Resiliency & Microgrids Working Group
Multi Property Tariff Phase: Safety

Resiliency and Microgrids Team, Energy Division

March 8, 2021

California Public
Utilities Commission

WebEx and Call-In Information

Join by Computer:

https://cpuc.webex.com/cpuc/onstage/g.php?MTID=e5905e1b98e17cee841d4acc7cd66f7b7

Event Password: RMWG8

Join by Phone:

- Please register using WebEx link to view phone number.

(Staff recommends using your computer's audio if possible.)

Notes:

- Today's presentations are available in the meeting invite (follow link above) and will be available shortly after the meeting on https://www.cpuc.ca.gov/resiliencyandmicrogrids.

- This meeting will not be recorded and there will not be meeting minutes.

WebEx Logistics

- All attendees are muted on entry by default.
- Questions can be asked verbally during Q&A segments using the “raise hand” function.
  - The host will unmute you during Q&A portions and you will have a maximum of 2 minutes to ask your question.
  - Please lower your hand after you’ve asked your question.
  - If you have another question, please “re-raise your hand” by clicking on the “raise hand” button twice.
- Questions can also be written in the Q&A box and will be answered verbally during Q&A

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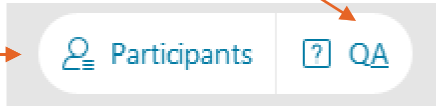

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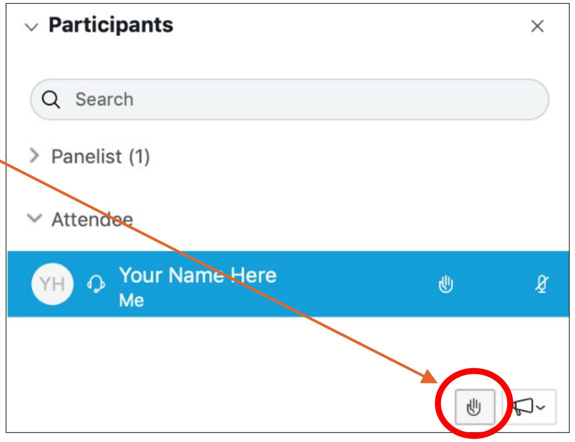

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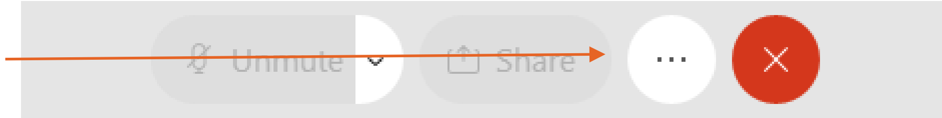

WebEx Event Materials

Event Information: Resiliency and Microgrids Working Group Meeting

Registration is required to join this event. If you have not registered, please do so now.

English : San Francisco Time

Event status: Not started (Register)

Date and time: Tuesday, March 2, 2021 9:30 am
Pacific Standard Time (San Francisco, GMT-08:00)
Change time zone

Duration: 1 hour

Description:

Event material: RMWG Meeting Material_EXAMPLE.docx (31.7 KB)

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Agenda

I. Introductions		2:00 – 2:05
• WebEx Logistics		
• Review agenda		
II. Safety Considerations		2:05 – 3:55
• Introduction	Presenter: Jeremy Donnell, PG&E	
• Human Safety Consequences	Presenter: Greg Walters, SDG&E	
• Microgrid Operations	Presenters: Thomas Verkaik, SCE and Roger Salas, SCE	
• Engineering & Design	Presenter: John Friskel, PG&E	
• Physical & Cyber Security	Presenter: Abraham Jose, PG&E	
• System Protection	Presenters: Chris Bolton, SDG&E and Mike Jensen, PG&E	
V. Next Steps		3:57 – 4:00

Microgrid Safety Presentation

Resiliency & Microgrids Working Group

Introduction: Why?

There are many laws, codes, and standards we use to ensure safety, but several are key foundational premises for this discussion:

- **Code of Federal Regulations, Title 29, Standard 1910** – governs the Occupational Safety and Health Administration (OSHA) law and electric power generation, transmission and distribution standards.
- **Public Utilities Code §399.2(a)** – mandates the electric corporation's responsibilities over all aspects of the distribution grid.
- **Public Utilities Code §8371** – ensures that system, public, and worker safety are given the highest priority.

