

# IEEE Std 1547-2018

Bulk System Opportunities from New  
Distributed Energy Resource  
Interconnection and  
Interoperability  
Standards

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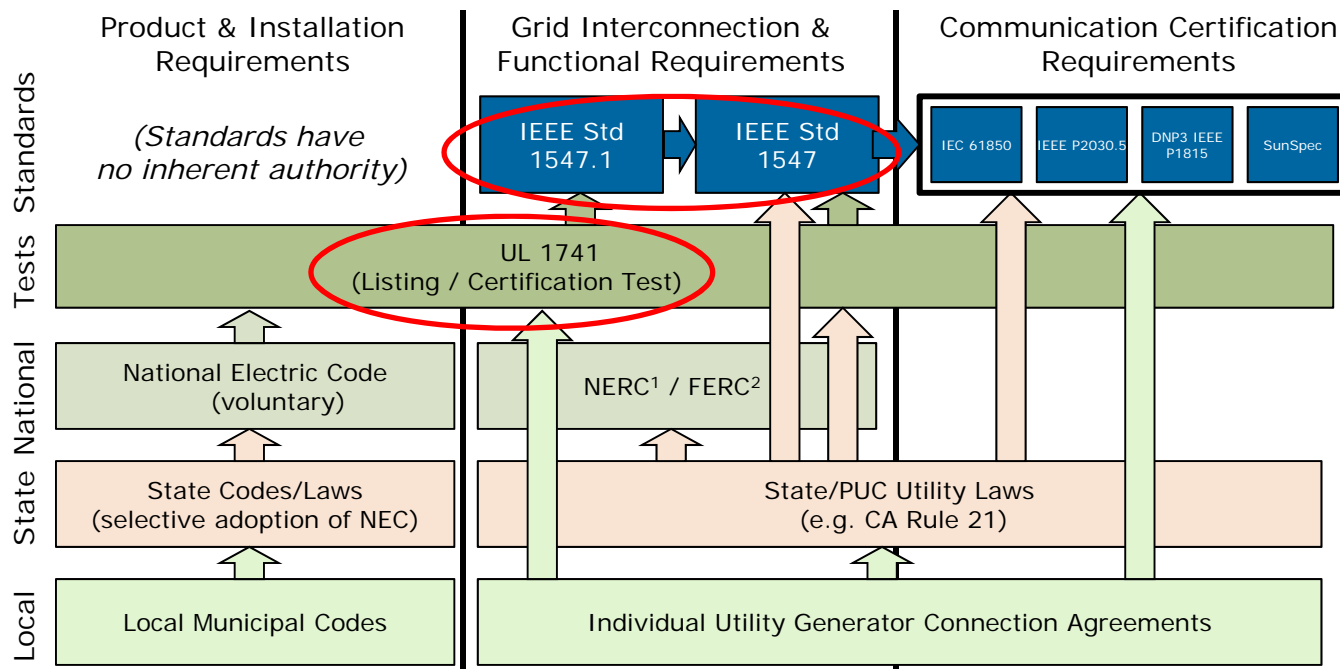
NERC SPIDER WG Meeting

Austin, TX, Jan 8-9, 2019

# Disclaimer and Acknowledgment

- This presentation and discussion represents the authors' views and are not the formal position, explanation or position of the IEEE or the IEEE Standards Association.
- This slide deck has been peer-reviewed by IEEE Standard Coordination Committee 21 (SCC21) and IEEE P1547 Officers.
- The presenters acknowledge the contributions of the IEEE Std 1547-2018 Working Group, Balloters and Officers.

# Overview on North American Standards



- Approval rate of >90% among 380 balloters
- IEEE 1547 is a voluntary industry standard – no inherent authority
- Requires adoption by an Authority Governing Interconnection Requirements
  - For example, a PUC, municipal or cooperative/ governing board

<sup>1</sup> e.g., NERC PRC-024-02, <sup>2</sup> e.g., FERC Order No. 828

# Example Adoption of IEEE Std 1547-2018



## ISO New England

- Coordination between ISO-NE and the MA's utilities in the [Massachusetts Technical Standards Review Group](#)
- Reference to UL 1741 SA as a stopgap to verify DER ride-through capability in the interim
- Harmonization of voltage & frequency trip settings with IEEE Std 1547-2018 ranges of allowable settings



## PJM Interconnection

- Two ad-hoc stakeholder workshops in 2018 for DER ride-through categories and trip settings ([PJM website](#))
- Initiation of formal stakeholder proceedings in 2019
- Aiming at full adoption of IEEE Std 1547-2018 for jurisdictional DER by early 2020



