EPIC Workshop

June 27, 2023

The EPIC program is funded by California utility customers under the auspices of the CPUC

Energy for What's Ahead®

SOUTHERN CALIFORNIA EDISON®

Agenda

- Introduction (9:00 – 9:15)
  - Safety Moment
  - Opening Remarks from Commissioner Shiroma
  - Welcome from SCE
- EPIC III Progress Towards Creating a More Flexible Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy (9:15 – 10:25)
  - PG&E EPIC 3.11: BTM DERs in Microgrids [Arcata Microgrid]
  - PG&E EPIC 3.32: System Harmonics for Power Quality Investigation
  - SCE GT-18-0019: Distributed Energy Resources Dynamics Integration Demonstration
  - SCE GT-18-0017: Service and Distribution Centers of the Future
  - SDG&E Project 7: Mobile Batteries
- Models for IOU/CEC Collaboration (10:25 – 11:25)
  - Current Mechanisms
  - Examples of Collaboration
  - Needs/Opportunities
  - Candidate Future Mechanisms
- Additional Questions & Answers (11:25 – 11:55)
- Closing Remarks (11:55 – 12:00)

Fireworks Safety (CalFire Link)

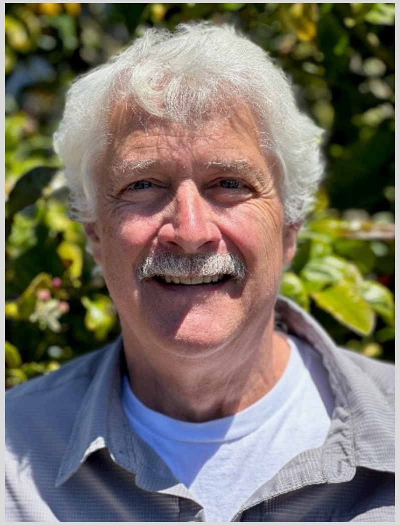
- Know the Law
  - Zero tolerance for illegal fireworks
    - Most fireworks that explode, go into the air, or move on the ground in an uncontrollable manner
  - Fireworks must carry "Safe & Sane" seal
  - Parents are liable for damage their children cause
- Safety Tips
  - Use state-approved fireworks
  - Never use near dry grass or flammable material
  - Keep water nearby
  - Back up after lighting fireworks
  - Don't wear loose clothing or lean over fireworks being lit

Opening Remarks by Commissioner Genevieve Shiroma

Welcome from SCE Senior Vice President Erik Takayesu

Creating a More Flexible Grid to Maintain Reliability as California Transitions to 100% Clean Energy

Select EPIC III Projects' Progress



Dave O'Connor
Product Manager, Expert
PG&E

Jordan Smith
Grid Edge Innovation, Consulting Engineer
SCE

Laurence Abcede
Distributed Energy Resources Manager
SDG&E

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EPIC 3.11: FTM DERS in Microgrids aka Redwood Coast Airport Microgrid (RCAM)

INTERNAL

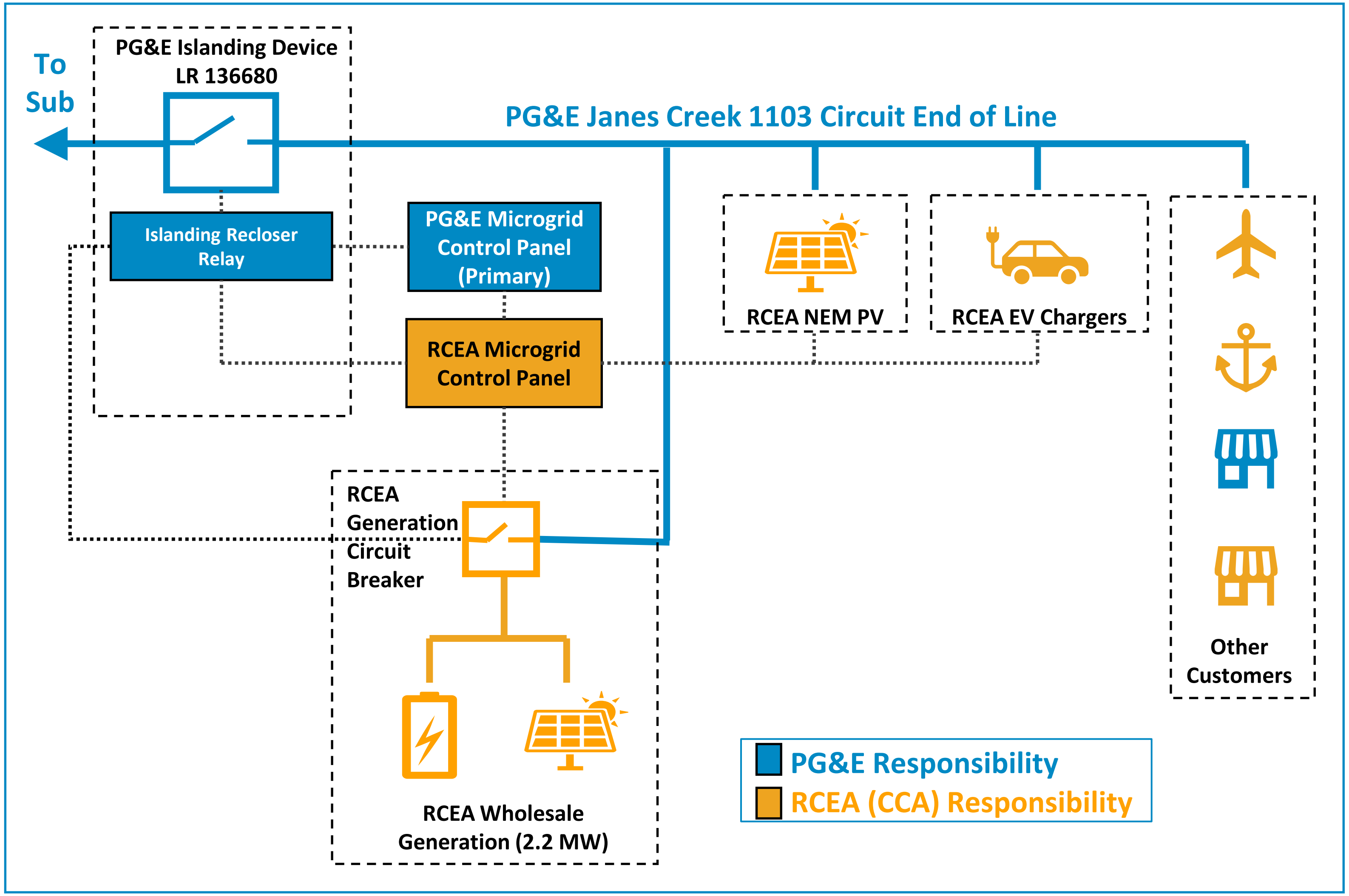
RCAM Design and Testing Partners

- Development of RCAM required close collaboration among multiple partners
- SERC was an excellent partner in bringing experience and expertise to the project
- SERC and SEL developed the majority of the microgrid logic/control design
- PG&E provided oversight, review, testing, DCC integration, and expertise for input especially around architecture, protection, fail-safes, testing, and roles and responsibilities

Internal

RCAM Overview

- PG&E Owned and Operated Distribution Circuit at Arcata Airport: Janes Creek 1103
- PG&E Owned Islanding Device Controller & Microgrid Controller with PG&E having “primary” control
- RCEA (CCA) Owned Generation
  - Wholesale: 2.2MW PV & 2.3MW/8.8MWh Storage
  - NEM: 320kW PV
- Combination of RCEA and PG&E Customers
  - 175kW Average Load with Typical Range of 125-360kW
  - 29 kW RCEA EV Chargers



