Distributed Resources Engineering (DRE) Updates

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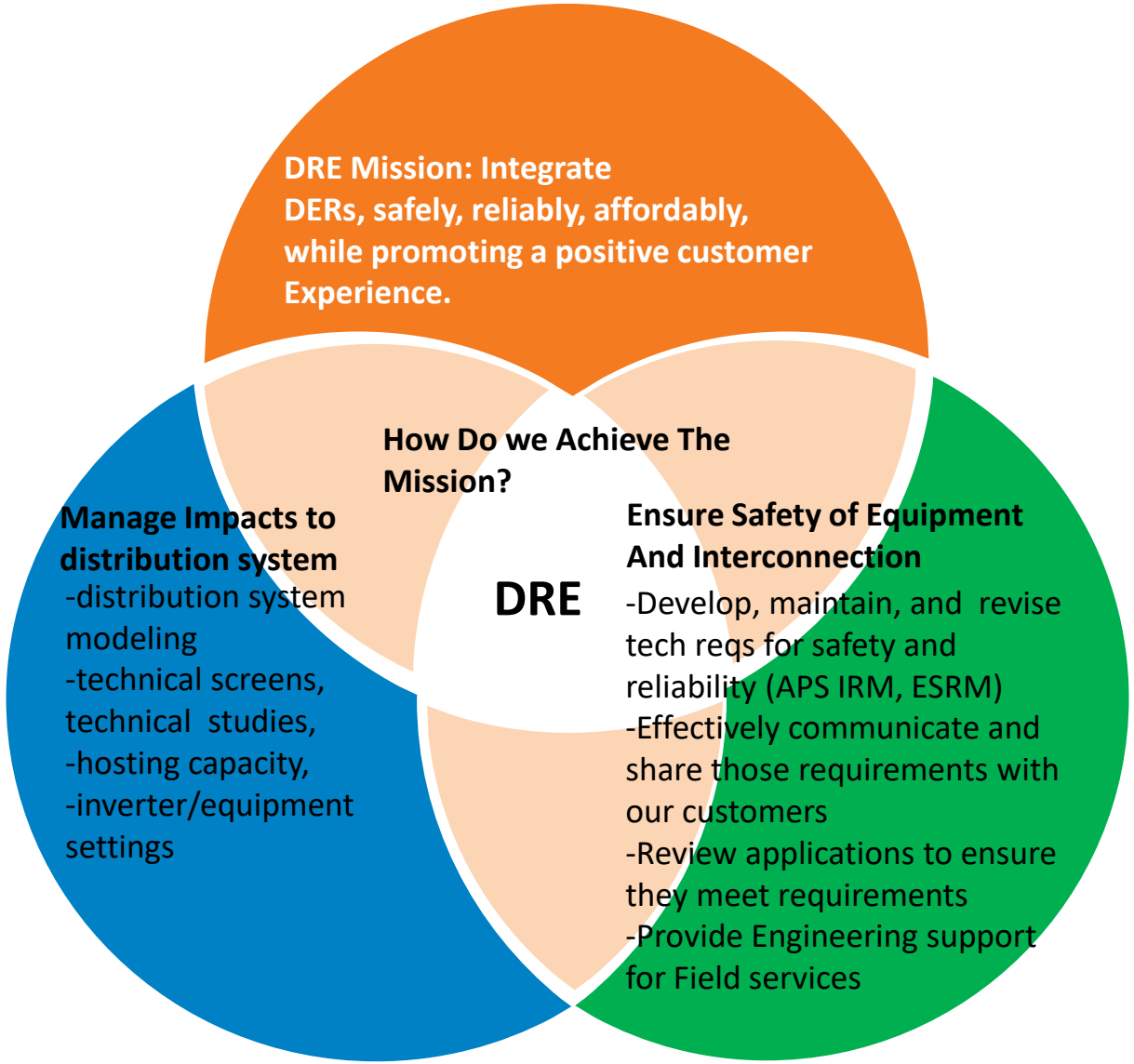
DRE's Mission:

To partner with our customers to sustainably integrate DERs to the distribution grid with a focus on safety, reliability, flexibility, power quality, and customer affordability.