## Minnesota Public Utilities Commission

- Phase 1 (2017): Interconnection Process, Applications, Agreements
- Phase 2 (2018): Technical Requirements consistent with IEEE Std 1547-2018 ([MN PUC website](#))
- Coordination with regional reliability coordinator, e.g., MISO

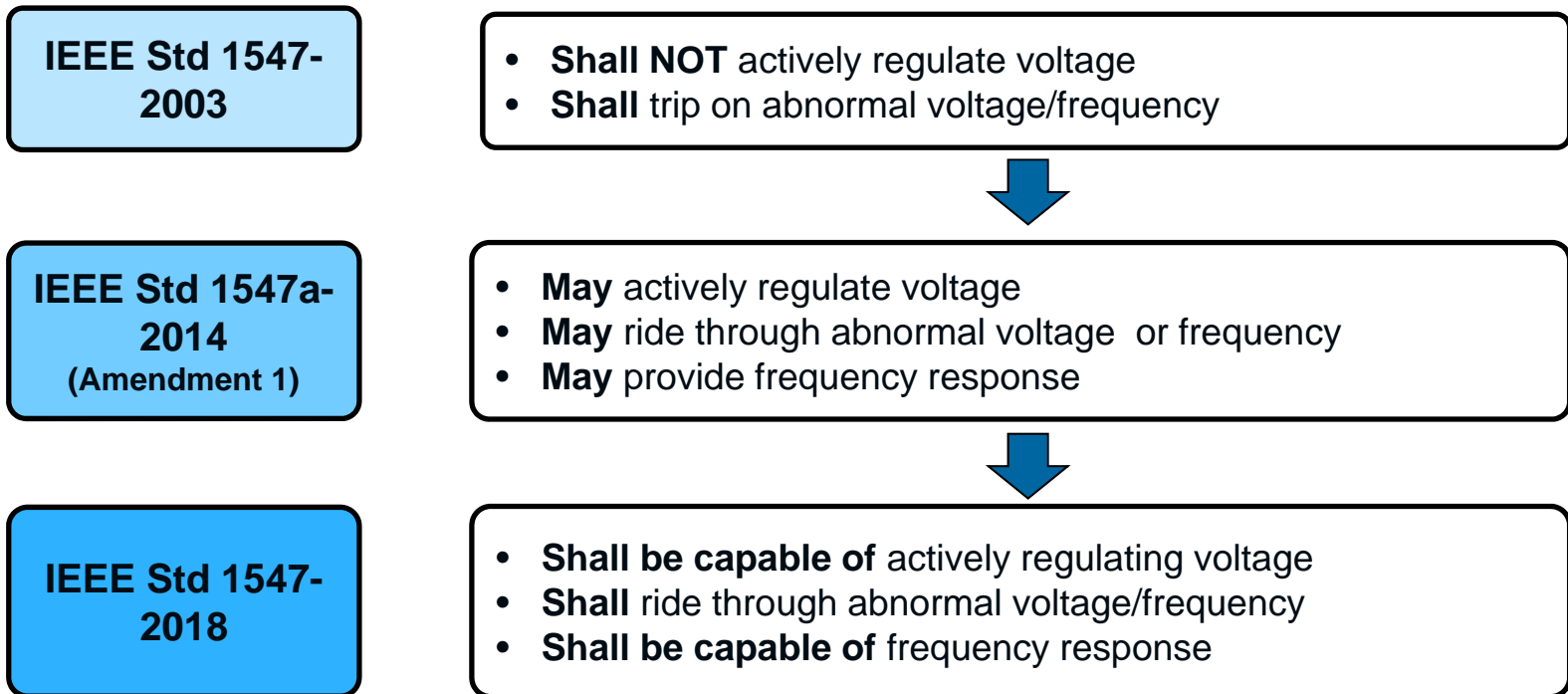
# Definition of Distributed Energy Resource

- In the context of IEEE 1547:

“A source of electric power that is not directly connected to a bulk power system.”