EPIC 3.11 Contributions to CPUC's ESJ Action Plan

"Consistently integrate equity and access considerations throughout CPUC proceedings and other efforts."	• RCAM is a blueprint for future multi-customer microgrids
"Increase investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health."	• RCAM is 100% clean energy
"Strive to improve access to high-quality water, communications, and transportation services for ESJ communities."	• EV Charging is a growing part of RCAM and energizes a critical regional airport
"Increase climate resiliency in ESJ communities."	• RCAM has shown proven reliability facing storms and earthquakes

RCAM's Impact on the Future of Microgrids

- Inverter based protection schemes
- Operating parameters and technical studies for microgrids
- Microgrid Operating Agreement
- Community Enablement Tariff
- Community Microgrid Enablement Program
- Microgrid Incentive Program for $200M to go towards kickstarting microgrid enterprises to provide clean and resilient energy for those that need it the most

Part of the EPIC 3.11 Heritage

Community Microgrid
Technical Best Practices Guide

For Multi-Customer Distribution Microgrids

Inclusive of projects utilizing PG&E's Community Microgrid Enablement Tariff (CMET), Community Microgrid Enablement Program (CMEP), Microgrid Incentive Program (MIP), and other distribution microgrids

"The current version of this Guide is based largely on the Redwood Coast Airport Microgrid in McKinleyville, California, because that is the first multi-customer Community Microgrid that has been deployed and is functional and operating on PG&E's Distribution System."

https://www.pge.com/pge_global/common/pdfs/residential/in-your-community/community-microgrid/pge-community-microgrid-technical-best-practices-guide.pdf

PG&E is continuing to advance microgrid research and development

EPIC 3.11 - Location Based DERs (RCAM) Direct Follow-On Activity

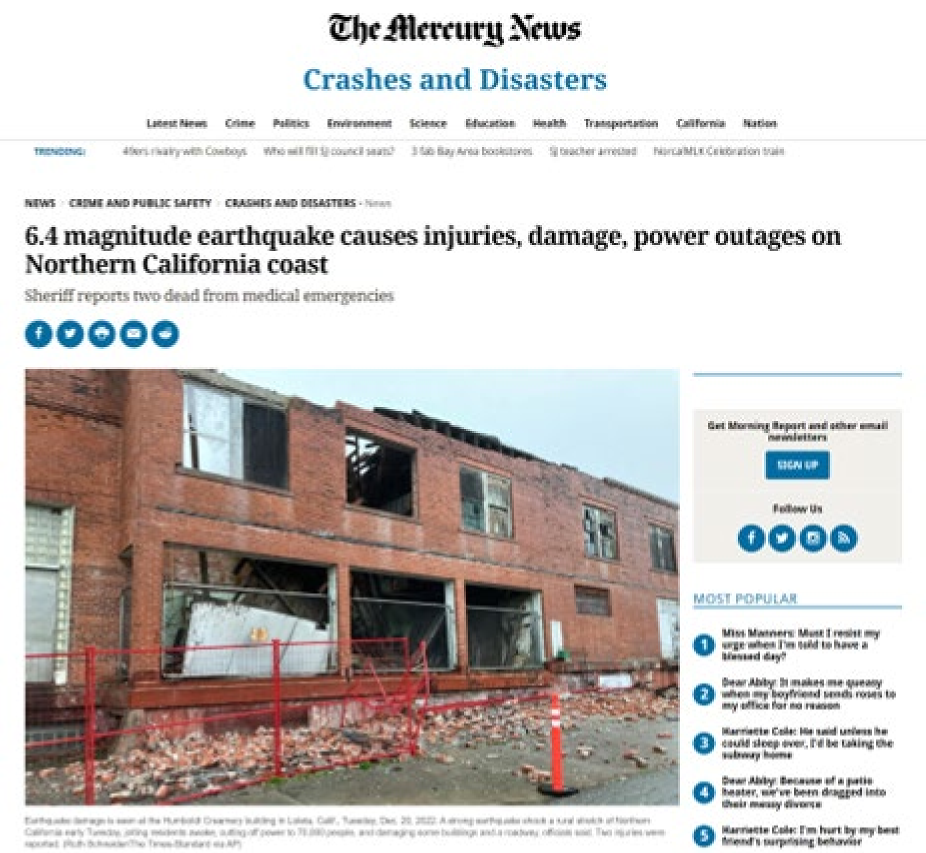
- Test new microgrid controllers
- Evaluate mid-feeder microgrids
- Develop advanced protection schemes

EPIC 3.11b – Foresthill Distribution Microgrid Pilot

- Explore technical solutions to control BTM DERs for resiliency
- Develop and implement standard and operational processes for use-cases, including Cleaner PSPS support

RCAM has performed as designed across a variety of hazard scenarios

6.4 Earthquake Dec. 20th, 2022


The Mercury News

Crashes and Disasters

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6.4 magnitude earthquake causes injuries, damage, power outages on Northern California coast

Sheriff reports two dead from medical emergencies

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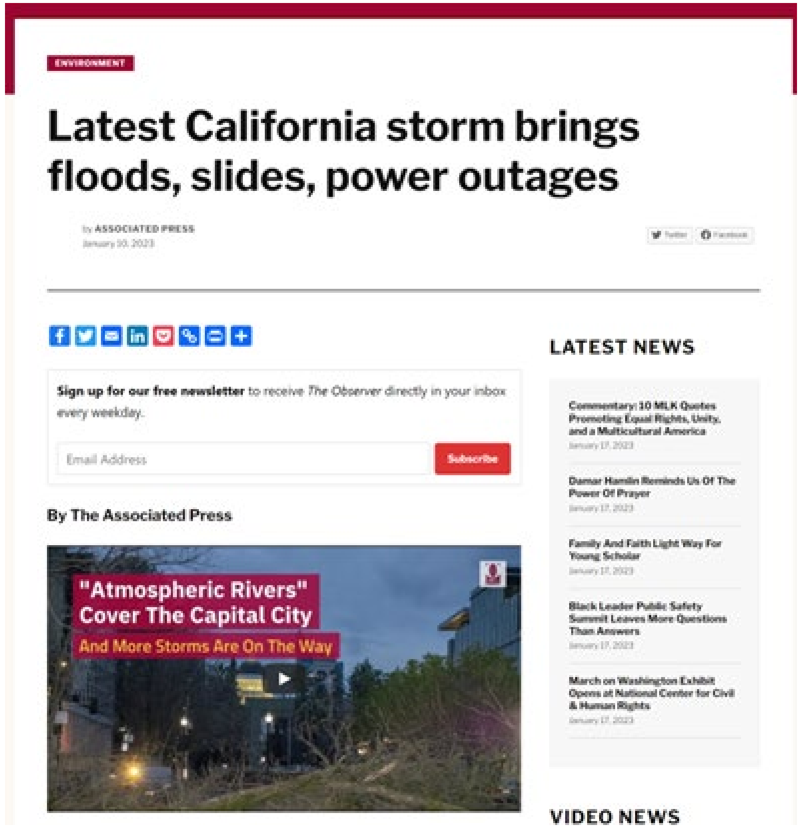
3 Harriette Cole: He said unless he could sleep over, I'd be taking the subway home

4 Dear Abby: Because of a patio heater, we've been dragged into their messy divorce

5 Harriette Cole: I'm hurt by my best friend's surprising behavior

"Storm Parade" Jan. 4th, 2023


ENVIRONMENT

Latest California storm brings floods, slides, power outages

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VIDEO NEWS

Earthquake: 2:34am Dec. 20th, 2022

- 6.4 Magnitude with an epicenter 39 miles South-Southwest of project site
- 70,000 PG&E customers out in the region including 7,243 on Janes Creek 1103.
- RCAM immediately detected line loss and transitioned automatically and seamlessly to islanded mode.
- BESS hit min state of charge at 17:22 and microgrid was de-energized. Airport and Coast Guard moved to diesel gen backup
- Power Restored, 15h:33m later