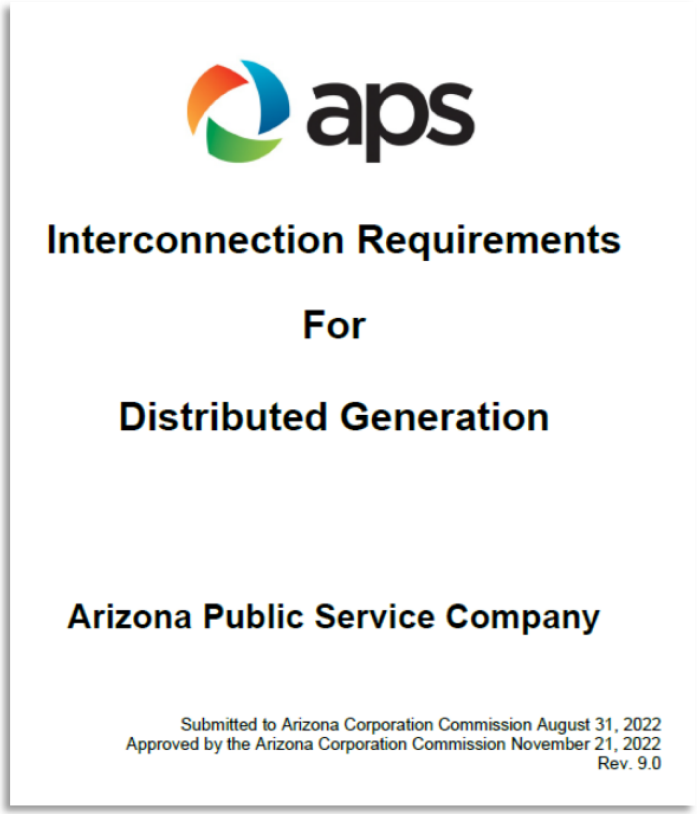
Topics of Discussion

Overview of Interconnection Requirements Manual Updates

Advanced Inverter Updates

Summary of Interconnection Manual Updates

APS IRM Background



The APS Interconnection Requirements Manual (IRM) is based on multiple national codes, standards, and requirements such as OSHA, NEC, UL and NFPA 70E and

It been a guidebook for safe and reliable interconnections to the APS distribution system since 1985.

Current IRM approved in November of 2022

The IRM is a living document on a proposed 2 year life cycle (Q1 2023-Q1 2025).

State level interconnection rules have provisions for emergency updates if necessary

APS holds the Industry Forum annually in April as well as the Interconnection Manual Collaborative twice annually in which installers and stakeholders share questions and suggestions

Modifications and clarifications suggested by stakeholders, installers, and APS technical teams are redlined into currently approved version on a continuous basis, for inclusion in future drafts.

Goals of IRM Updates

Start process to improve readability by reorganizing and simplifying content to provide a path to an improved user experience

Provide increased clarity to select existing requirements

Propose updates to best align with technology advances and industry best practices

Overview of Updates

- Requirements revised to reflect current industry practices as well as work practices.
- Requirements were simplified wherever possible
- Updates to improve clarity, by deleting, simplifying, and reorganizing content throughout the document
  - Some sections were relocated to for better alignment with other sections in the document
- References to requirements were strategically inserted to make it convenient for customers to find in the IRM rather than having to search through other documents.
- Added clarity to scenarios that allow for variations in requirements and equipment.
- Added section on ways to limit active power across the point of interconnection. This helps explain how to utilize inadvertent export and other power limiting options to aid customers in moving forward with their project as an alternative to downsizing their system if study results show negative impacts to a feeder.