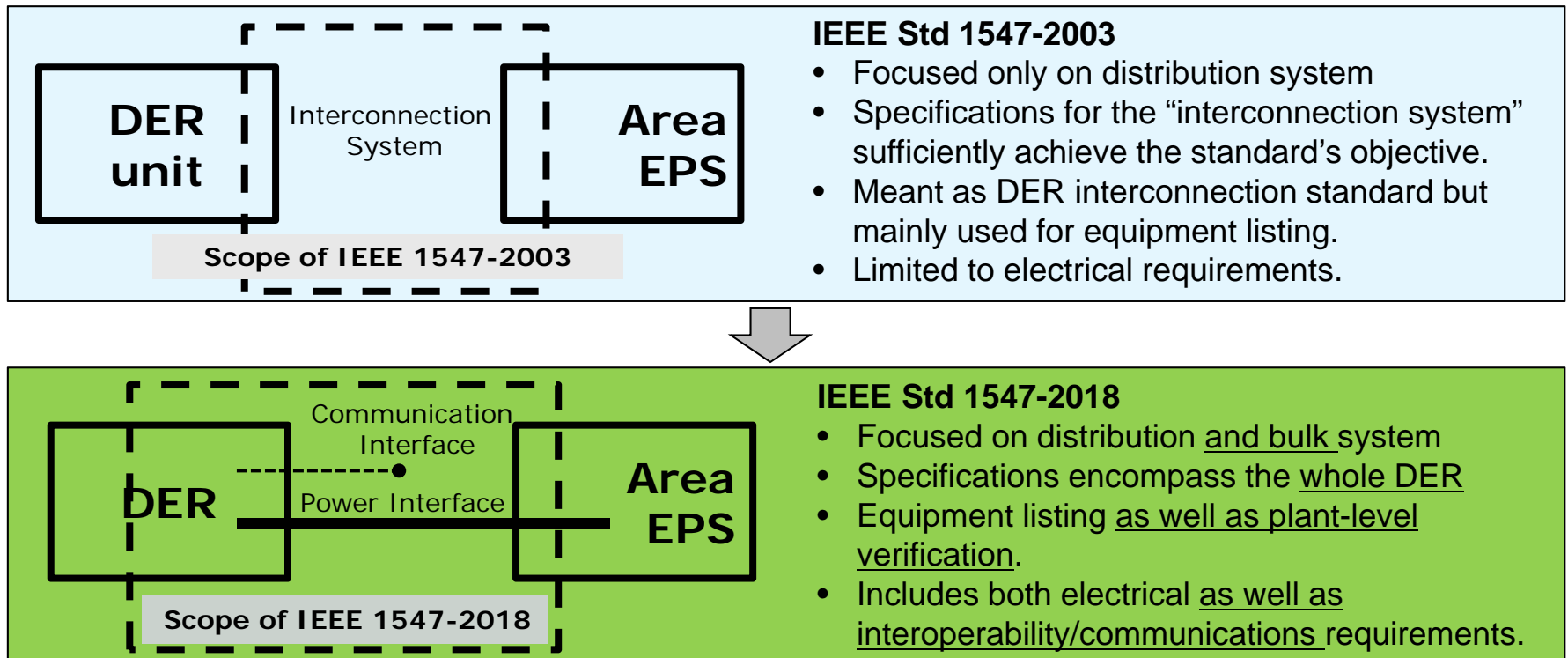
- Includes distributed generators.
- Includes distributed energy storage technologies.
- Does not include controllable loads used for demand response.
- Does not include DER that is behind a transfer switch with <100msec
- Exempts emergency/standby generators that are not intended to parallel with the Grid from many requirements.

# Evolution of grid support functions



Source: NREL

# Important changes in focus and coverage



Source: EPRI

# Bulk System Opportunities

Standards for DER		Listing/ Certification			Interconnection Standards			State/ PUC/Utility Rules	
Function Set	Advanced Functions Capability	UL 1741	UL 1741(SA) 2016	IEEE 1547.1 -2017*	IEEE 1547-2003	IEEE 1547a-2014	IEEE 1547- 2018	CA Rule 21 (Phases)	HI/HECO Rule 14H & UL SRDv1.1
All	Adjustability in Ranges of Allowable Settings			Δ		√	‡		
Monitoring & Control	Ramp Rate Control		Δ				‡	‡ (P1)	‡
	Communication Interface			Δ			‡	‡ (P2)	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			Δ			‡	‡ (P3)	‡
	Limit Active Power			Δ			‡	‡ (P3)	
	Monitor Key DER Data			Δ			‡	‡ (P3)	
Scheduling	Set Active Power							[ ‡ (P3) ]	
	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡	‡ (P1)	X
	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡	‡ (P1)	‡
	Autonomously Adjustable Voltage Reference			Δ			‡	!!!	!!!
	Active Power-Reactive Power (Watt-Var)			Δ	X		‡		‡
	Constant Reactive Power	√		Δ	√	√	‡		
Bulk System Reliability & Frequency Support	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡	‡ (P3)	‡
	Dynamic Voltage Support during VRT						√	[ ‡ (P3) ]	
	Frequency Ride-Through (FRT)		Δ	Δ			‡	‡ (P1)	‡
	Rate-of-Change-of-Frequency Ride-Through			Δ			‡	!!!	!!!
	Voltage Ride-Through (VRT)		Δ	Δ			‡	‡ (P1)	‡
Other Advanced DER Functions	Voltage Phase Angle Jump Ride-Through			Δ			‡	!!!	!!!
	Frequency-Watt		Δ	Δ	X	√	‡	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip			Δ			‡	‡ (P1)	‡
	Transient Overvoltage						‡		‡
	Remote Configurability						‡	‡ (P2)	‡
	Return to Service (Enter Service)						‡	‡ (P1)	‡