Date	Description	Customers Restored	Customers Out	Minutes Out	Customer Minutes
12/20/22 02:34	SOURCE JANES CREEK OPEN	0	7243		.
12/20/22 04:22	CB 1101/2 OPEN	0	.		.
12/20/22 04:22	CB 1103/2 OPEN	0	.		.
12/20/22 04:22	CB 1104/2 OPEN	0	.		.
12/20/22 04:22	CB 1102/2 OPEN	0	.		.
12/20/22 17:47	SOURCE JANES CREEK CLOSE	0	.		.
12/20/22 18:04	CB 1104/2 CLOSE	147	7096	930	6735990
12/20/22 18:06	CB 1103/2 CLOSE	3176	3920	932	6750182
12/20/22 18:06	CB 1101/2 CLOSE	2301	1619	932	6750182
12/20/22 18:07	CB 1102/2 CLOSE	1619	0	933	6751801

Device History

FNL	Outnum	Circuit ID	Customers Affected	Interval	Cause
12/20/22 02:34	22-0140719	19239	7243	Sustained	Environmental/External, Earthquake

Storm Outage: 7:15am Jan. 4th, 2023, Janes Creek

Tree fell across all three phases of Janes Creek 1103.

Significant storm related outages across Norther California: 3,079 PG&E customers impacted.

RCAM immediately detected line loss and transitioned automatically and seamlessly to islanded mode.

Power was restored, 8hs 16min later.

EPIC 3.32: System Harmonics

System Harmonics Issue

Increase in customer complaints

Reactive, inefficient, and resource-intensive data collection

Seasonal issue

Extensive analysis to determine root causes

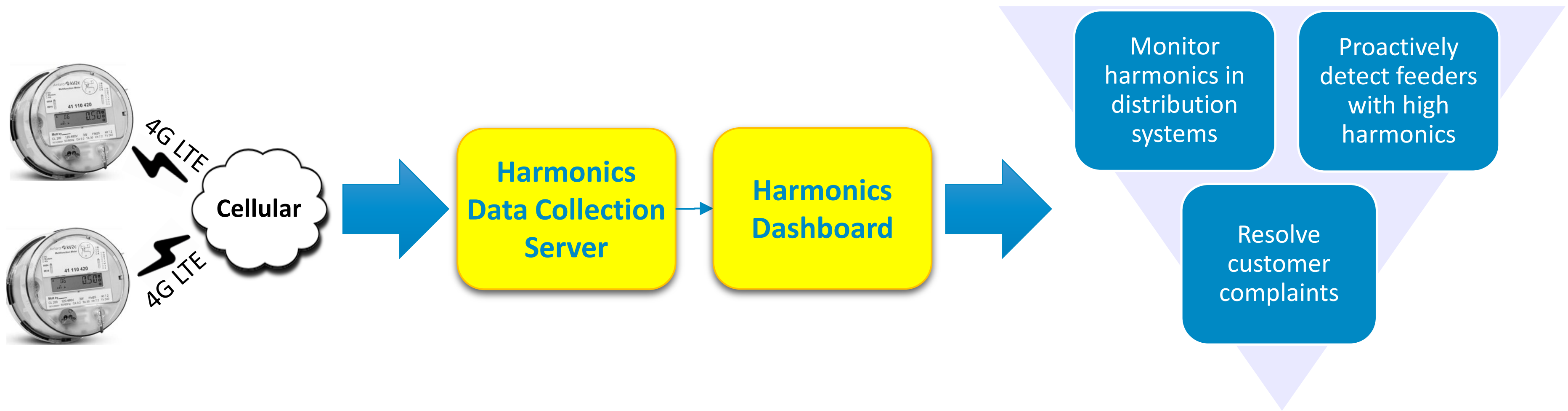
Project Objectives

Demonstrate the feasibility of using Advanced Meter with Power Quality (AMPQ) to collect harmonics data and assess the potential value that AMPQ can provide for Power Quality investigation.

Determine the size of the harmonics issues in PG&E distribution systems.

- Where are the harmonics issues and when do they occur?
- What is the root cause(s) of the harmonics issue?

Build a harmonics dashboard and analysis tools that Power Quality engineers can use to monitor, investigate, and assist in resolving harmonics issues.