Microgrids: Context for Safety Presentation

	Behind-the-Meter (BTM)	In-Front-of-Meter (IFOM)
Configuration	• Onsite generation main purpose is to provide power to host customer	• Energy is generated produced by generation resources and injected to the primary system
Infrastructure	• Mostly non-utility infrastructure	• Exclusively depends on utility- or third-party-owned primary voltage infrastructure for the distribution of power to all served customers
Isolation	• Single point of isolation between customer and utility infrastructure	• Typically a single demarcation between utility and microgrid (point of common coupling)
Electric Service	• Onsite generation provides power intended for local host energy needs	• Utility is responsible for the management of power flowing over its system and all related services (voltage, frequency)
Accessibility	• Accessible to customer but not public	• Accessible to the public, utility workers, first responders
Safety Impacts	• Must be properly designed and constructed with equipment that meets all codes, standards, and certification. • Must be operated and maintained by qualified electrical workers. • Generally, only accessible to BTM owner/operator.	• Greater complexity • Greater customer impacts • More sources of potential backfeed • Greater liability • Greater arc energies involved • Hazards are more accessible to the public and other third-party workers who are now capable of coming in contact with energized equipment

Agenda and Objectives

Human Consequences

- Looking at microgrid safety from the worker perspective
- Presented by SDG&E

Microgrid Operations

- Safe operations during PSPS event and that power is not flowing on overhead lines
- Presented by SCE

Engineering, Design, Security

- Ensuring safe design and interconnection
- Physical- and cyber-security measures
- Presented by PG&E

System Protection

- System protection mechanisms to prevent unintentional backfeed
- Presented by SDG&E and PG&E

Discussion and Q&A

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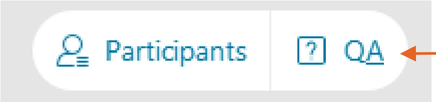

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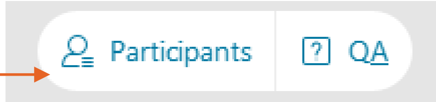

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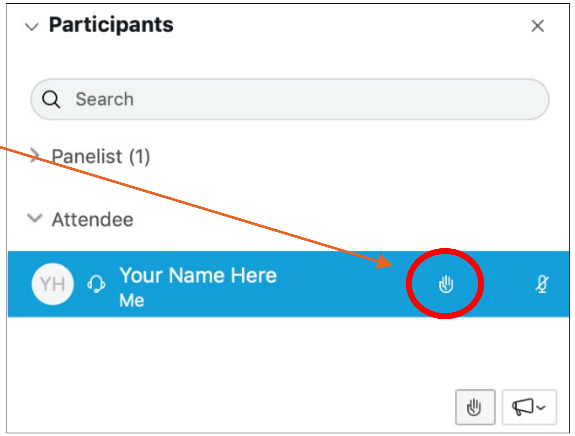

Human Safety Consequences

Presented by:

Greg Walters, Electric Engineering

Agenda

- Overview of the Job
- Utility Power Grid
- Safety-Dangers of Working High Voltage
- Safety Precaution & Work Procedures
- OSHA Levels of Arc Flash Protection
- Questions

Overview of the Job

Qualified Power-Lineman

Everyday serious injuries, near-misses and in some instances, fatalities occur when operating, maintaining and performing construction on the grid.

Daily work on voltages ranging from 120V to 500,000V

- Work is constantly performed suspended 50 feet in the air
- Performing work requires numerous safety standards and safety measures
- **Ranked as one of the top 10 most dangerous jobs**