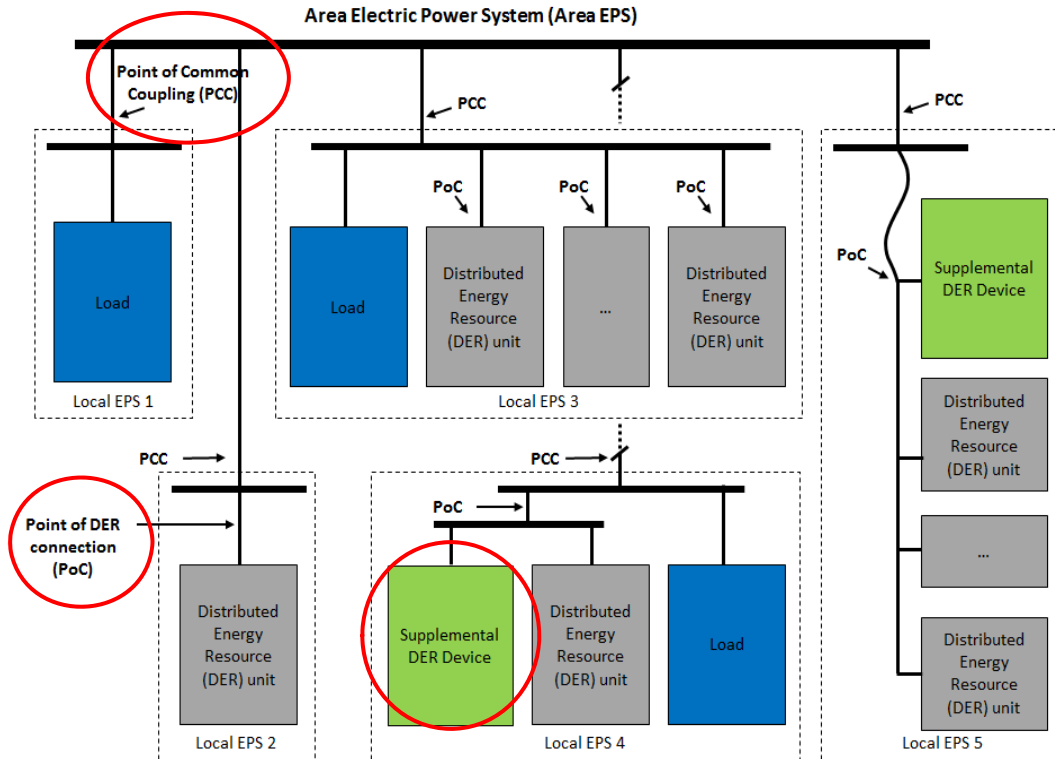
Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined Source: EPRI.  
[ ... ] Subject to clarification of the technical requirements and use cases, !!! Important Gap

Source: EPRI

Source: EPRI. Please contact EPRI for any suggested updates to this table.