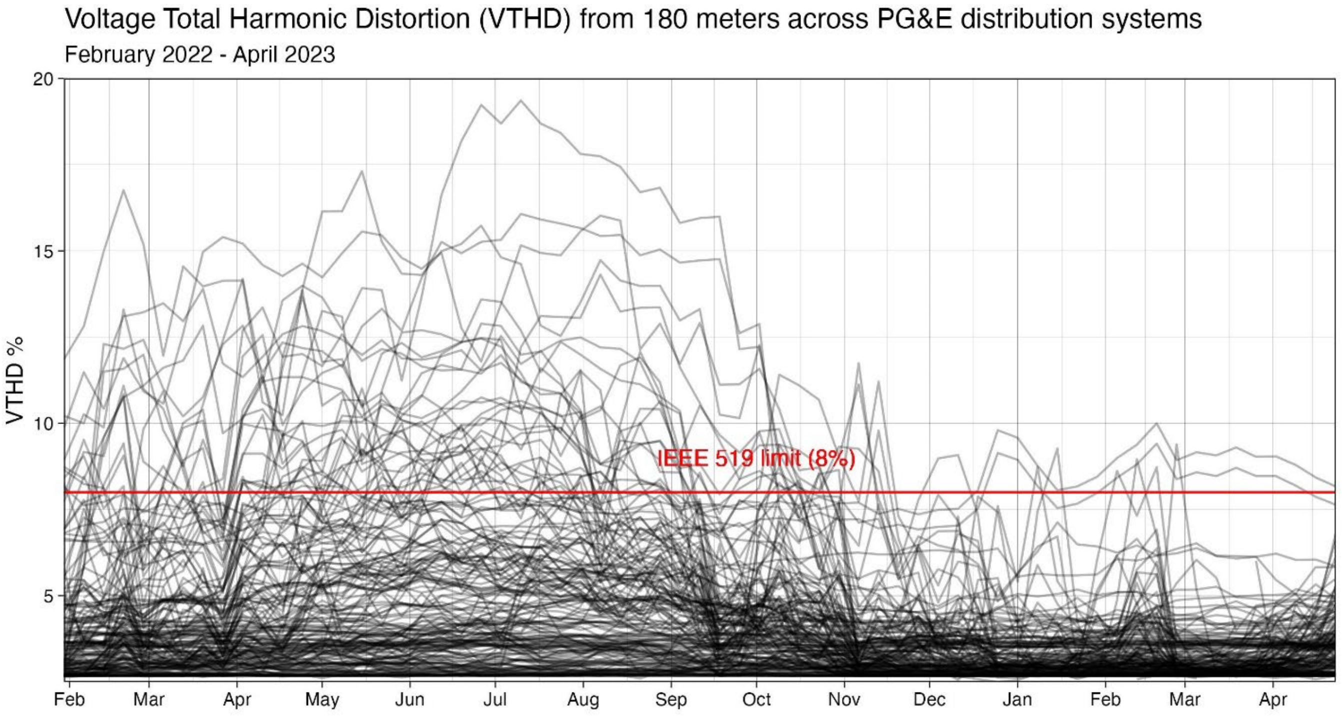


Key Results

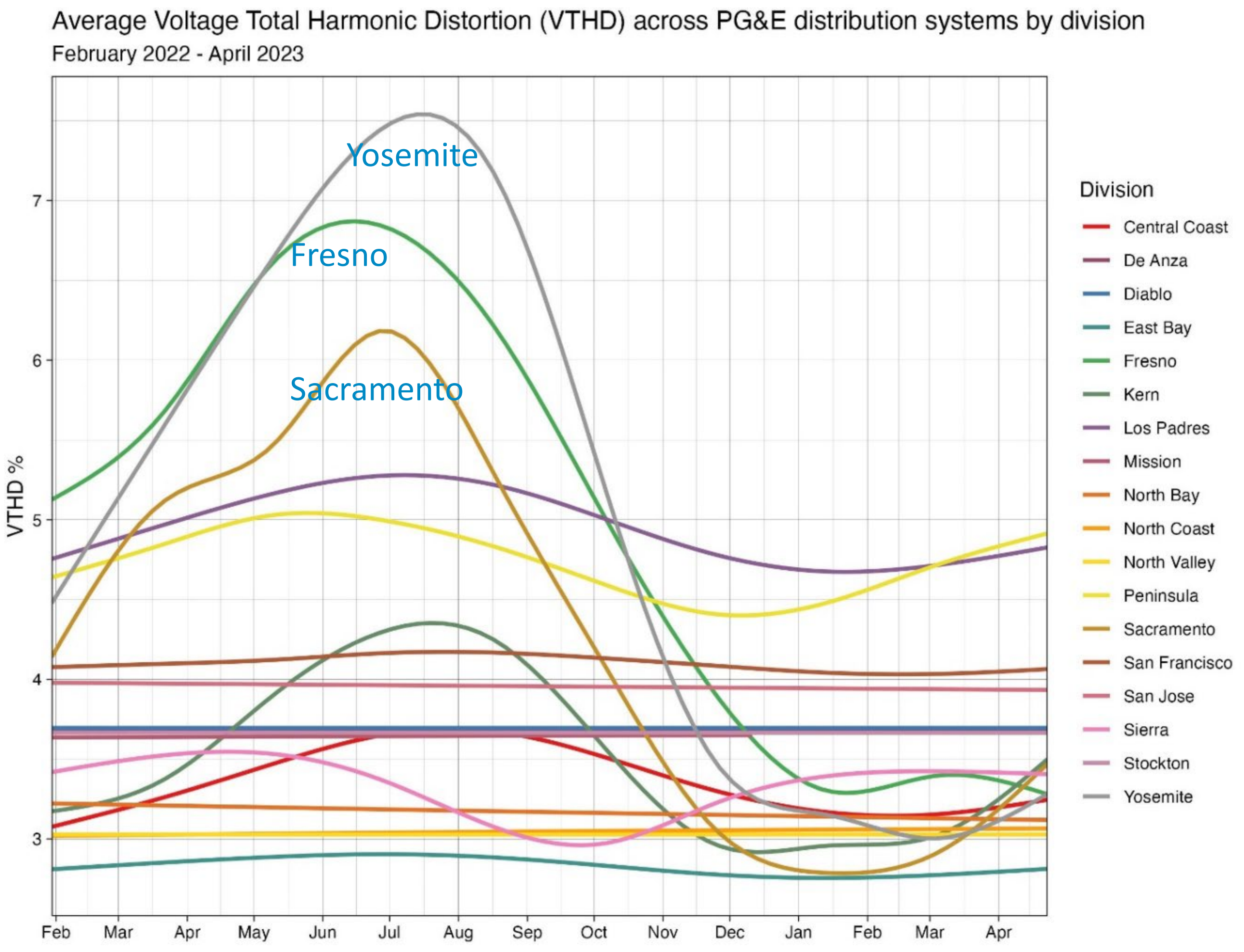
1. The AMPQ can reliably collect harmonics data on a large scale at a lower cost than RVM/PQM (Unit cost of AMPQ >$1000 vs ≈$10,000 for RVM/PQM and AMPQ can transmit the data remotely)

2. 33 of 125 selected distribution feeders have harmonics level exceeding IEEE 519 limit during the monitoring period. Many of these feeders (10-15 feeders) were not on PG&E's radar.

3. 10 feeders have very high harmonics level up to 15 – 20% total voltage harmonic distortion (VTHD) that will likely impact customer equipment now or in the future if customer installs sensitive equipment.

