Comparison and Application of IEEE 1547, CA Rule 21 and Hawai'ian DG Interconnection Requirements

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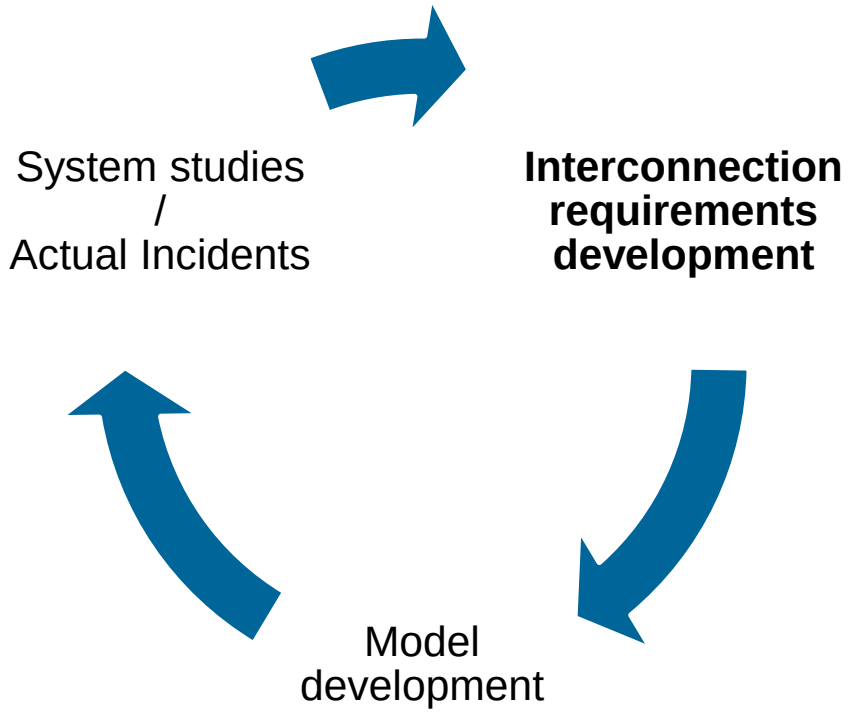
The Race between DER Deployment and Updates to Interconnection Requirements

- Lessons learned from **Germany** and other regions around the world:
  - DER deployment may happen very quickly
    - *Previous solutions may not hold in the future*
  - You cannot plan for everything
    - *Built in capabilities prior to their utilization*
  - Expect mistakes and make the system flexible
    - *Require communication capability*