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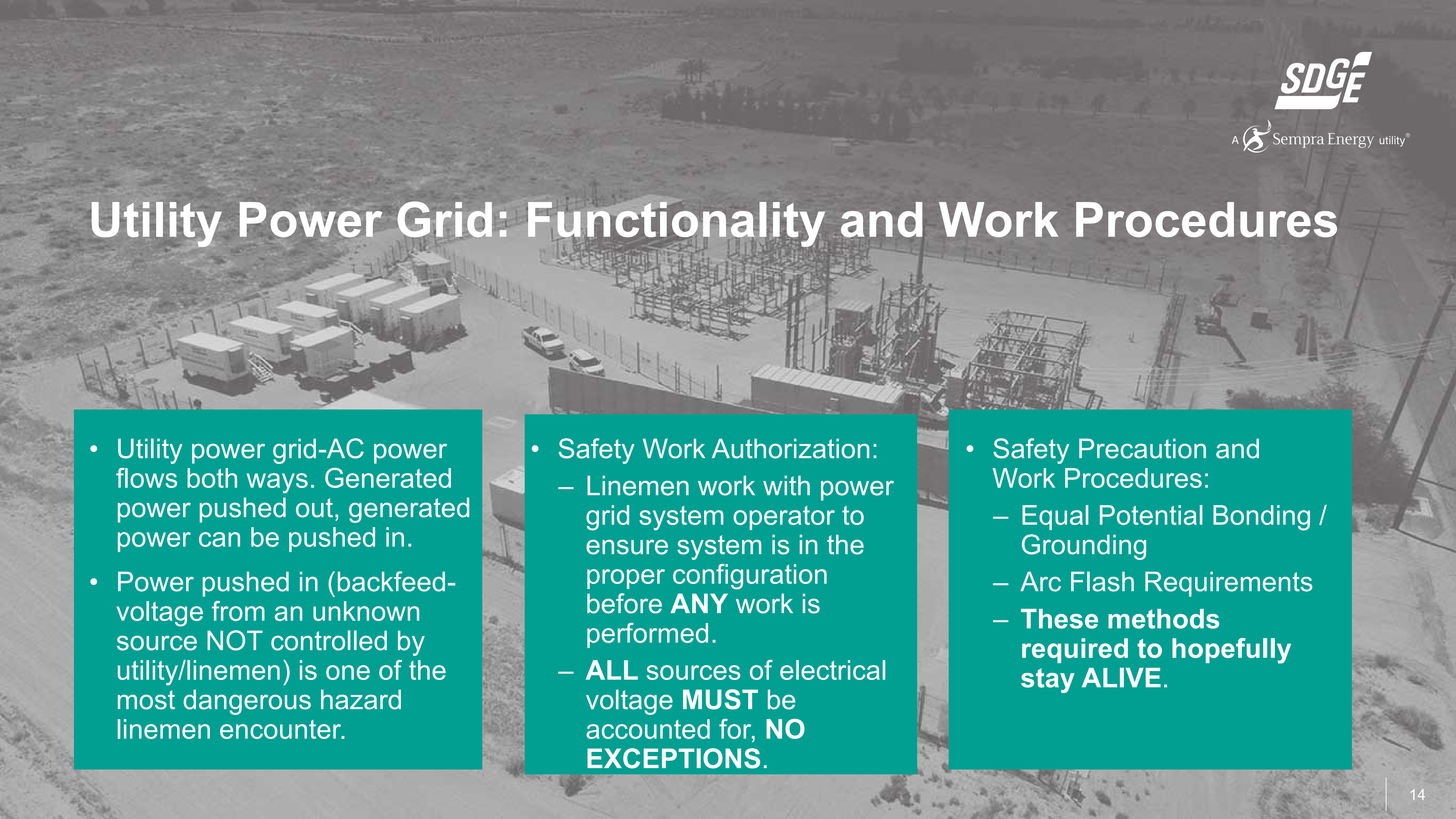

Utility Power Grid: Functionality and Work Procedures

- Utility power grid-AC power flows both ways. Generated power pushed out, generated power can be pushed in.
- Power pushed in (backfeed- voltage from an unknown source NOT controlled by utility/linemen) is one of the most dangerous hazard linemen encounter.

- Safety Work Authorization:
  – Linemen work with power grid system operator to ensure system is in the proper configuration before **ANY** work is performed.
  – **ALL** sources of electrical voltage **MUST** be accounted for, **NO EXCEPTIONS**.

- Safety Precaution and Work Procedures:
  – Equal Potential Bonding / Grounding
  – Arc Flash Requirements
  – **These methods required to hopefully stay ALIVE.**

Safety-Dangers of Working On or Near High Voltage

Not all equipment will work/operate 100% of the time as designed. There are three primary types of injuries that can happen due to contact with a high voltage electrical current. From OSHA reportable of the **45** employees electrocuted in 2020, **44** resulted in a fatality (OSHA report).

- **Electrocution**
  - This occurs when an electrical current passes through the body, which can be fatal Item.
  - https://www.youtube.com/watch?v=m2b2IT0dqv4
- **Electric shock**
  - An individual that comes into contact with a current, either directly or indirectly, could suffer severe burns and other long-term consequences.
- **Burns**
  - Severe burns can take place from an electrical current as well as from electrical fires and explosions.

Safety Precaution & Work Procedures Equipotential Grounding/Bonding (EPZ)

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Equipotential Zone (EPZ): Temporary personal protective grounding/EPZ equipment placed in an area to provide an identical state of electrical potential for two or more items at any given time. Temporary protective grounding equipment shall be placed in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential – e.g. , to prevent current from flowing through a person.

Example of hazardous difference in **electrical potential**:

- Voltage from an unknown source **NOT controlled** by Utility/Linemen
- Unintentional backfeed from customer generator and microgrid
  https://www.youtube.com/watch?app=desktop&v=1kwqKqOmYZU
  https://www.youtube.com/watch?v=K_RqBtGBLDs
  https://www.youtube.com/watch?v=PfnfnBhazU4

Generated voltage outside of the utility's control MUST have the ability to be completely isolated from the utility's system.

New OSHA Level of Arc Flash Protection

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Arc Flash (Flashover):

- The hazardous light and heat produced from an arc fault, a type of electrical explosion or discharge resulting from low-impedance passage of current through air to ground or another voltage phase.
- Arc flash temperature can reach 10,000ºF and is usually accompanied by blast and molten projectiles

Hazard Assessment:

- Determine if utility arc flash procedures require updates to ensure safe conditions when microgrids are connected to the utility grid.
- How does the arc flash in a normal utility design become more dangerous when you are in a microgrid?
- You no longer know all your sources into the system when you are a field worker.