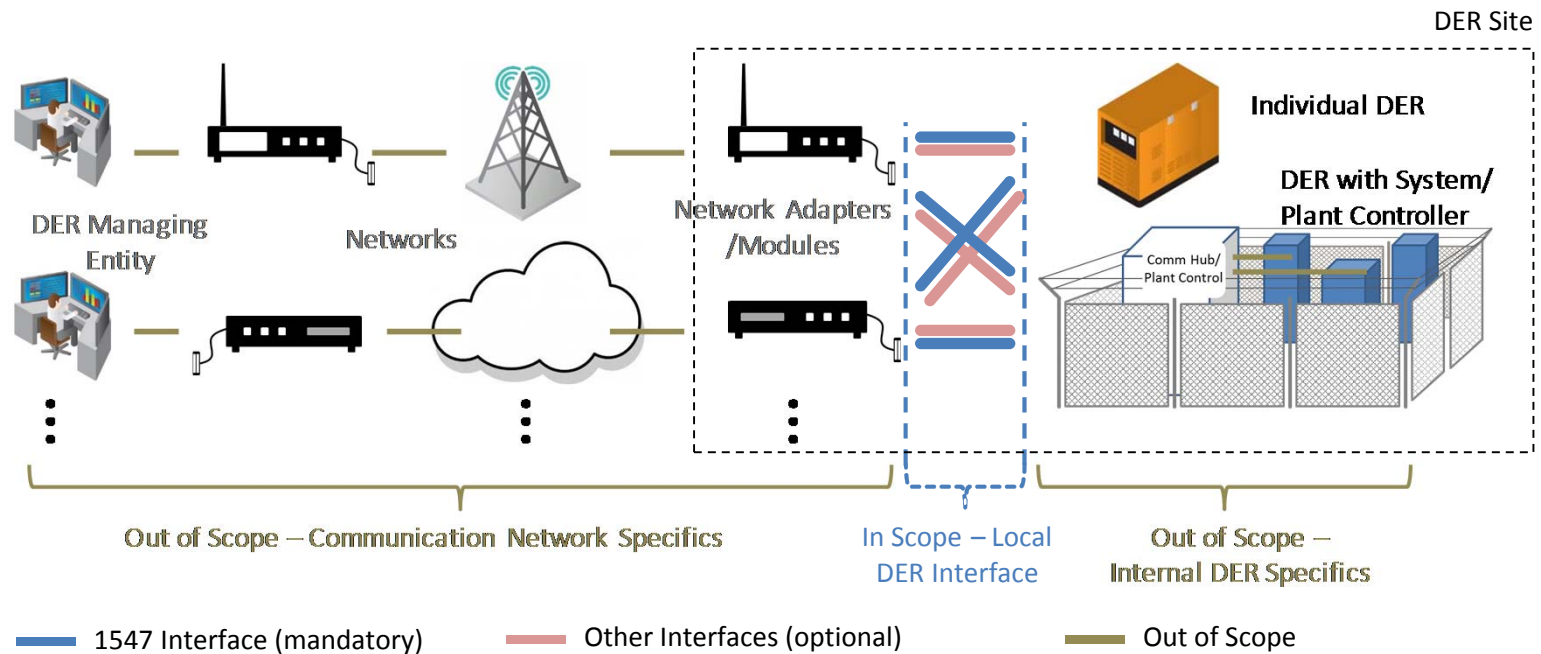


# Reference Point of Applicability (RPA)



- RPA is where performance requirements apply
- IEEE 1547 specifies RPA depending on three criteria:
  - Aggregate DER rating
  - Average load demand
  - Zero sequence continuity
- Generally:
  - PoC (DER terminals) for small and load-immersed DER
  - PCC for large exporting installations

# Mandatory Communication Interface



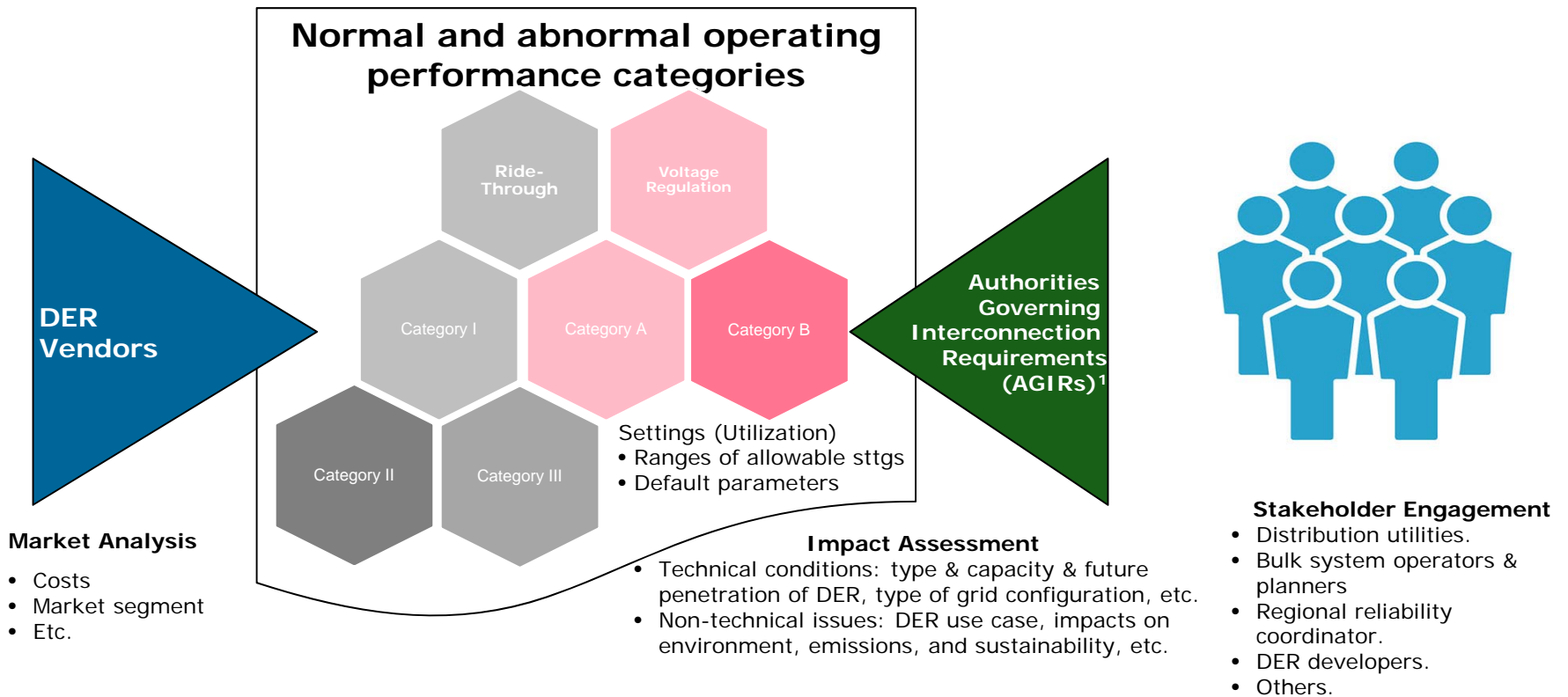
Requirements in IEEE Std 1547-2018 are limited to the "Local DER (Communication) Interface"