Summary of Sections

- Section 1: Definitions-Added a few to reflect new technologies as well as to provide clarity
- Sections 2-7: Largely unchanged.
- Section 8 – INTECONNECTION TECHNICAL REQUIREMENTS
  - Added clarity to scenarios that allow for variations in requirements and equipment.
- Section 9 – METERING REQUIREMENTS
  - This Section was updated to improve clarity, by deleting, simplifying, and reorganizing content.
- Section 10 – PROTECTION
  - Made updates to relay settings, power limiting, and reorganized some content.
- Section 11 – REMOTE MONITORING AND Remote DISCONNECT REQUIREMENTS
  - This section primarily applies to systems 2MW and greater.
  - Clarified and reorganized content
- Section 12 – ADVANCED GRID SUPPORT FEATURES
  - Updated to clarify application and requirements and utilization of advanced grid support features

Summary of Sections Cont.

- Section 13 – SOURCE TRANSFER EQUIPMENT
  - This Section was updated to the most current OSHA/UL 1008/IEC Standards for Transfer Switches and vetted with Industry Manufacturers.
  - To enhance clarity, the organization was improved by deleting, simplifying, and rearranging content.
- Section 14 – TESTING AND START-UP REQUIREMENT
  - This section primarily applies to systems 2MW and greater.
  - Clarifies project commissioning and start up process
- Section 15 – OPERATIONAL AND MAINTENANCE REQUIREMENTS
  - Clarification was added for customer to monitor and follow approved operating characteristics
- Section 16 – APPLICATION PROCESS AND GENERAL REVIEW REQUIREMENTS
  - sections were consolidated to avoid repeating information throughout the section or already mentioned in previous sections.

Benefits of IEEE 1547-2018 Adoption & Advanced Inverter Settings

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Highlights/Overview

- APS plans to adopt advanced inverter settings found within IEEE 1547-2018 for grid-support functions that align with best industry practices.
- These settings have the potential to minimize the negative effects that high penetrations of Distributed Energy Resources (DERs) can have on the grid and allow more customers the opportunity to interconnect.

Advanced Inverters & Grid-Support Functions

Advanced (smart) inverters have the capability to monitor and respond to information (e.g., voltage, frequency) to maintain grid stability

- Adjust output to achieve longer operational time vs. reaching threshold and ceasing operation
- Ride through abnormal conditions