8 Cal/cm2 w/glove

25 Cal/cm2

40 Cal/cm2

Discussion and Q&A

WebEx Tip

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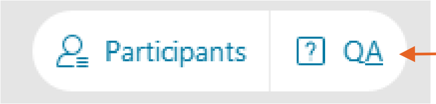

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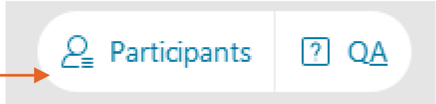

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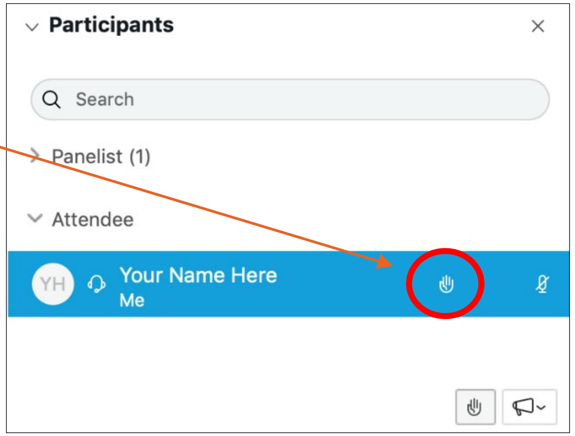

Microgrid Operations

Presented by:

Thomas Verkaik, Troubleman
Roger Salas, Senior Manager in Electric System Planning

Agenda

- Grid Operating Safety Practices
- Implication of Multi-Customer Microgrids on Grid Operational Practices

Grid Operational Safety Practices

Training

Utility Operating Personnel (TM) undergo a rigorous training program composed of classroom, field, and on-the-job (OJT) training exercises

- ✓ Must first become lineman
  - 20 weeks of classroom training to become a lineman over a three-year period.
  - 3 years of field/on-the-job training (OJT), to be a lineman.
- ✓ To become a TM
  - Must be a lineman for 2 years
  - Six months of OJT, 6 weeks classroom, and constant refresher classes

Grid Operational Safety Practices

Documentation

Utility grid operation rely and follow well-documented operating practices including:

- *Distribution Operation and Maintenance Manuals*
- *Substation System Instructions*
- *System Operating Bulletins*
- *Electric Service Requirements*
- *GO 165 – inspections*
- *GO 95 – overhead*
- *GO 128 – underground*
- *Accident Prevention Manual*
- *Rubber glove manual*
- *Grounding manual*
- *Environmental Policies and Procedures*
- *Traffic and Pedestrian Control Manuals*
- *Line clearing manual*

Grid Operational Safety Practices

Implementation

Before ANY planned work on the system, various levels of qualified operating personnel must carefully coordinate grid operating procedures

- **Program writers** create and document step-by-step switching programs for executing operations procedures
  - Accounts for proper de-energization, isolation, and lockout/tagout (clearance) practices
- **System Operators** review, approve, and direct the execution of the step-by-step switching programs
- **Field Operators (TMs)** executes the procedure in coordination with system operators
  - Uses tested, calibrated, properly maintained tools for verifying and performing switching operations

- Personnel are trained and expected to STOP progress on an operating condition that may have a safety implication

Implication and Consequences of In-Front-Of-Meter (IFOM) Microgrids on Grid Operational Practices

System Operating Conditions Information are Critical for Safe Grid Operations

- Distribution breakers, switches, protection (fast curve), available fault duty, operating conditions (322, red flag)
- Distribution abnormal condition, abnormal equipment, and clearances (lockout/tagout)
- Limitation on system equipment (thermal ratings and protection settings)
- Generation sources operating parameters (microgrids, large generators, etc.)
- Customer equipment (primary service equipment) status
- Communication with system operator is critical to all operating

Implication and Consequences of IFOM Microgrids on Grid Operational Practices

Implication of In-Front-Of-Meter Microgrids

- Microgrid projects will have large energy sources capable of energizing large sections of the distribution grid

- Microgrids will require close contact coordination with utility personnel for safe operation of microgrid and distribution systems

- Microgrids may require redundant equipment to properly provide isolation of microgrid and distribution equipment

- The utility troubleshooting the circuit must have 24/7 real time control of system for emergencies

Implication and Consequences of IFOM Microgrids on Grid Operational Practices

Safety Implications if Grid Operations are Not Properly Performed by Trained Personnel