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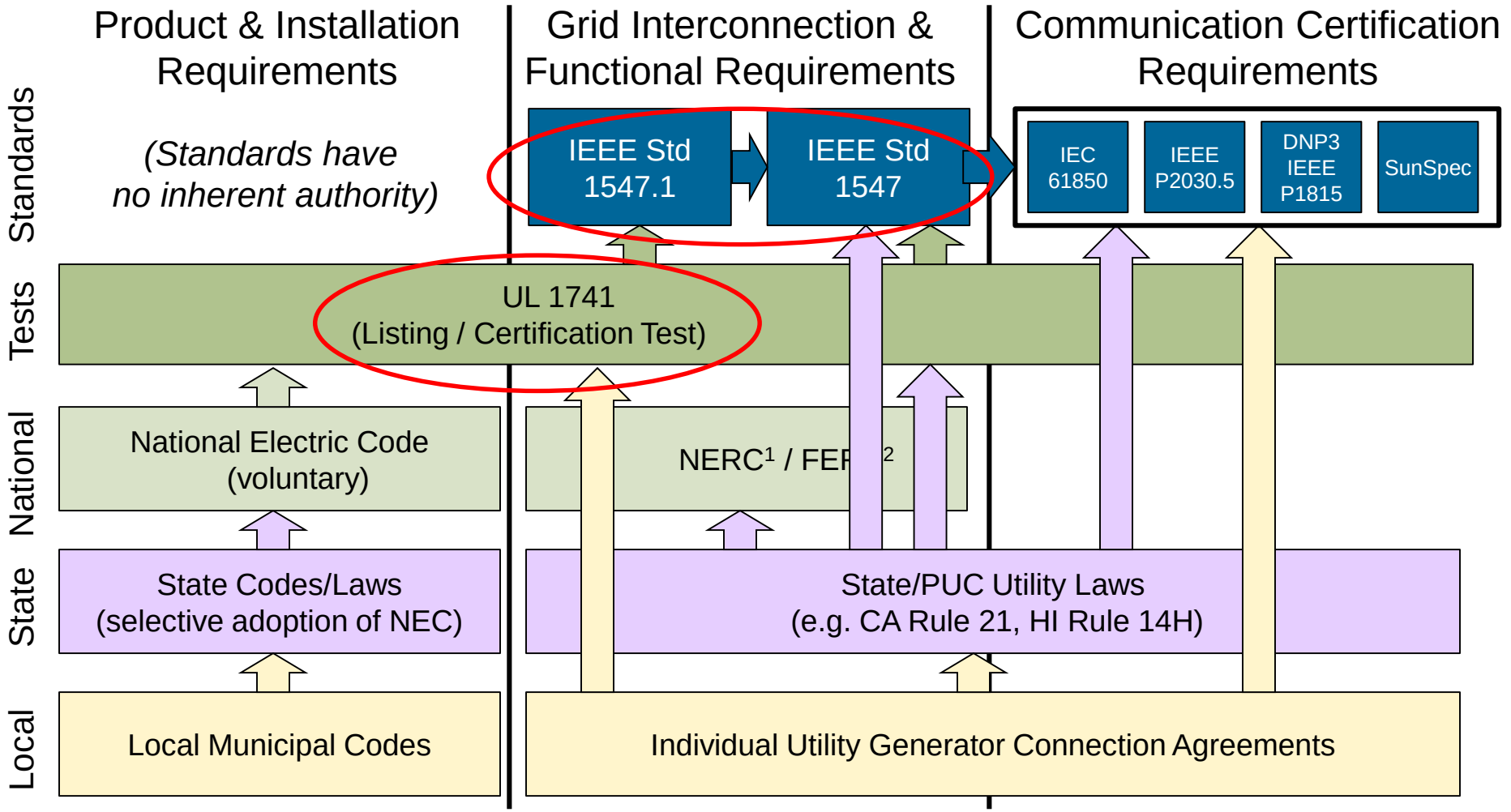
Overview on North American Standards Developments



[1] e.g., NERC PRC-024-02,
[2] e.g., FERC Order No. 828

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Timeline of P1547

March 2014:	P1547 Program Authorization Request (PAR) approved
November 2014:	Working group meeting, coalesce filtered subset of topics into six subgroups for action
February 2017:	Working group meeting, draft revision content stable, vote, and final refinements before balloting
May–Dec 2017:	IEEE-SA public balloting
January 2018:	RevCom made recommendation for the approval the draft standard
February 2018:	IEEE SASB Standards Board approved the draft standard.
April 2018:	**Publication of revised standard**
…	
2018-2019:	***Early adoption of parts of IEEE Std 1547-2018***
End of 2018:	Revision of IEEE P1547.1
2020+:	Fully-certified DER equipment compliant with new 1547 available.
…:	Full adoption of IEEE Stds 1547-2018 and 1547.1-20xx

Latest timeline: http://grouper.ieee.org/groups/scc21/1547_revision/docs/1547-Revision-Milestone-Schedule.pdf