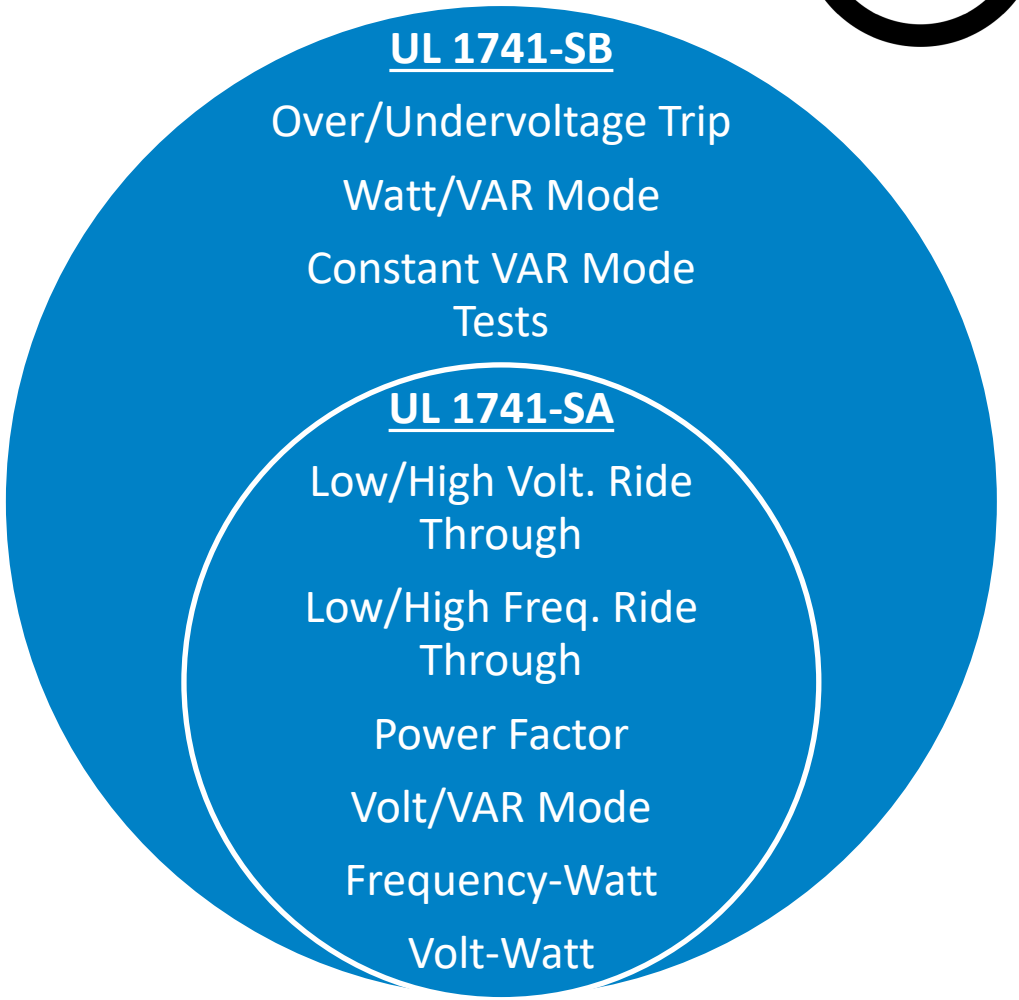
IEEE 1547 & UL 1741-SB Certification

- UL 1741 is the industry standard for Inverter Safety
  - The tests which advanced inverters must pass to receive UL 1741 certification were designed to meet or exceed the requirements set forth by IEEE 1547-2018
- UL 1741-SB introduced interoperability conformance testing in accordance with IEEE 1547.1-2020, which established testing procedures for advanced inverter capabilities

UL 1741-SA & -SB Certification Differences

Supplement B references IEEE Std. 1547.1-2020 to standardize certification and ensure testing covers the *full range* of allowable settings required by IEEE 1547-2018

- SA-compliant devices are more narrowly certified to non-uniform performance requirements



IEEE 1547 & UL 1741-SB Certification (cont.)

- Per the effective APS Interconnection Requirements Manual (IRM) revision, which was approved Nov. 2022, APS had planned to require UL 1741-SB certified inverters alongside recommended settings July 2023.
  - However, SB-Certified inverters were not widely available, so APS continued to work with industry partners and manufacturers to continue approval of UL 1741-SA certified inverters
- The upcoming revision of the IRM will require SB certification upon approval from the ACC.
- Stakeholder Communication will be sent ahead of adoption/requirement changes.

Arizona Administrative Code (AAC) & Implementation of Advanced Settings

AAC Title 14, Chapter 2, Article 26, Section R14-2-2625 C. allows for grid-support features to be implemented via Advanced Inverters upon mutual consent between customers and utilities

