Potential Grid Services and Integration Challenges

Microreactors as Distributed Generation

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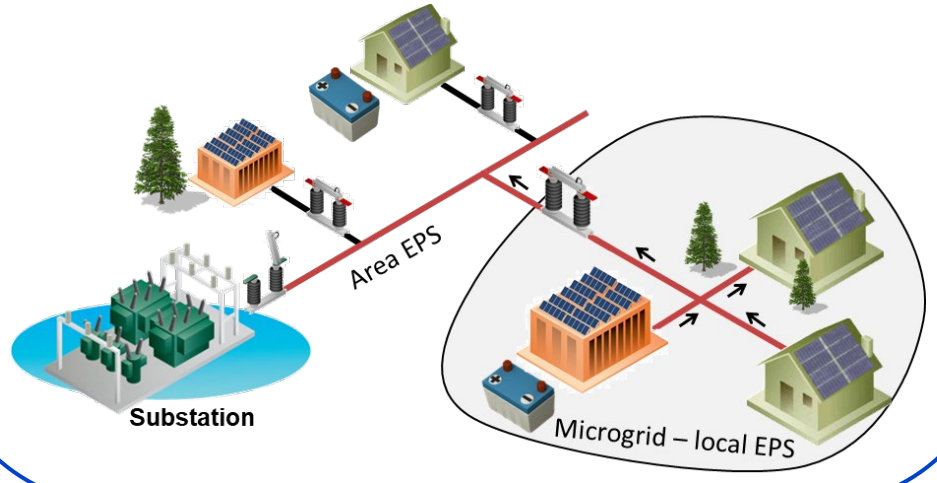
Today's Discussions

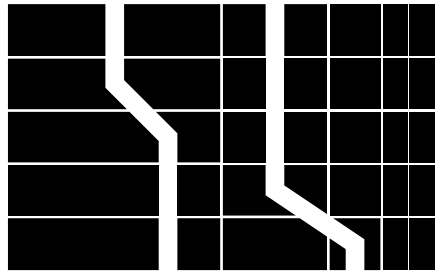
Grid Services

What services can microreactors potentially provide at the edge of the grid?



Integration Challenges and Considerations

How can microreactors integrate and provide these services & benefits?



Grid Services and Value Stacking

- There are many values which DGs and DERs can provide throughout the grid domain, including generation, transmission, distribution (T&D) and customer services.

Market Services

- Day-ahead energy time shift
- Load following
- Frequency regulation
- Spinning reserves
- Non-spinning reserves
- Resource Adequacy Capacity

T&D Services

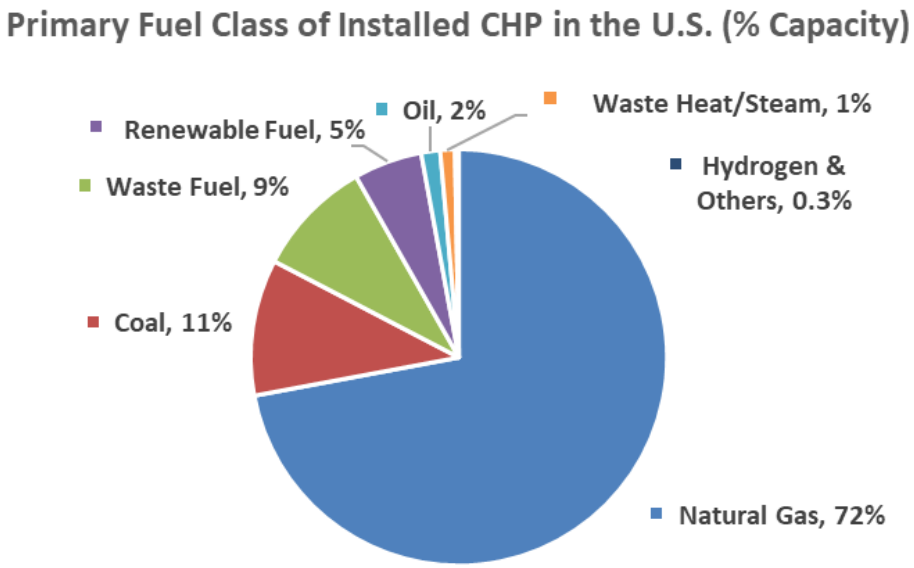
- Transmission/ distribution upgrade deferral
- Reliability/resilience