- Arc-flash that can severely injure operating personnel
- Inadvertently re-energize line section where operating personnel are working exposing workers to electrocution
- Overloading equipment leading to catastrophic equipment failure exposing workers to the catastrophic failure
- Cutting line to de-energize line section while still energized by alternative sources (such as from microgrid) will lead to worker being injured.
- Unplanned outages due to miscommunication (fast curve)

Discussion and Q&A

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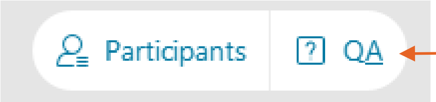

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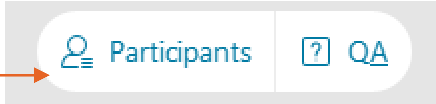

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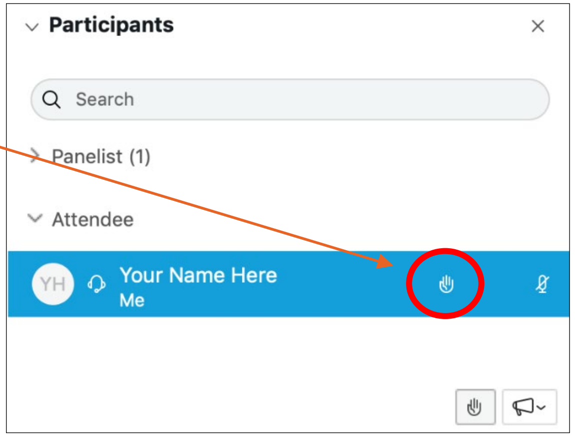


Engineering & Design

Presented by:
John Friskel, Energy Strategy & Innovation

Realizing the Benefits of Microgrids Means Managing Hazards

Voltage-source inverters behind the meter.
Grid workers may be unaware that primary lines are energized if the rest of circuit is without power.

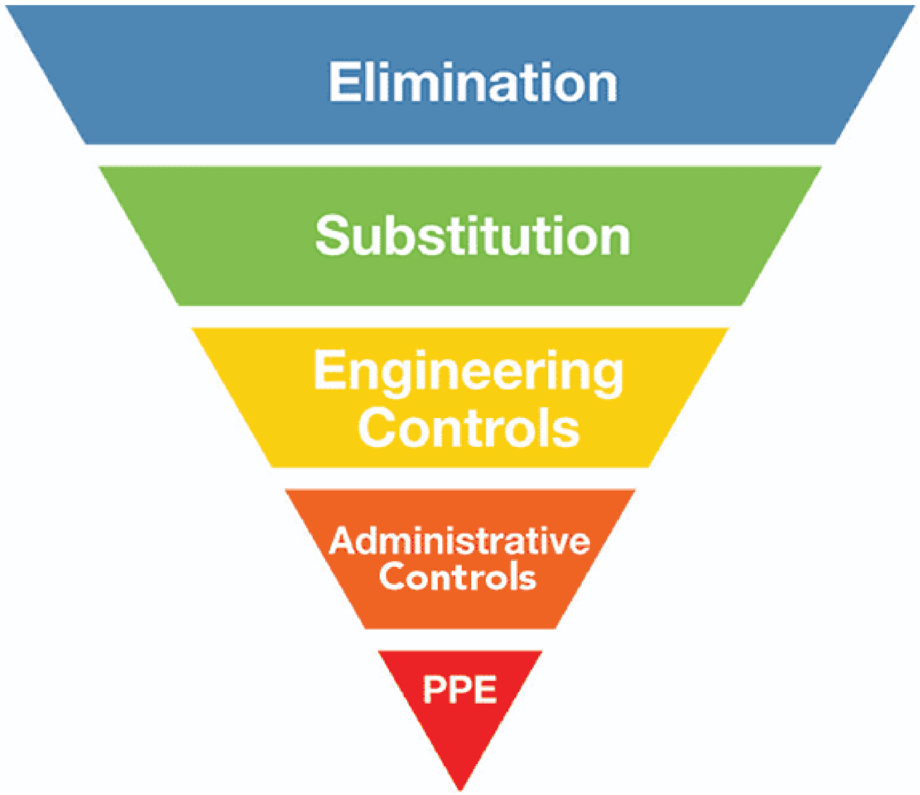
Multiple energy insolation points.
Unintentional backfeeds energize lines during maintenance.

Complex controls in multiple operational modes.
Microgrid acts in an unexpected way due to failures in protection, communications, or hardware.

Adverse fire weather over microgrid.
Microgrid remains islanded and during a high wind event resulting in ignition.