# Measurement and Control

- Telemetered Data
  - Nameplate Data – As-built characteristics of the DER, e.g.:
    - Manufacturer/model/Active and reactive power rating, etc.
  - Monitoring Information – Measured values of:
    - Active and reactive power, Voltage, etc.
- Operational Control / Management information
  - Change of *Permit Service* logical to disabled and shut down
  - Limit active power output
  - Change control modes and settings, e.g. Volt/Var, Trip, etc.

Interoperability capabilities allow Area EPS Operator a great level of DER control if communication infrastructure is implemented

# Assignment of Performance Categories



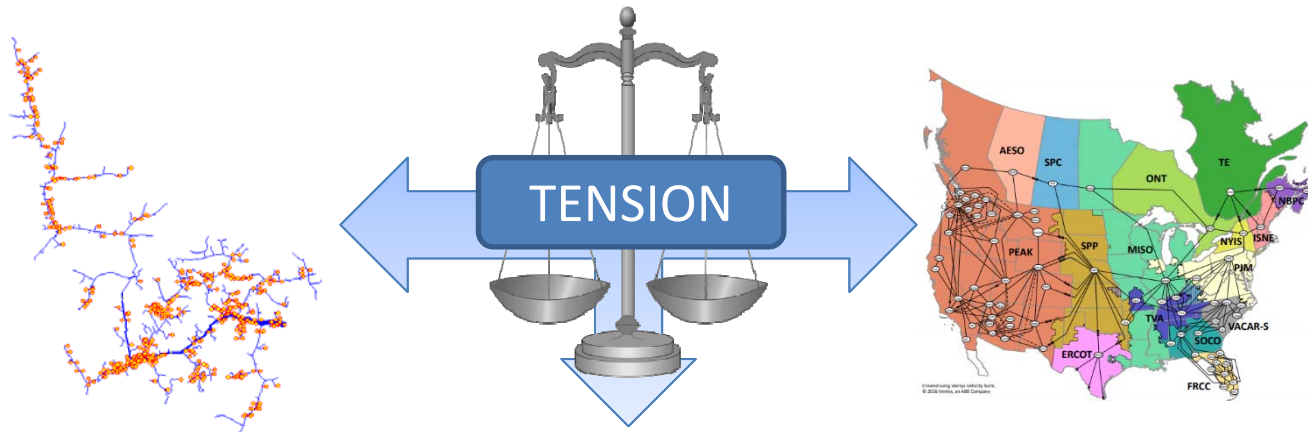
<sup>1</sup> State Regulator, Area EPS or bulk system operator, etc.

# Abnormal Performance Capability

Category	Objective	Foundation
I	Essential bulk system needs and reasonably achievable by all current state-of-art DER technologies	German grid code for synchronous generator DER
II	Full coordination with bulk power system needs	Based on NERC PRC-024, adjusted for distribution voltage differences (delayed voltage recovery)
III	Ride-through designed for distribution support as well as bulk system	Based on California Rule 21 and Hawaii Rule 14H

Category II and III are sufficient for bulk system reliability.