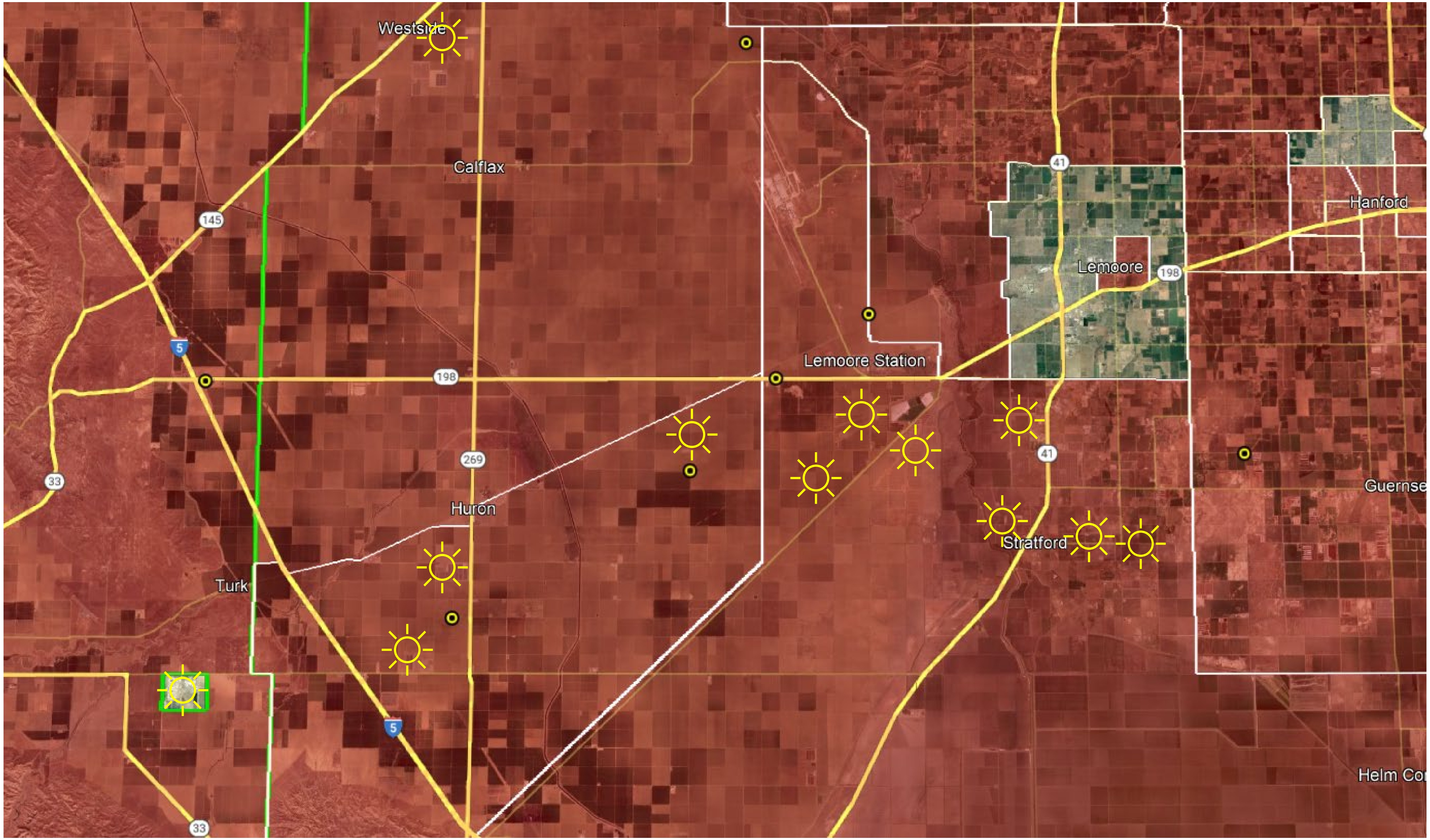


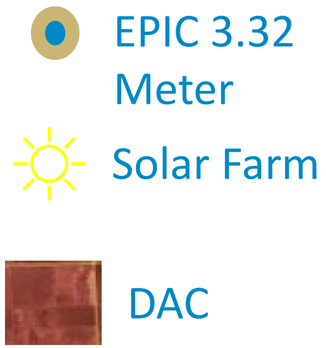
Key Findings



- Feeders in the Agricultural areas (Fresno, Sacramento, Yosemite) show significant increase in harmonics during irrigation season. These Divisions consist largely of DACs.
- The increase in harmonics correlates directly with increase in irrigation loads on agricultural feeders.
- Non-agricultural feeders have generally flat harmonics through the year.
- Variable Frequency Drives (VFD) are the direct cause of the current harmonic issues in PG&E distribution systems. Solar PV and EV chargers currently do not produce a significant harmonics issues—yet.
- PG&E can address the harmonics issues with policy and technical solutions targeting the VFDs.

Typical Infrastructure Distribution in Fresno Division





Strategic Value and Benefits of AMPQ

Greater Reliability	• Ability to obtain high-resolution harmonics data to proactively monitor, detect, and mitigate harmonics issues impacting PG&E and customer equipment.
Increased Safety	• Reduce exposure to high voltage for field personnel with installation of RVM and PQM.
Lower Costs	• Reduce truck rolls and cost of harmonics data collection.
Societal Benefits	• Facilitate adoption of PV/DER and EV chargers where harmonics could otherwise become a limiting factor by increasing costs to customers.
Customer Satisfaction	• Improve customer satisfaction where harmonics prevent customer equipment to operate correctly by resolving harmonics complaint in a timely manner

Moving Forward

- Explore use of existing smart-meter and AMI platform
- Adapt business process/practices
- Improve the scalability and maintainability harmonics dashboard and create more analysis tools
- Advance two harmonics mitigation pilot projects
- Potentially pursue IP position
- Leverage EPIC 3.32 data to evaluate the impact of harmonics on PG&E distribution assets
- Support Industry Alignment
- AMI 2.0, harmonics mitigation equipment, potential EPIC 4 project

Recommendations

1. Incorporate harmonics data collection into 3,000 – 4,000 smart-meters installed at large customers to get visibility of harmonics level in all distribution feeders.

2. Focus engineering and policy solutions on VFDs on ag feeders and ag customers

3. Create a process to monitor and resolve harmonics issues in distribution systems in anticipation to expected increase in harmonics level and sensitive loads that are underway (DER, Solar and EV).

4. Evaluate and standardize harmonics mitigation equipment

Thank You
Questions?

Distributed Energy Resources Dynamics Integration Demonstration

Overview

Opportunity and Scope

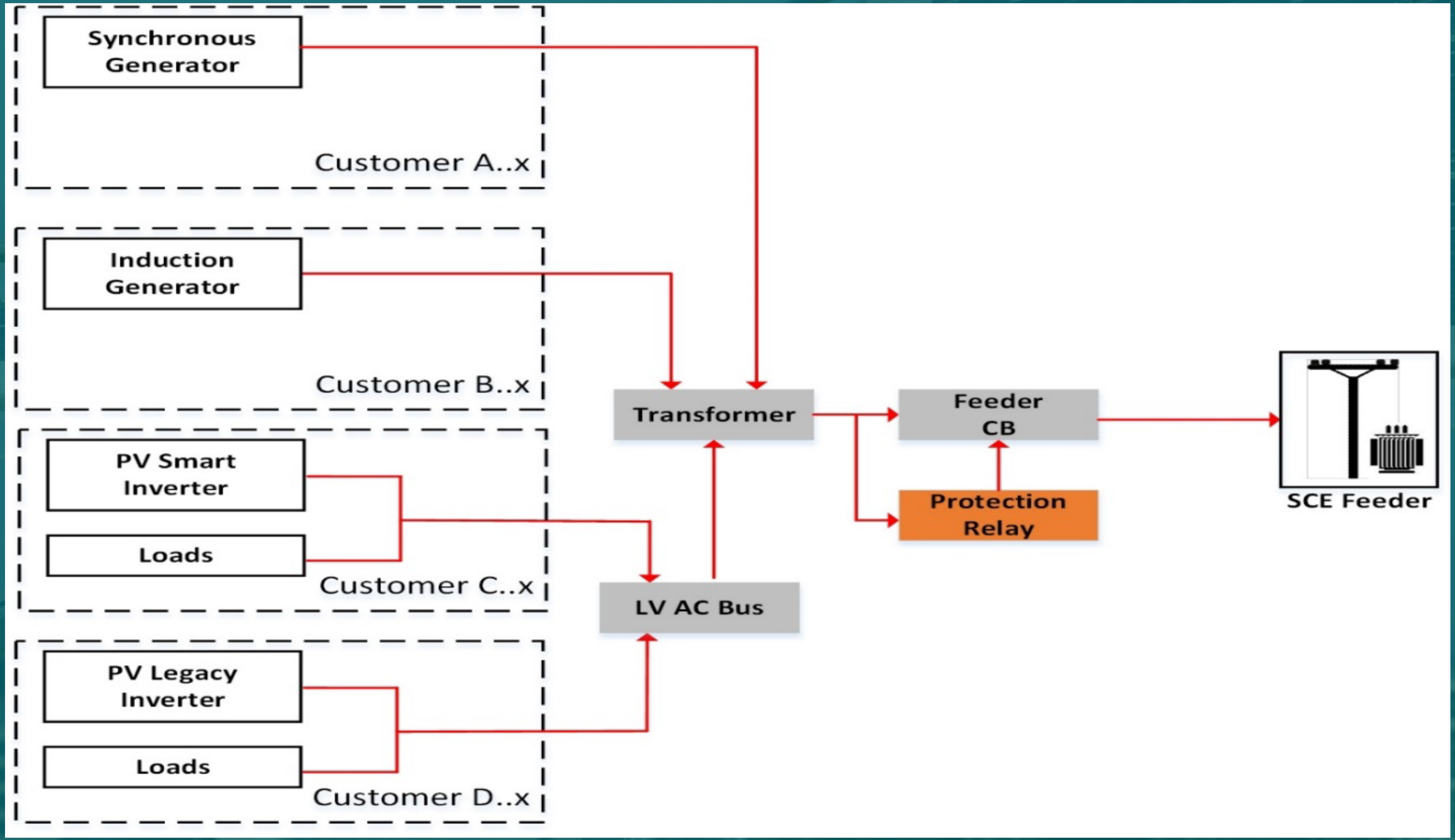
- Evaluate both the ways the **proliferation of DERs impacts the feeder protection system** and the interactions between inverter-based and non-inverter-based DERs
- This project has performed a **detailed PSCAD modeling and simulation study** of the PV-based system followed by **power hardware-in-the-loop (PHIL) testing**

Deliverables

- Understanding of how **high penetration of Rule 21 smart inverters and IEEE-1547 2003 legacy inverters affects SCE's relaying feeder protection systems**
- Observing the **interaction between traditional DERs and smart inverter-enabled DERs** with advanced functions and the **impacts on feeder protection systems**
- Analyzing interaction between multiple models of inverter using different **anti-islanding detection algorithms**
- Finding whether increased DER penetration necessitates **new protection settings**

