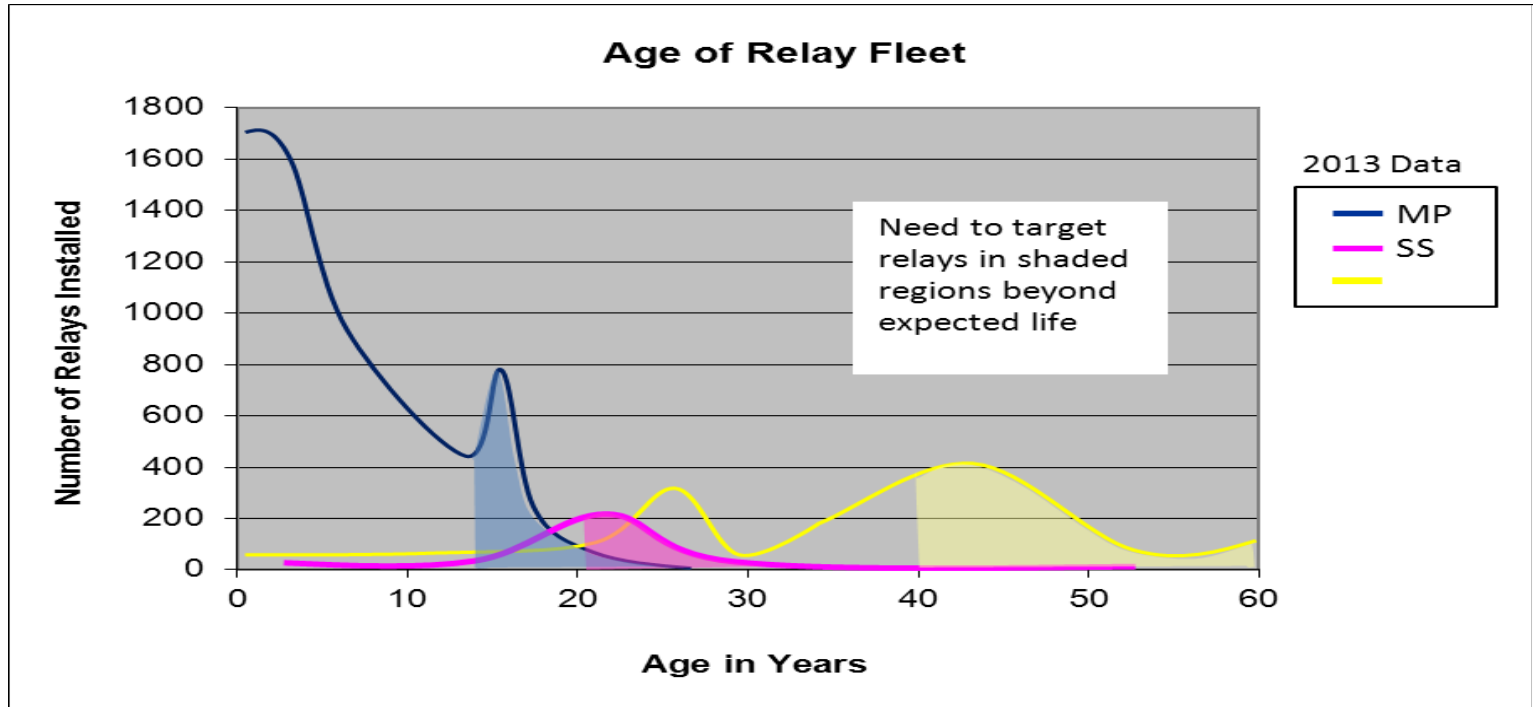
Fleet Profile by Relay Class



Asset Performance

Targeted relay replacements

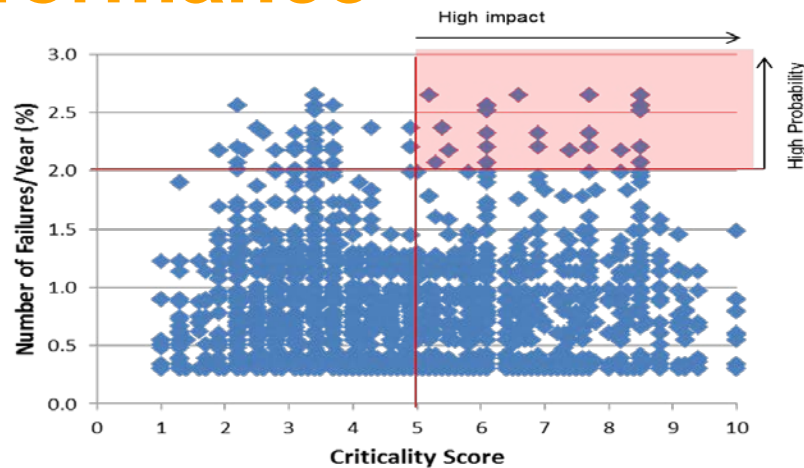
- Age based / Performance based / Risk based