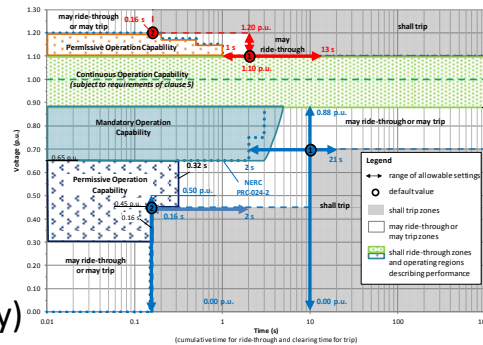
# Balancing Bulk & Distribution Grid Needs



## Distribution Grid Safety

- Short trip times
- Ride-through *with* momentary cessation
- Voltage rise concerns
- Protection coordination
- Islanding concerns (line worker safety)

➤ *Utility-owned equipment may defeat DER ride-through!*



## Bulk System Reliability

- Long trip times
- Ride-through *without* momentary cessation
- Reactive power support

➤ **T&D Coordination**

Source: EPRI

# Further Information

■ <http://sites.ieee.org/sagroups-scc21/standards/1547rev/>

- General
- Scope
- Purpose
- Leadership Team

– **Sources**

✓ **discounted copies**

- **SCC21-Reviewed Slide Decks Available for Interested Lecturers**

– **Further Reading**

– **Webinars**



■ **Please submit further reading suggestions via the web form!**

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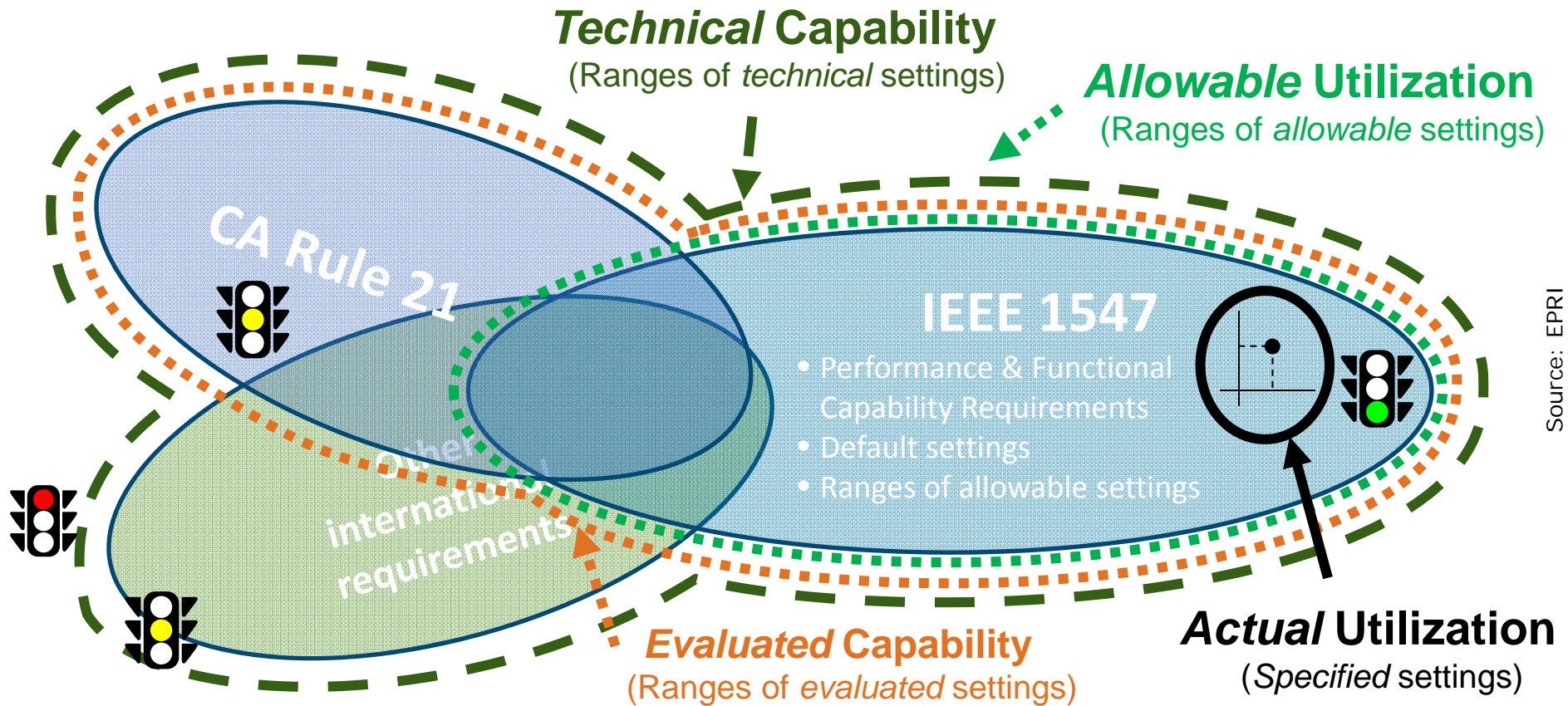