Customer Services

- Onsite generation, including combined heat and power
- Reliability/resilience
- Power quality
- Energy and demand charge management

Fueled DGs in Low Carbon Future

- **Combined Heat & Power:**
  - Capacity dominated by combustion turbine, steam turbines
  - Primary fuel: natural gas, followed by coal
  - Co-locating thermal and electric generation is more efficient than separately
  - ***Decarbonization industrial heating is challenging***
    - Low-carbon technologies and options limited
    - High temperature applications
  - Increased interest in disaster resilience and reliability

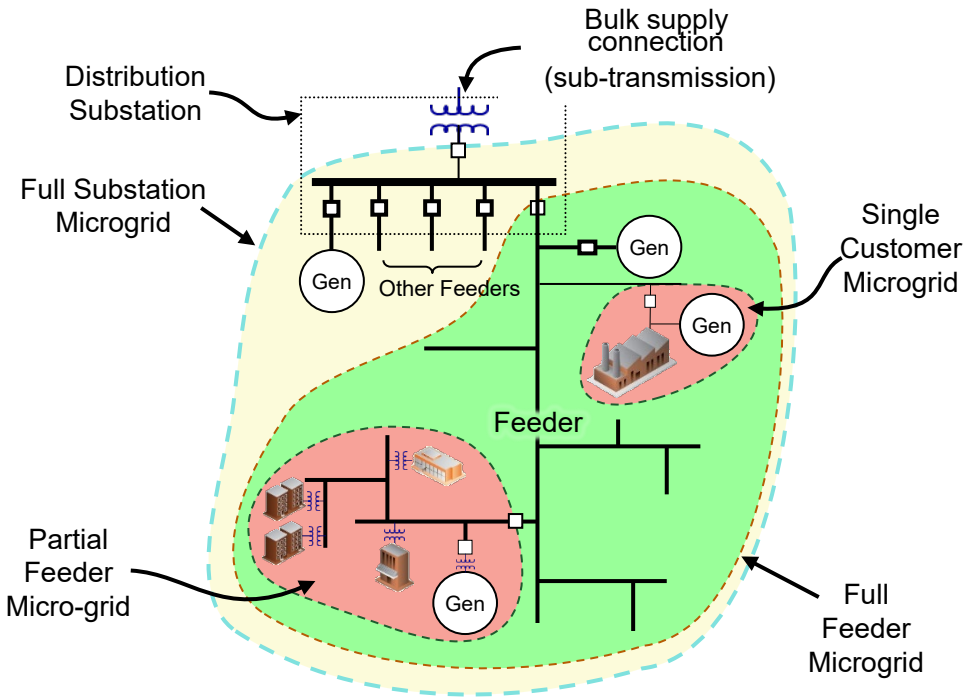