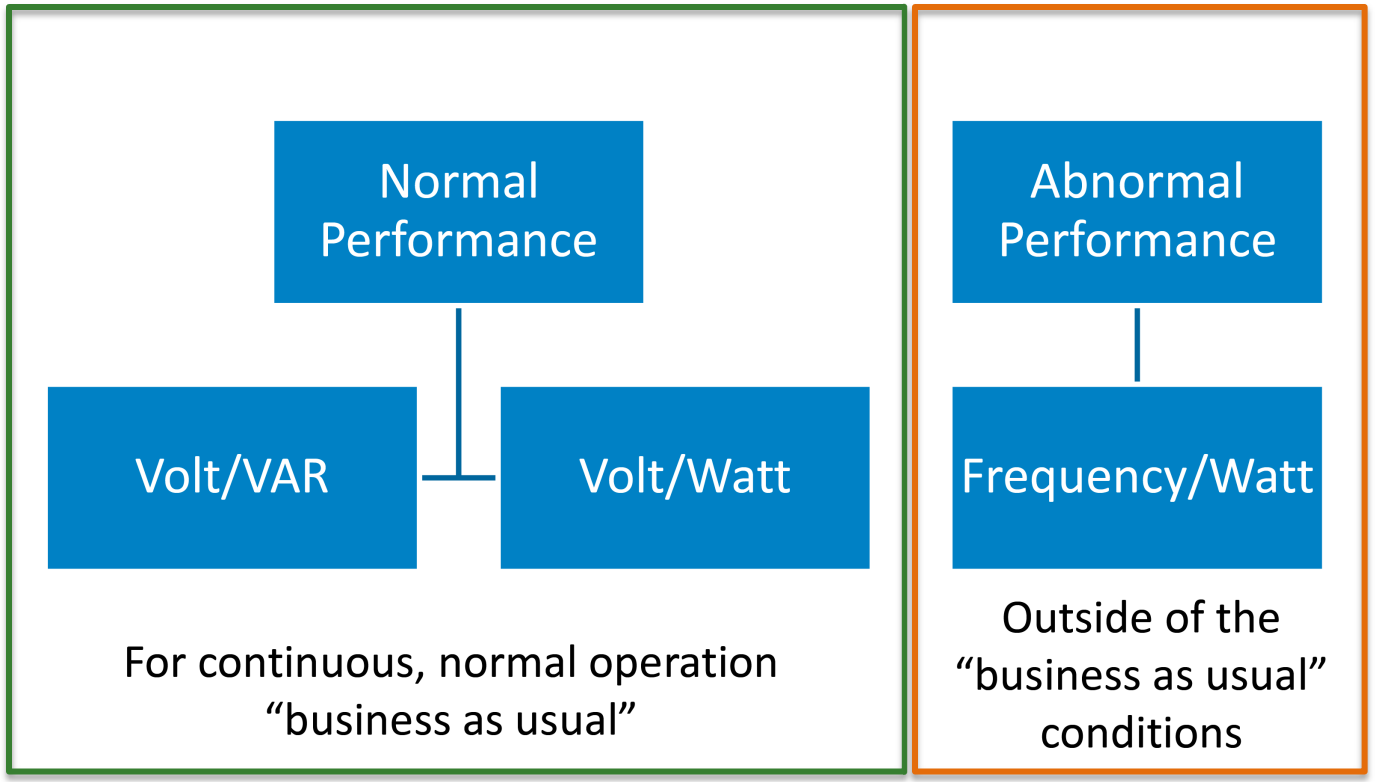
- Volt/VAR
- Volt/Watt
- Fixed Power Factor
- Soft-Start Reconnection
- Frequency/Watt

APS Grid-Support Features

- Where we are:
  - Minimum Power Factor capabilities have been a long-standing requirement of the APS IRM, and Fixed Power Factor has been employed on a case-by-case basis.
- Where we're going:
  - With APS' adoption of IEEE 1547-2018, Volt/VAR will replace the Fixed Power Factor mode of operation.

APS Adoption of IEEE 1547-2018 Advanced Inverter Settings

Adoption of default setting values found within Category B for Normal Performance & Category III* for Abnormal Performance



* Category III includes the IEEE 1547A-2020 Amendment

APS Adoption of IEEE 1547-2018 Advanced Inverter Settings (cont.)

Proposed settings & documentation align with what is stated within AAC section R-14-2-2625, including a section for mutual agreement with customers

System Features:

Is this a three phase system? *

- ○ Yes
- ◉ No

Specify the type of connection * ?

- ◉ Load side
- ○ Supply side (solar ready)
- ○ Load side tap
- ○ Supply side tap
- ○ Meter socket adapter

Is the production metering enclosure CT Rated (e.g. Secondary Service > 200A, Primary Service,etc.)? *

- ○ Yes
- ◉ No

☐ I warrant that the inverter(s) selected are in full compliance with IEEE 1547-2018 & UL 1741-SB, and will implement the default settings of Category B for Normal Performance & Category III for Abnormal Performance found within IEEE 1547-2018 & 1547a-2020, unless otherwise agreed upon with APS.

The following disconnect switch(es) must be located in an accessible location that provides 24/7 unrestricted access.

Utility Disconnect Switch * ?