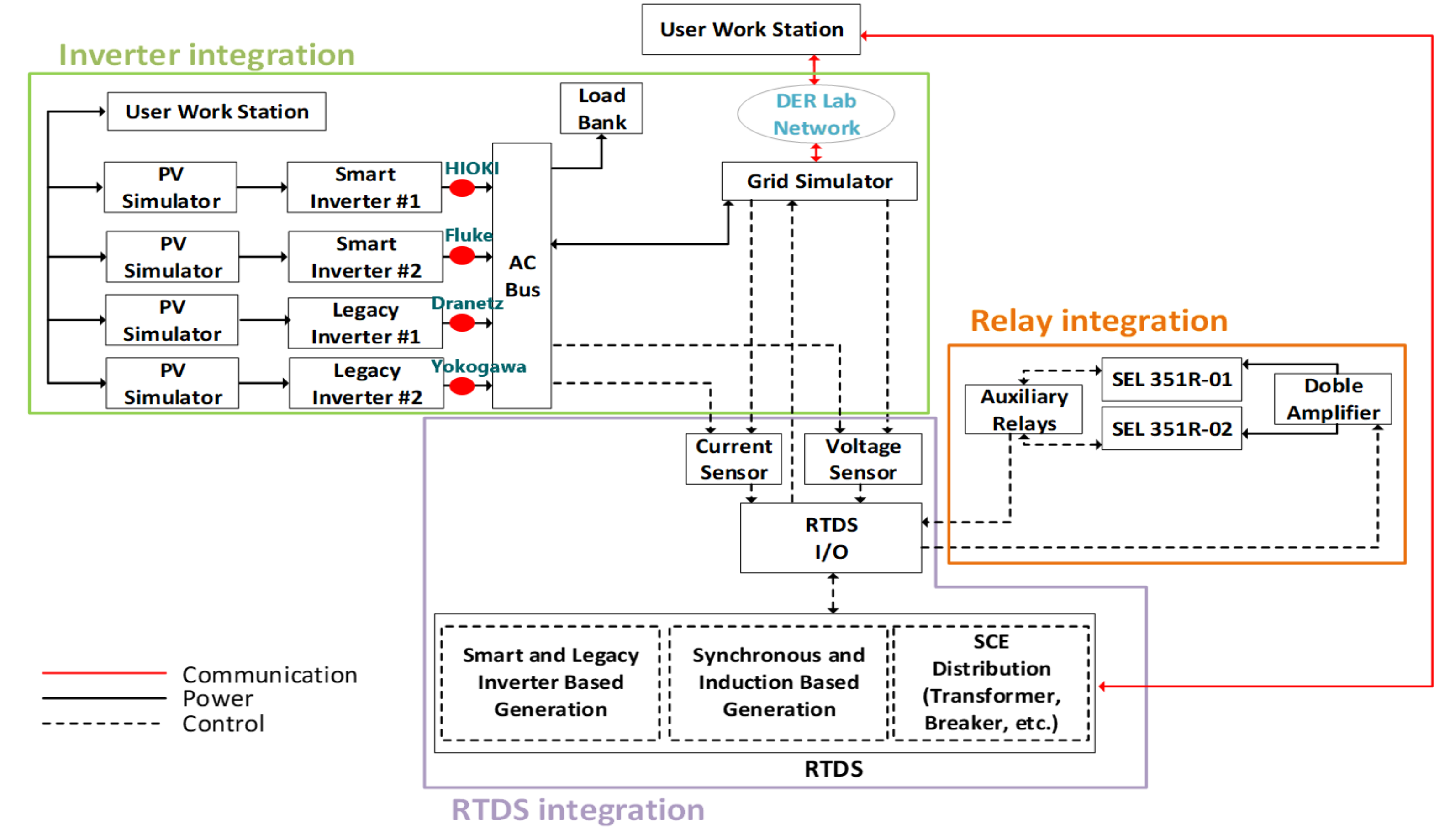
Simulation

- Feeder – DER integrated feeder
- Equipment – Standard rated
- Load – Peak load on a hot day



Demonstration

- **Subsystem – Inverter, relay, RTDS**
- **Equipment – Relay, sensor, inverter**
- **Protection – SEL 351R**



Findings

- High DER Integration: ***At up to 120% of DER penetration, the present protection setting is optimal***
- Interaction Between DER: ***VRT and FRT worked as expected except one inverter***
- Anti-Islanding Algorithm: ***Sandia Voltage Shift is preferable to Sandia Frequency Shift***
- New Protection Method: ***No new protection method is required***

Stakeholders and Future Plans

- Stakeholders
  - Internal: Protection and Distribution System Analysis
  - External: CPUC, PG&E, SDG&E
  - Working Groups: *UIWG, SIWG, NREL*
  - Industry and Academia: *IEEE, APEC, Hybrid and EV Technologies Symposium*
- Potential EPIC 4 Plans
  - **Simulation and demonstration of synthetic iner**tia using Inverter-Based Resources (IBRs)
  - Investigate further on **anti-islanding** efficacy
  - Evaluate the **protection impact of different distribution relays** that SCE uses

Service and Distribution Centers of the Future

Overview

Opportunity and Scope

- The expansion of EV use necessary to meet state climate goals requires **technology leveraged in line with VGI principles**
- **Fleet depots must optimize their electrification**, while standard interfaces can **provide grid resources**
- The SCOF project **electrifies the vehicles and buildings at a fleet vehicle depot that hosts light, medium, and heavy-duty service vehicles** in accordance with best BE and VGI practices, incorporating controls and DERs
- A **utility site energy management system interfaces with a utility grid management system**, minimizing total energy costs while maintaining fleet operational integrity and using resources at the site to support the local grid

Deliverables

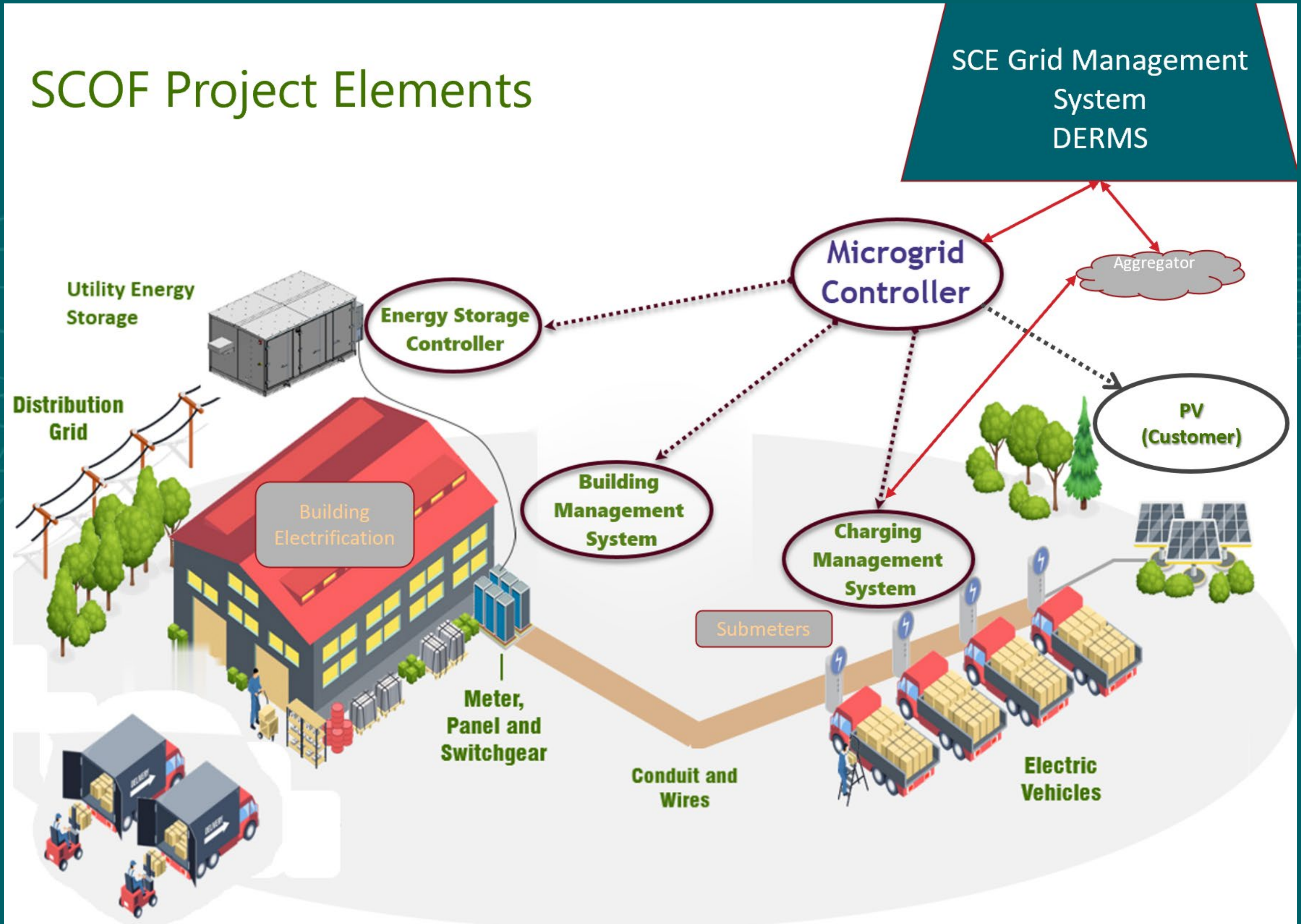
- Test **utility-owned microgrid control system configured to serve large, high-demand service centers**, interfacing with charge management, fleet management, and building management systems, as well as utility-owned energy storage with secure communications
- Demonstrate **grid support functions**
- Build **power outage resiliency** to sustain EV charging essential for fleet operation
- Test **building electrification and management system**, controlling a location with electric space and water conditioning
- Use **EV charging submetering and advanced metering options**, including DC