Source: DOE CHP Installation Database

Definition of Microgrid

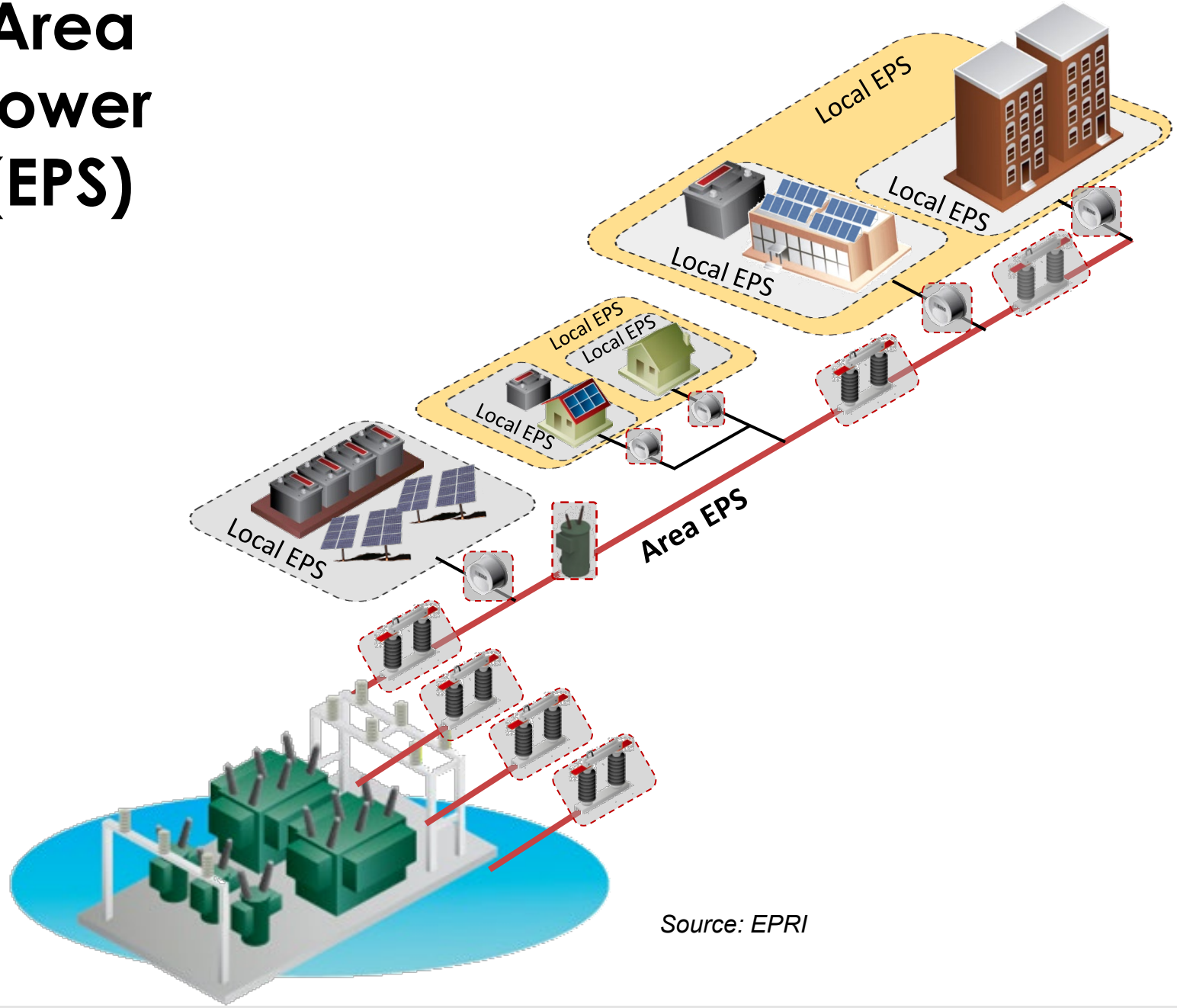
EPRI's Definition of "Microgrid"

"A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such grid to enable it to operate in both grid-connected or 'island' mode."



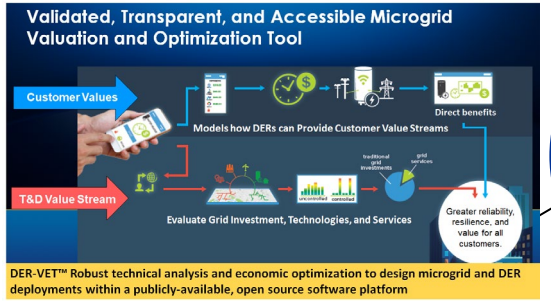
- While a microgrid must, by definition, be able to operate islanded, there are few reasons to island if the external grid is available.
- Microgrids may or may not be capable of long-term islanded operation.
- Varied circumstances encountered in microgrid proposals present challenges to cost-benefit analysis.