Asset Performance

- Replace poor performing relays
- Target high impact relays
- Modernize relay fleet
 - More than 1500 replaced annually
- Implement controls to reduce human errors
 - Simplify design standards (prints, settings, logic)
 - Standardize panel wiring
 - Add additional relay isolation (more FT and physical RCO switches)
 - Standardized FT switch labels
 - Automate work flow for relay settings (peer review) testing, and as-left review. Consolidate protection and test databases.





Portfolio Management Based on Risk

Risk Informed Budget Allocation (RIBA) :

A process weighting the proposed projects by their expected risk reduction to the system, in order to determine the capital expenditure within the future year Investment Plan.

RIBA Score

Public & Employee

Safety

Impact Level

&

Frequency Level :

Major Factor being:

- XPRD Kit Retrofitted*



Environmental

Impact Level

&

Frequency Level :

Major Factor being:

- Oil Leaks/Release*



Reliability

Impact Level

&

Frequency Level :

Major Factors being:

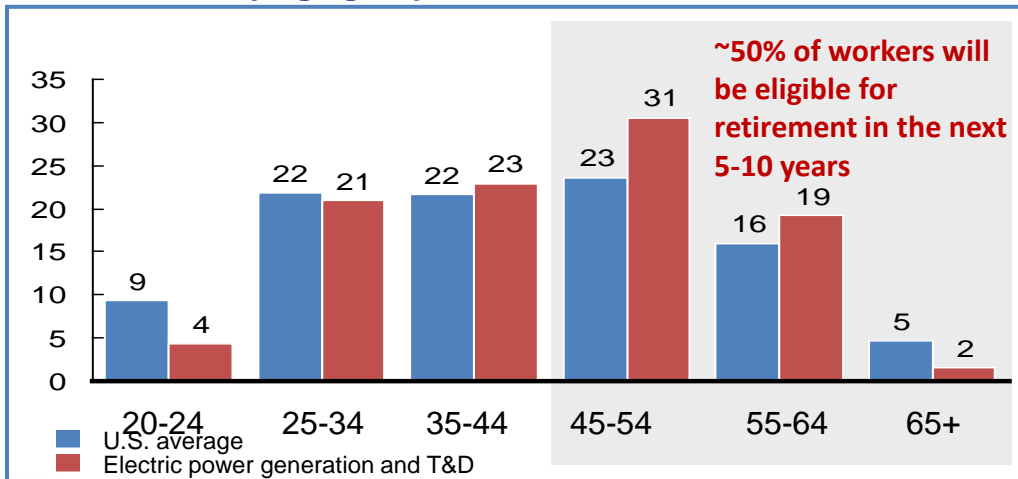
- Customer Count & Health Index*

Skilled Workforce

- Perfect Storm: Aging Workforce + Aging Assets = Reliability Decline
- Requirement: Programs to attract, train and develop engineers, linemen, station electricians, protection/control resources, and other technical resources
- Workforce implications and educational or training needs should be considered as integral factors of research and policy initiatives

The U.S. utility workforce is getting old ...

% of workers by age group, 2011



...limiting the labor pool for utilities

- Utility workforce not adequately replenished
- Recession has hurt development effort
- Long training lead times
- Limited utility labor supply

Staffing and Demographics

Baby Boomers



Generation X



**Generation Y
"Millennial"**



1946

1965

1975

2000

IEEE PES Membership Depth and Breadth

- Benefiting from the strength of our diversity and wide variety of technical backgrounds:
 - Utilities, Municipalities and RTOs/ISOs
 - Academics and Research
 - Equipment Manufacturers and System Suppliers
 - Government and Regulatory
 - Testing Labs, Consulting and more



Our strength is in attracting wide audiences by creating and implementing new technical ideas and applying best practices through output and initiatives

Events to put on your Calendar

2017 IEEE PES ISGT Asia Conference
(Innovative Smart Grid Technologies)
Nov-Dec 2017 - Auckland

2017 i-PCGRID Workshop
Late March 2017 (3 days)
San Francisco, PG&E (Main Auditorium)

NASPI North American
Synchrophasor Initiative

NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION





Thank you!

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Together, Building
a Better California