Ensuring Safety of the Electrical Distribution System

Grid Operator



IEEE

UL

ANSI
American National Standards Institute

30

Microgrid-Specific Hazard Controls Must be Developed

New Engineering Controls

- Protection
- Testing & Modeling
- System Commissioning
- Ongoing Maintenance

New Administrative Controls

- Global Design & Implementation Standards
- Project Design & Development
- Operational Procedures and Protocols

Discussion and Q&A

WebEx Tip

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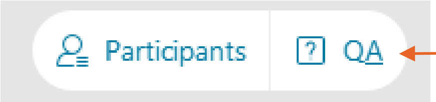

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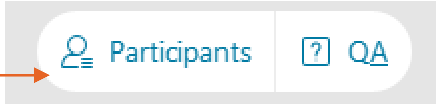

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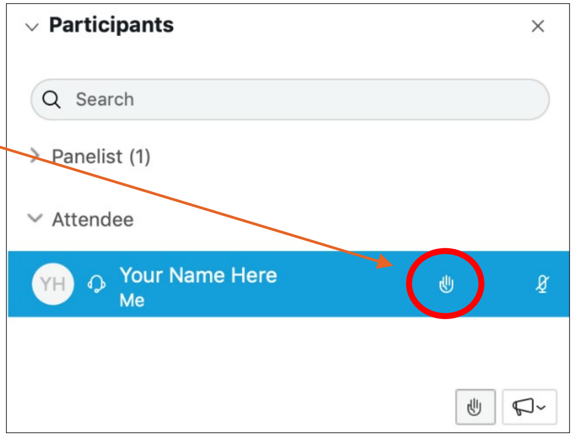

Physical and Cybersecurity

Presented by:

Abraham Jose, Cybersecurity Risk & Strategy

Microgrids: Engineering for Safety and Security

Safe and controllable functioning of microgrid requires us to adopt security practices that are broadly divided into two categories: **Physical Security and Cybersecurity.**

Key Concept	How it applies to Physical Security and Cybersecurity
Defense in depth or layered security	• A strategy that seeks to delay rather than prevent the advance of an attacker to an intended target, allowing time for detection and response. • Rather than defeating an attacker with a single, strong defensive line, defense in depth relies on multiple layers of defense allowing time for detection and analysis of the threat and, if necessary, response to the incident.
Delay measures	Physical security measures installed to delay an intruder's access to a physical asset and that provide time for incident assessment and response. Delay tactics can incorporate CPTED methods.
Detection measures	Physical security measures installed to detect unauthorized intrusion and provide local and/or remote intruder annunciation.
Deterrence measures	Visible security measures installed to persuade individuals to seek other, less secure targets.
Electronic access control system	A computerized access system composed of card readers, electrically operated locks, local and centralized computers and associated software, and related communications system.

Microgrids: Engineering for Safety

Physical Security Controls:

- Define and implement Physical Security Perimeter – boundary walls, fences, gates, etc.
- Secure buildings to house control devices.
- Physical Access Control (electronic or manual) with auditable log maintained.
- Continuous monitoring of physical perimeter – security personnel, cameras, system detection.

Cybersecurity Controls:

- Identity and Access Management supporting role-based access control.
- Perimeter security and advanced firewall.
- Data security and encryptions.
- Secure device management – firmware upgrade, patching, etc.
- Procedures and technologies in place for vulnerability monitoring and remediation.
- Hardened and secure hardware devices.
- Serial (non routable) communication interface with utility owned device (No dual network).

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PG&E Pacific Gas and Electric Company®

System Protection

Presented by:

Chris Bolton – SDG&E Engineer, System Protection Automation & Control Engineering

Mike Jensen – PG&E Engineer, System Protection

Microgrid Protection Topics

- Microgrid Safety
- Microgrid Interconnection Protection
- Microgrid Operating Modes

Microgrid Safety

Safety is of utmost importance when operating and protecting a microgrid, just as it is with a traditional utility operated grid.

- Faulted conditions shall be detected and isolated
- Sources of generation shall be removed from faulted circuit segments
- The ability to detect and isolate faults as quickly as possible can greatly reduce damage to people and equipment
- Protection must be designed to prevent unintentional backfeed
- The speed at which protection operates can greatly reduce the chance of causing catastrophic wildfires (fault energy reduction)

Microgrid Interconnection Protection

Pacific Gas and Electric Company

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Protects **utility personnel and the general public** from feeders that should be de-energized during fault conditions

- Maintain Adequate protection during parallel and microgrid operations

Protects **utility personnel, general public and generation** from

- Fault backfeed which can cause great bodily harm and equipment damage
- Abnormal operating conditions which would otherwise cause damage