Local vs Area Electric Power Systems (EPS)

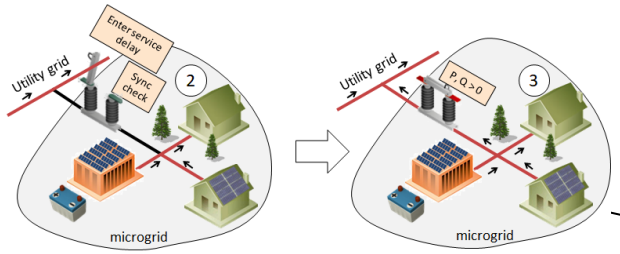


Source: EPRI

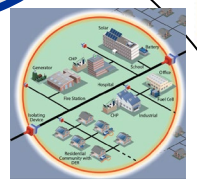
Key Themes: Microgrid and Resilience Research Activities

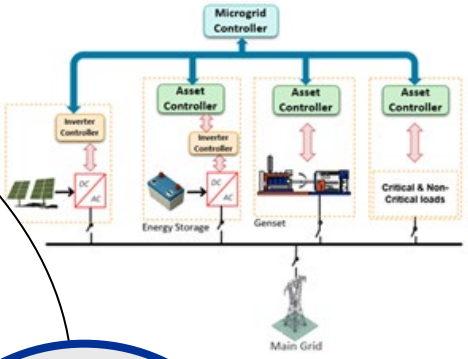


Economic Considerations

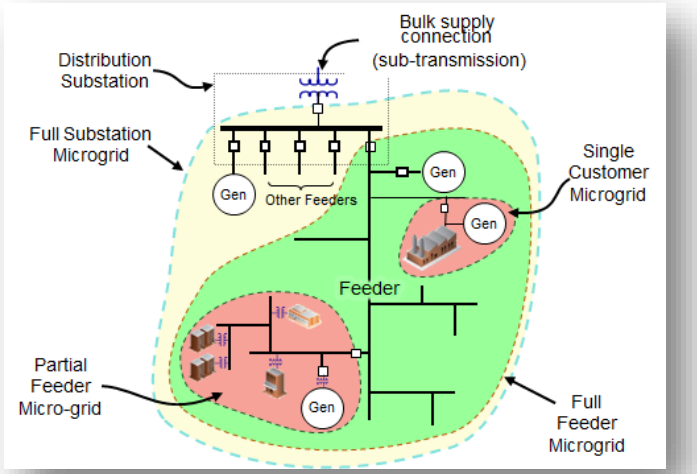


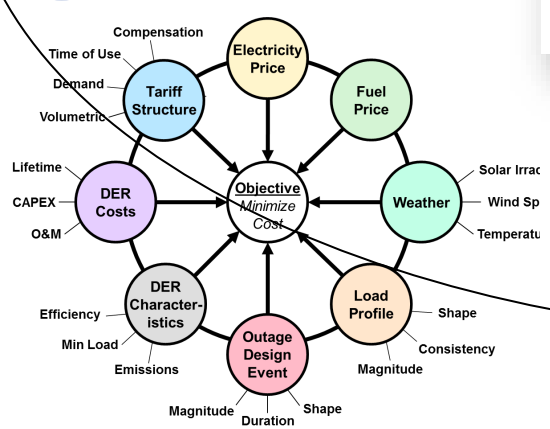
Interconnection



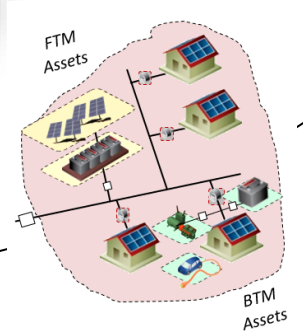


Decarbonization Pathways





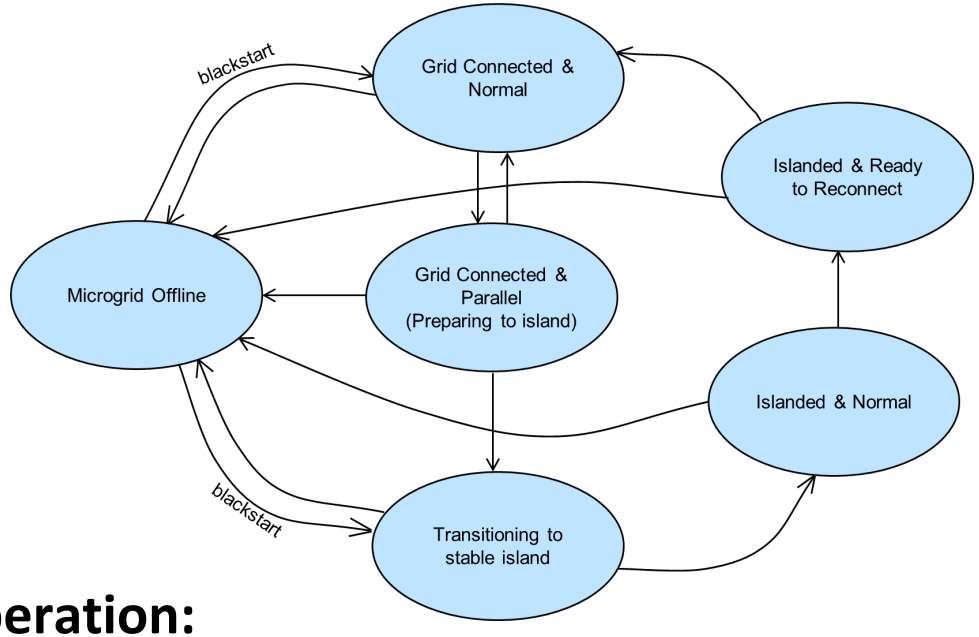
Utility Programs



Controls & Design Evaluation