Utility Disconnect Switch Manufacturer *

Select... ⌄

Utility Disconnect Switch Model *

⌄

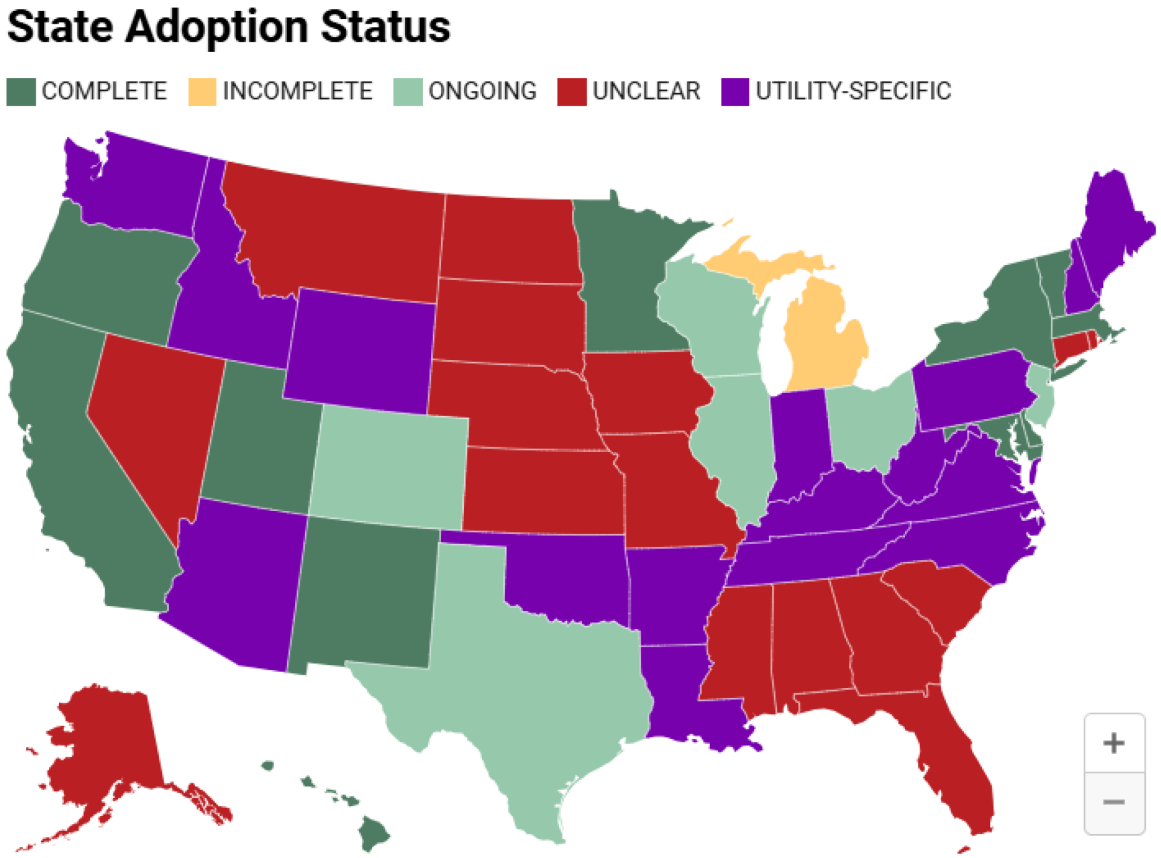
Non-BES (Bulk Electric System) Voltage Schedule Letter

- APS Non-BES with POI voltage < 100kV & nameplate capacity >= 10MW
- Accessible via OASIS website
- With regards to Inverter-Based Resources:
  - Default Operating Mode: Volt/VAR Control
  - Alternative Modes: Automatic Voltage Regulation, Power Factor Regulation
- Volt/VAR settings can be found in Attachment 1, other mode settings will be communicated upon approval