Protect **utility/microgrid customers from poor reliability and power quality**

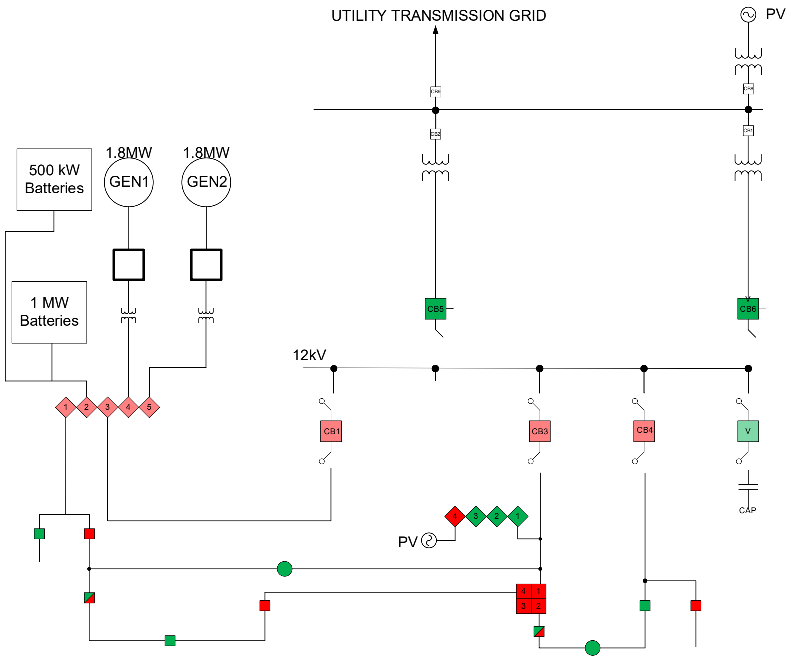
- Sufficient operating limits need to be defined to ensure protection systems protect customers and their equipment from damage

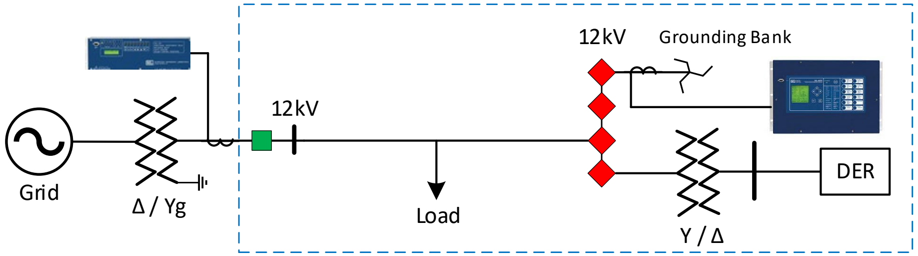
Microgrid Operating Modes

- Protection systems are typically designed to operate utilizing the traditional utility model of a robust grid as a source feeding customer load. Microgrids introduce new paradigms with respect to a more dynamic system topology, which can change states or "modes":

- **Grid Following – Microgrid Operates in Parallel with Utility Grid**
  - Protection is designed for normal Grid configuration with fault current provided by a robust utility source
  - Distributed Generation is configured for Grid Following and will separate or "trip" upon loss of Grid Source
  - Stable system grounding is provided by the robust utility source

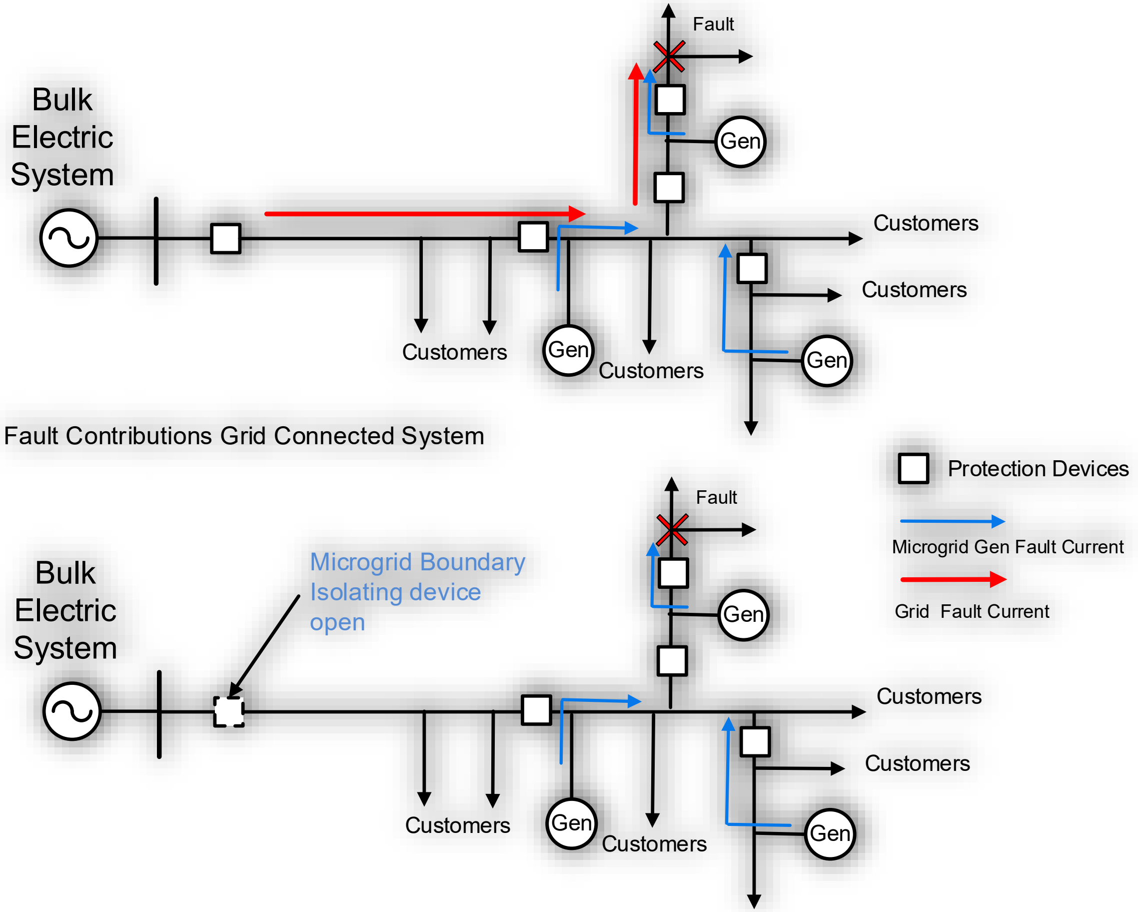
- **Grid Forming – Microgrid Operates in an Islanded State Separate from Utility Grid**
  - Circuit is supplied solely by the islanded generation, resulting in greatly reduced fault currents. Absent a robust utility grid and powered by relatively weak inverter-based generation (solar, batteries, etc.), fault duty is greatly reduced which poses significant challenges for protection schemes to detect faults and operate as intended
  - Protective devices are not traditionally configured to detect the reduced fault currents, so dynamic protection setpoints may be required to ensure utmost safety
  - System grounding likely needs to be supplied by the microgrid due to loss of utility ground source