Location

- Focus on SCE Service Center located in DAC – Dominguez Hills
- One of largest SCE Service Centers in central location providing critical service – light, medium, and heavy vehicles
- Local grid constraints

Project Elements

- Microgrid control system configured with SEL
  - Factory configuration and testing
  - Protection designs
  - SCE laboratory testing and simulations – Westminster labs controls test bed
  - Power hardware in the loop testing – Pomona labs microgrid test bed
  - Cybersecurity controls
  - DERMS integration



Findings

- Fleet management systems: ***Nascent and need to develop cybersecure standard communications***
- Charge management systems: ***Proprietary, emerging, need for systems integration***
- Microgrid control systems: ***System architecture and cybersecurity definitions***
- Energy storage integration: ***Siting and interconnection challenges***

Stakeholders and Future Plans

- Stakeholders:
  - Internal: *SCE Fleet, New Development Planning, eMobility, TE Roadmap, Integrated Planning*
  - External: *CPUC, CEC, PG&E, SDG&E*
  - Working Groups: *IEEE 2030.13, USDRIVE – GITT, National IWC*
  - Industry and Academia: *IEEE, AQMD Clean Fuels Advisory Group*
- Potential EPIC 4 Plans
  - **System simulations using demonstrated load shapes** and scenarios coupled with TE forecasts
  - Additional storage and PV and other generation, **V2G**
  - **Autonomous systems**, edge computing, DC service

Mobile Battery Energy Storage Solution (MBESS)

EPIC 3, Project 7

MBESS Project Objective

CPUC Approved

The objective of this project is to undertake a pre-commercial demonstration of a mobile battery energy storage system (MBESS). The project will examine the possibilities for using a mobile battery at multiple locations within SDG&E's service area.

An MBESS is a battery energy storage system on wheels that can provide multiple use cases based on a single MBESS application or a combination of several applications (stacking of applications) to provide grid support and reliability/resiliency solutions for utility projects and/or customers at different sites.

Included in the project are trials of IEEE 2030.5 to highlight the benefit and challenges associated with the communication protocol. Test cases will leverage 2030.5 as a means of controlling the MBESS to provide a demonstration of alleviating constraints on Operational Flexibility under specific scenarios.

The objective is to evaluate the effectiveness of mobile batteries when rotated between applications and identify preferred applications and strategy for the rotation.

Project Focus

Module 3

Additional Use Case Applications

- This third module of EPIC 3, Project 7 will include CPUC driven operational flexibility demonstrations using the IEEE communication protocol 2030.5 to communicate with the MBESS and in the future, customer owned DERs
- The demonstrations will also include the deployment of the MBESS during planned outages, emergency events, and Public Safety Power Shutoff (PSPS) events.

Institute of Electrical and Electronics Engineers (IEEE) 2023.5 is a protocol to test inverter communications for renewable energy resources

Mobile Batteries

- Currently testing:
  - 100kW/225 kWh Battery
  - Single phase 120/240V
  - 20ft trailer

Mobile Batteries

- Currently testing:
  - 362kW/1499 kWh Battery
  - 3 Phase 480V
  - 48ft Drop Deck Trailer

Mobile Batteries

- Potential Future Use:
  - 14kW/500 kWh Battery
  - Single Phase 120/240V
  - Remote Controlled
  - 2 EV Chargers On board

Operational Flexibility Use Cases For IEEE 2030.5 Protocol

Use Case	Grid Paralleling / Islanding
Operational Flexibility to Manage Constraints during Reconfiguration	Parallel to Grid
Capacity by increased Generation to Meet Requested Production	Parallel to Grid
Constant Voltage Boost	Parallel to Grid
Voltage Reduction	Parallel to Grid
Increased Mobility	Both

Additional Use Cases

Use Case	Grid Paralleling / Islanding
Planned Outages	Islanding
Emergency Events	Islanding
Public Safety Power Shutoffs	Islanding

Summary of Initial Benefits Assessment for Module 3

Improved Operational Flexibility

Using a battery to facilitate power reduction or curtailments during abnormal circuit configurations

Improved Operational Capacity

Coordinated dispatchable or scheduled electricity production

Improved Reliability and Power Quality

Reduce outages associated with overloads, as well as voltage control. Use as backup power source during outages

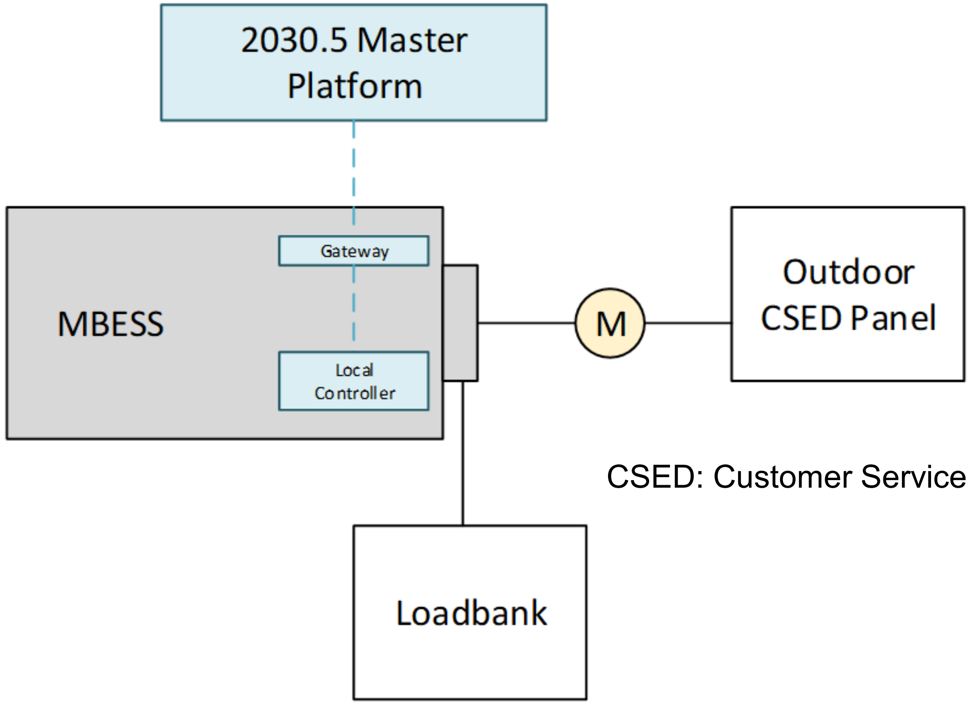
Improved Performance of Power System

Helps reduce electrical losses in the system

Evaluating the stacking of benefits, using two assets

Module 3 Progress – for Operational Flexibility IEEE 2030.5

- Test plan complete
- Hardware installed
- Integration testing complete
- Currently conducting tests at the laboratory