Technical Considerations for Microgrid Interconnection

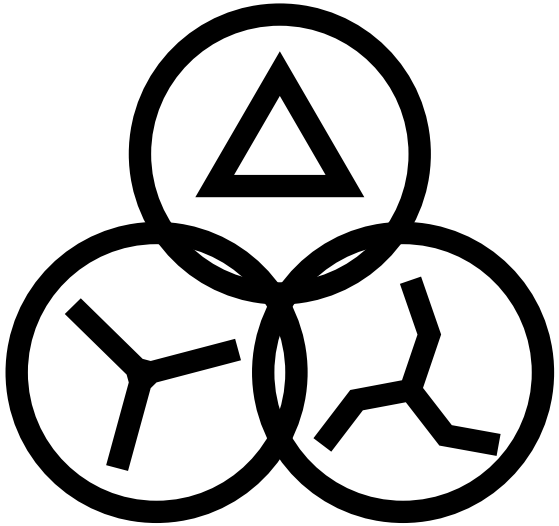
- **Transition Requirements:**
  - 1547-2018 highlights, standards consideration
    - Clause 8 – Islanding
    - Annex F – use cases
  - Planned utility grid disconnection
    - Utility communication and permissions
    - Seamless disconnect option
  - Black start
    - Break-before-make option
    - Inrush and cold load considerations
  - Resynchronization, paralleling
    - Seamless reconnect option
    - Cold load pickup allowance