Microgrid Operating Modes

- Example of fault current change between connected and microgrid modes of operation.
  - Top – Grid Following
  - Bottom – Grid Forming
- To provide adequate protection, the "Protection Device" settings need to be modified to account for the change in fault duty.
  - Settings may need to be dynamically altered during change of operating mode to ensure proper operation for safety
- The islanded generation needs to supply adequate fault current to allow clearing of all faults within the microgrid.
  - Generation resource type needs to be studied to determine if sufficient stability can be achieved with proper fault characteristics
- Boundary isolating device is a critical part of microgrid safety in that it also provides a means of preventing unintentional backfeed to the utility grid
  - Helps protect personnel and public safety as well as equipment integrity
  - Cannot be operated without proper controls to ensure safety



Discussion and Q&A

WebEx Tip

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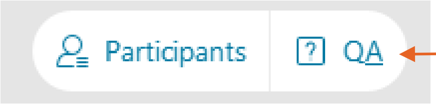

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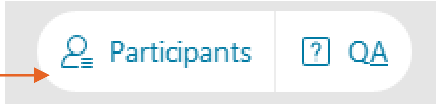

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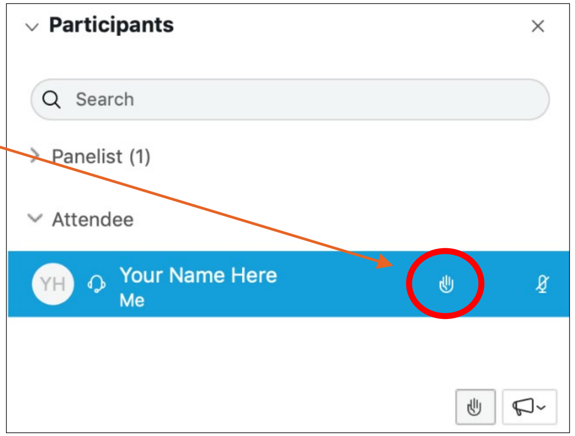

Next Steps

Action Request from Members:

- Let us know if you have other tariff development-related resource suggestions that may be helpful for the working group members to be aware of.

- Let us know if you think you will likely have a proposal to share with the working group in April.

Next Meeting

- Monday, March 22, 2021, 2-4PM
  Topic: Consumer Protection and Alternative Structures

Upcoming Meetings:

- There will ***not*** be a meeting on 4/5/2021.

- Please put a hold on your calendars for the tentative meeting below. The date and topic may be subject to change, and we will confirm the meeting at the 3/22 meeting.
  RCEA's End User Perspective on CMET   Monday, April 12, 2021, 2-4PM

- Depending on the number of members that would like to share a proposal, there may be weekly meetings for the rest of April.

For more information:

Jessica.Tse@cpuc.ca.gov

https://www.cpuc.ca.gov/resiliencyandmicrogrids/