CSED: Customer Service Electrical Device

Module 3 Progress – for Operational Flexibility IEEE 2030.5

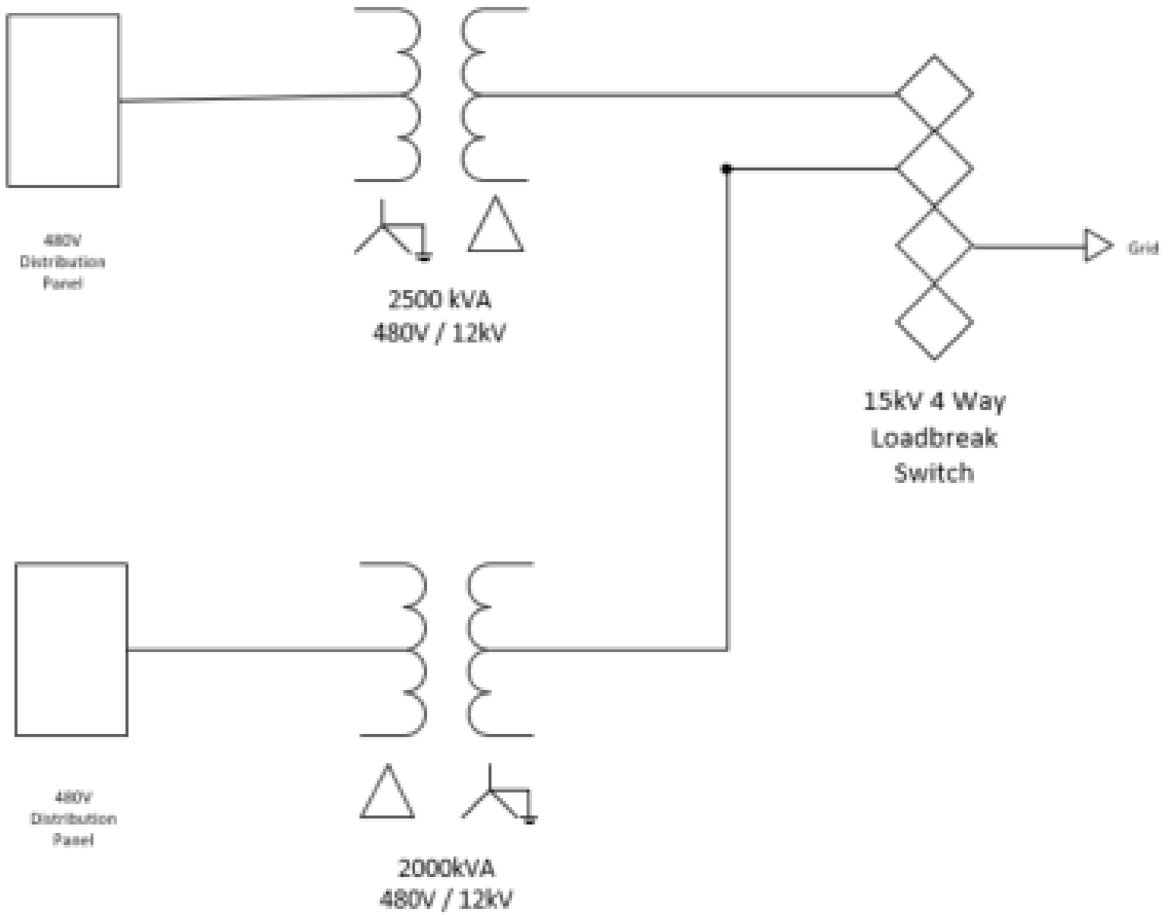
Dell blade server with Kitu Citadel installed

MBESS on trailer

Outdoor Customer Service Electrical Device (CSED) Panel

Plan for Additional Use Cases

- Building a customized "Companion Trailer"



Problems or Issues Encountered

Module 3

Supply chain constraints

- Long lead times for equipment needed on mobile companion trailer
- Long lead times for new transformers and switch. Using one available at SDG&E, and a reconditioned unit that is readily available. Also reserved a switch is in stock

EPIC 3 to EPIC 4 – Work continues

Strategic Objective: Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid Initiative – DER Integration

Research Topic Area: Integrated Distributed Energy Resources ("IDER") Operational Flexibility

As DERs become more common in both commercial and residential applications, the demand for electric utilities to integrate and manage these resources to help maintain resilient and reliable power services is increasing. The benefits gained in this research topic area will provide real-world experience in seamlessly integrating greater amounts of DERs, while harnessing the flexibility of the demand side of the system to lay the foundation for operational flexibility.

Questions?

Collaboration Models

Dan Gilani
Senior Manager, R&D Operations
PG&E

Juan Castaneda
Principal Manager, Grid Technology Innovation
SCE

Cynthia Carter
EPIC Program Manager, Advanced Clean Technology
SDG&E

Current Mechanisms IOUs use to Engage in CEC EPIC Work

- Offer a **letter of support** to a bidder
- Offer a **letter of commitment** to a bidder
- Offer to be on the **technical advisory committee** for whoever gets awarded the project
- **Partner** with a bidder as a sub
- **Bid directly** on a solicitation
- Bid on a **federal cost-share** solicitation
- **Inform the scoping** of solicitations

Example of CEC & SCE Collaboration

- Electric Access System Enhancement (EASE)
- Won **2022 Utility Transformation Project of the Year** from the Smart Electric Power Alliance
- Worked to **streamline DER interconnections, improve supervisory access to grid assets and DERs, and optimize DERs** for grid reliability and market-based energy services
- Concluded in March 2022 and was supported by the DoE Enabling Extreme Real-time Grid Integration of Solar Energy program and the CEC's EPIC program as federal cost share
- Project team included Smarter Grid Solutions, Opus One Solutions, Kitu Systems, Inc, Clean Power Research, Inc, National Renewable Energy Laboratory, and the City of Santa Ana

Example of CEC & SDG&E Collaboration

- CEC was the grant provider for SDG&E's Borrego 2.0, "Borrego Springs: California's First Renewable Energy-Based Community Microgrid“
- CEC's role was as the program manager, and they oversaw the deployment of SDG&E's first advanced microgrid controller
- SDG&E provided data to CEC from demonstrations

Example of CEC & PG&E Collaboration

Redwood Coast Airport Microgrid (RCAM)

- CEC awarded SERC through an EPIC 2 solicitation, building on CEC's portfolio of microgrid research projects aimed at technology advancement towards commercialization.
- PG&E provided a commitment letter and executed an EPIC 3 sister project to develop design standards, testing capabilities, and DCC infrastructure to support operations within the utility-owned distribution grid.

Needs and Opportunities

Q&A

Closing Remarks from SCE Principal Manager of Grid Technology Innovation Juan Castaneda