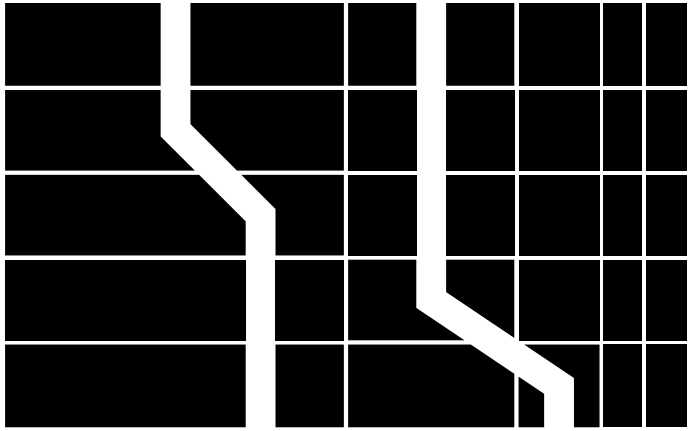
- **Island Operation:**
  - Mode change (grid forming)
  - Settings change (switch from anti-islanding)
    - Allowance for wider settings
- **Protection requirements and coordination**

Common Challenges

Grounding Sources

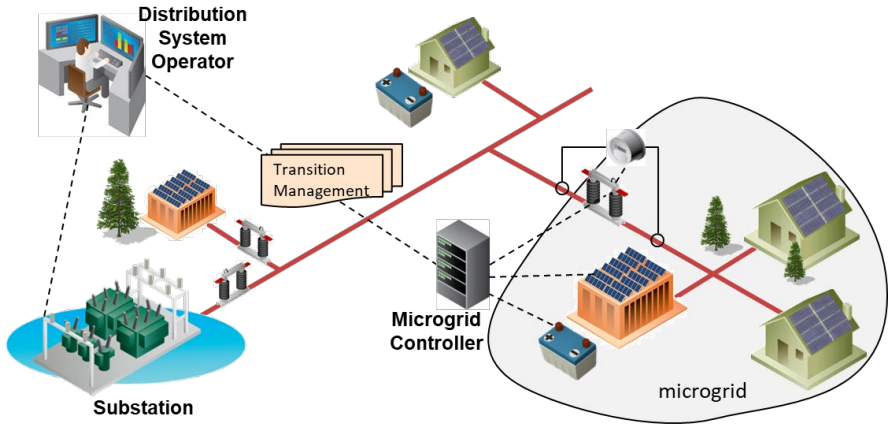


Protection Coordination



Some Grid Integration Considerations for Microreactors…

- **Grounding**
- **Protection**
- **Islanding**
  - Unintentional, intentional, scheduled
- **Transitions**
  - Open transition, closed transition, “seamless” transfer
- **Black start**
  - How much load? Reactive power, inertia? Black start sequence?
  - Depends on primary mover of microreactors: response time, ramp rate, thermal requirements?
- **Integration**
  - Controller and how the DGs/DERs are managed
  - When connected to the grid versus islanding
  - Who is controlling interconnection? Who is managing the connectivity to protection devices?
- **System impact**
  - Will the microreactor have a negative impact on the broader system?
  - Interconnection considerations



Grid Considerations for Microgrids – Takeaways

- Interconnecting microgrids requires defining operating modes, transition scheduling and related Area EPS notifications.
- Microgrid transitions on and off the grid (i.e. open vs closed), and related design, need to consider nuances and potential gaps when applying IEEE 1547 requirements.
- Microgrid interoperability specifications need to address island scheduling and timing details, protection and grid support responsibilities. Standards may evolve to support these.
- Unscheduled island transitions from on grid disturbances need to also support ride-through requirements before exiting; this is a challenge to closed or "seamless" transfers.
- Microgrid behavior during loss of communications needs to be better defined; consequences vary and depend on the relative size and design.
- Permit service requirements in IEEE 1547 cover both synchronized, "closed," transition of islands and "open" DER return to grid service. (load restoration is not covered, and delay is not implied)
- This work identifies needed standards for facility (single customer or local EPS) microgrids. Future work is planned to address multiple customer (area EPS) microgrids.
- During island operations, facility (local EPS) microgrids are not included in the IEEE 1547 scope; future microgrid-specific standards may be needed to address off-grid performance.
- IEEE 1547 addresses grid-connected microgrids as intentional islands.

2021 Whitepaper: Grid Considerations for Microgrids (PID: 3002020344)

Together…Shaping the Future of Electricity

Thank you

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