# Backup Slides

## List of eligible protocols

Protocol	Transport	Physical Layer
IEEE Std 2030.5™ (SEP2)	TCP/IP	Ethernet
IEEE Std 1815™ (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

# Capability (versus Utilization, determined by settings)



Source: EPRI

# Specific abnormal performance terminology

- ❑ **Trip** – cessation of output without immediate return to service; not necessarily disconnection
- ❑ **Cease to energize** – no active power delivery, limitations to reactive power exchange; Does not necessarily mean physical disconnection. Can be either a *momentary cessation* or a *trip*
- ❑ **Permissive operation** – DER may either continue operation or may cease to energize, at its discretion
- ❑ **Mandatory operation** – required active and reactive current exchange
- ❑ **Momentary cessation** – cessation of energization for the duration of a disturbance with rapid recovery when voltage or frequency return to defined range
- ❑ **Return to service** – re-entry of DER to service following a trip
- ❑ **Restore output** – DER recovery to normal output following a disturbance that does not cause a *trip*.

## Other ride-through requirements

- Consecutive voltage disturbances, e.g.:
  - Voltage dips caused by multiple unsuccessful reclosing attempts on another circuit
  - Dynamic voltage swings in and out of normal range following bulk system fault
  - Repetitive faults
- Rate-of-change of frequency (ROCOF)
  - Severe bulk grid dynamic events
- Phase angle jumps, e.g.:
  - Unbalanced faults
  - Bulk system switching events (generator trip, line switching, etc.)

# Frequency response

- Increasing penetration of unconventional generation is reducing system inertia which can degrade system frequency stability
- Frequency droop (governor-like) response required of all DER
  - Active power output is modulated in response to frequency deviation
  - No mandate to maintain headroom to increase active power to provide under-frequency response
- Frequency response parameters:
  - Default droop 0.05 p.u. frequency for one p.u. active power change
  - Default deadband  $\pm 36$  mHz
  - Other parameter settings allowed as approved by the regional reliability coordinator

# Area of Concern beyond IEEE 1547

## Utility-Owned recloser at DER connection point may terminate ride-through!

IEEE 1547 General remarks and limitations (per clause 1.4): *“The ... ranges of allowable settings for voltage and frequency trip settings specified in this standard for DER are **not** intended to limit the capabilities and **settings of other equipment on the Area EPS.**”*

### IEEE Std 1547-2018 recommends:

- Area EPS protections conform to the voltage and frequency ride-through objectives of IEEE 1547 under normal circumstances (footnotes 80 and 99)
- Settings outside the allowable range only to be used occasionally and selectively to accommodate worker safety or to protect distribution infrastructure while in an abnormal configuration, such as:
  - Circuit reconfiguration
  - Temporary loss of direct transfer trip
- **Coordinate special settings with regional reliability coordinator**

# New SCC21 Website

- <http://sites.ieee.org/sagroups-scc21/>

IEEE.org | IEEE Xplore Digital Library | IEEE Standards | IEEE Spectrum | More Sites

## IEEE Standards Coordinating Committee 21 (SCC21)

Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

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### Home

#### SCC 21 Overview and Scope

The IEEE Standards Coordinating Committee 21 oversees the development of standards in the areas of fuel cells, photovoltaics, dispersed generation, and energy storage.

- Coordinates efforts in these fields among the various IEEE societies and other affected organizations
- Ensure that all standards are consistent and properly reflect the views of all applicable disciplines
- Reviews all proposed IEEE standards in these fields before their submission to the IEEE-SA Board for approval and coordinates submission to other organizations



# Discounted Distribution of SCC21-Sponsored Standards to Qualifying Parties

- <http://sites.ieee.org/sagroups-scc21/standards/discountedcopies/>
  
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  - Others at discretion of SCC21 Officers and P1547 Chair (1 copy per person or entity)
  
- Criteria for discretionary copies
  - Interested party has **hardship** acquiring a commercial copy of a SCC21-sponsored standard.
  - There is a **public benefit** associated with giving the interested party access to a discounted copy of the standard.
  
- Use the web form to request a discounted copy of a standard!

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- <http://sites.ieee.org/sagroups-scc21/resources/standardspresentations/>
  
- “Give and taken” approach:
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  - Requesting party edits slides as they see fit
  - SCC21 Officers review the updated slides
  - Requesting party sends final slide deck and feedback received
  
- Intellectual Property
  - SCC21 has executed a license agreement with IEEE
  - Need to specify copyrights on the slide decks produced
  - The parties maintain the ownership of their respective materials
  
- Professional Development Hours (PDH) Form is available
  - need to check whether these are accredited or not
  
- Use the web form to request a SCC21-reviwed slide deck!