Benefits of implementing Advanced Inverter settings

Follows Industry Best Practices

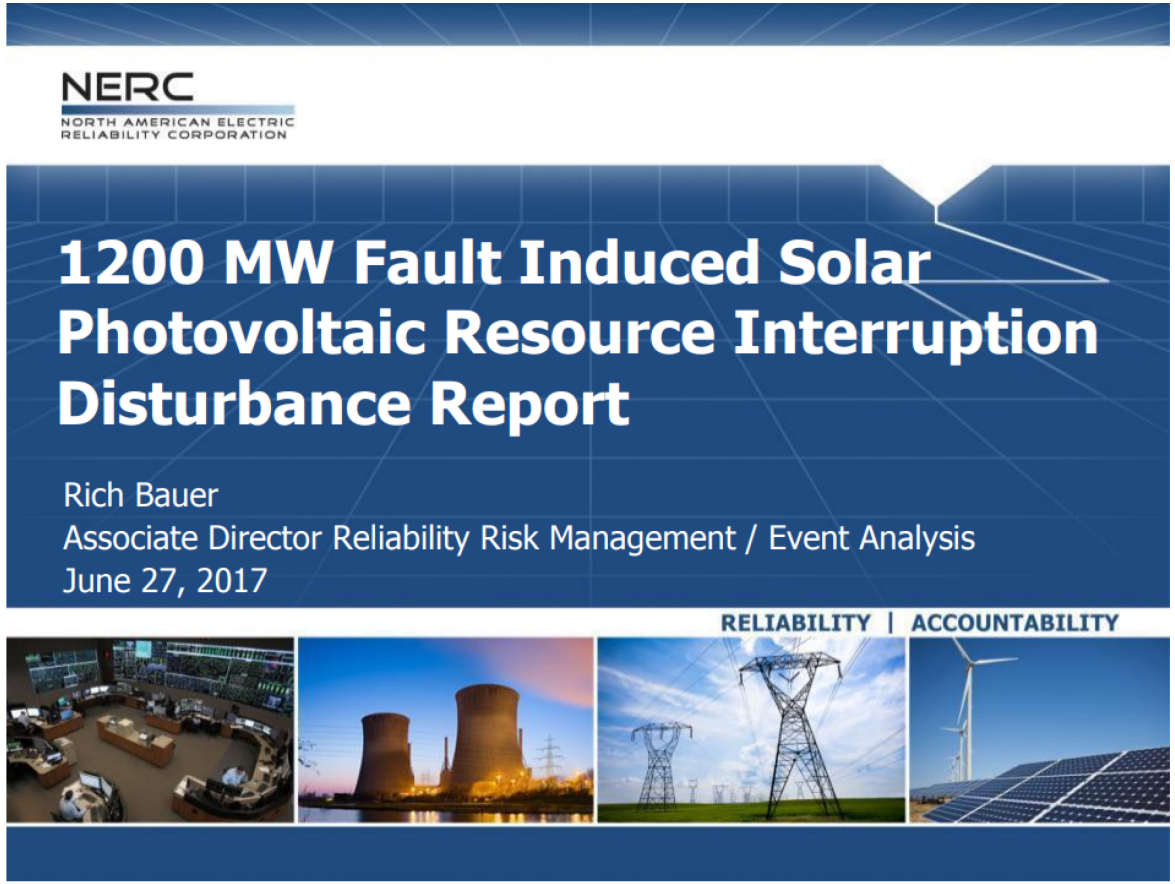
- Survey conducted by IREC on Utility IEEE 1547-2018 adoption illustrates peer utilities have already adopted the standard, and more plan to in near future
  - Arizona
  - New Mexico
  - California
  - Hawaii



Benefits of implementing Advanced Inverter settings cont.

IEEE 1547-2018 Category III Abnormal Performance functions were created as a mitigation in response to findings within NERC Report

"[…] is based on both BPS stability/reliability and distribution system reliability/power quality needs and is coordinated with existing interconnection requirements for very high DER penetration"



Benefits of implementing Advanced Inverter settings cont.

Customer Impacts

- Implementing these settings will minimize effects a Generating Facility (GF) could have on power quality and allow for greater Hosting Capacities (HC)
- Will not impact design of GFs, but to meet expected kW output, utilize the ratio below:
  - $\frac{kW\ (Real\ Power\ nameplate)}{kVA\ (Apparent\ Power\ nameplate)} = 0.9$, allows for a PF range of +/- 0.9

  Inverters < 10 MW (APS IRM Sec 12)
- Allow for more interconnections while also mitigating the potential need for line-side devices due to issues caused by GFs