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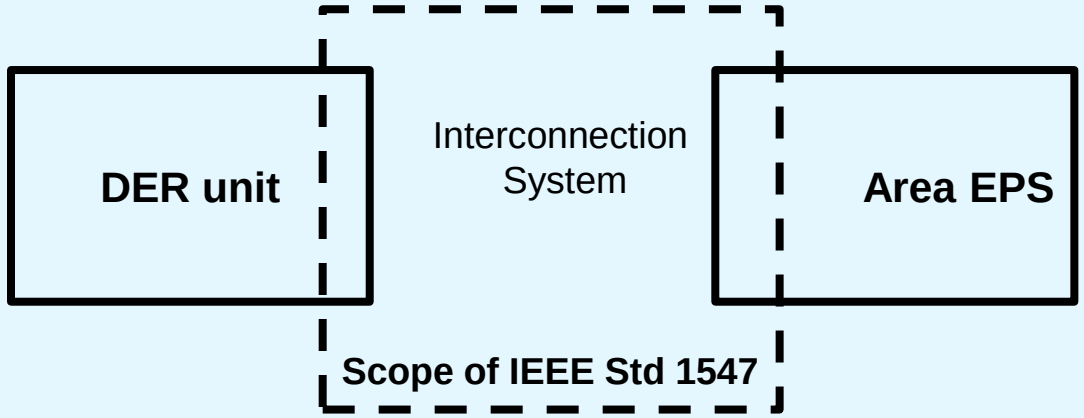
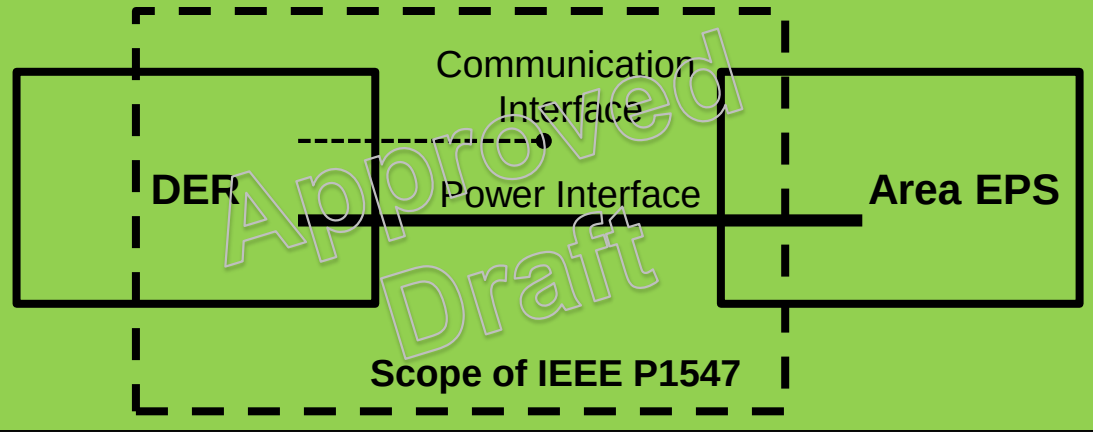
Important changes between IEEE Std 1547 (2003) and (2018)



IEEE Std 1547-2003

- Focused on distribution system aspects.
- Specifications for the “interconnection system” sufficiently achieve the standard’s objective.
- Meant as DER interconnection standard but mainly used for equipment listing.
- Limited to electrical requirements.



IEEE Std 1547-2018

- Focused on distribution and bulk system aspects.
- Specifications encompass the whole DER.
- Can be used for equipment listing as well as plant-level verification.
- Includes both electrical as well as interoperability/communications requirements.

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Comparison of IEEE Interconnection Standards, State/PUC Rules, and Listing/ Certification Standards

		Interconnection Standards			State/ PUC Rules		Listing/ Certification		
Function set	Advanced Functions Capability	IEEE 1547-2003	IEEE 1547a-2014	IEEE 1547 - 2018*	CA Rule 21 - 2015	HI Rule 14H - 2015	UL 1741	UL 1741(SA) 2016	IEEE 1547.1-201?*
Static	Adjustable Trip Settings		√	‡					Δ
Controlling	Active Power Curtailment			‡					Δ
	Disable Permit Service (Remote Shut-Off)			‡					Δ
	Ramp Rate Control				‡	‡		Δ	
Freq. Support	L/H Frequency Ride-Through			‡	‡	‡		Δ	Δ
	ROCOF Ride-Through			‡					Δ
	Frequency-Watt	X	√	‡		‡		Δ	Δ
Voltage Support	L/H Voltage Ride-Through (L/H VRT)			‡	‡	‡		Δ	Δ
	Dynamic Voltage Support during L/H VRT			√					
	Voltage Phase Angle Jump Ride-Through			‡					Δ
	Fixed Power Factor	√	√	‡	‡	‡	√	Δ	Δ
	Fixed Reactive Power	√	√	‡			√		Δ
	Volt-Var	X	√	‡	‡	‡		Δ	Δ
	Volt-Watt	X	√	‡		‡		Δ	Δ
	Watt-Var	X		‡					Δ

** Final requirements not confirmed.*

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined

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IEEE Std 1547-2018: 1.4 General remarks and limitations

- Applicable to all DERs connected at typical primary or secondary distribution voltage levels.
  - Removed the 10 MVA limit from previous versions.
  - **BUT: Not applicable for transmission or networked sub-transmission connected resources ➔ Gap, since NERC standards only apply to BES !!!**

- Specifies performance and not design of DER.

- Specifies capabilities and functions and not utilization of these.
  - While capabilities can be regarded as state of the art at no additional costs, utilization may impact both DER owners (active/reactive control) and utilities (ride through)

- Does not address planning, designing, operating, or maintaining the utility grid ("Area EPS") with DER.
  - **May be addressed in DER interconnection practices, incl. screening.**

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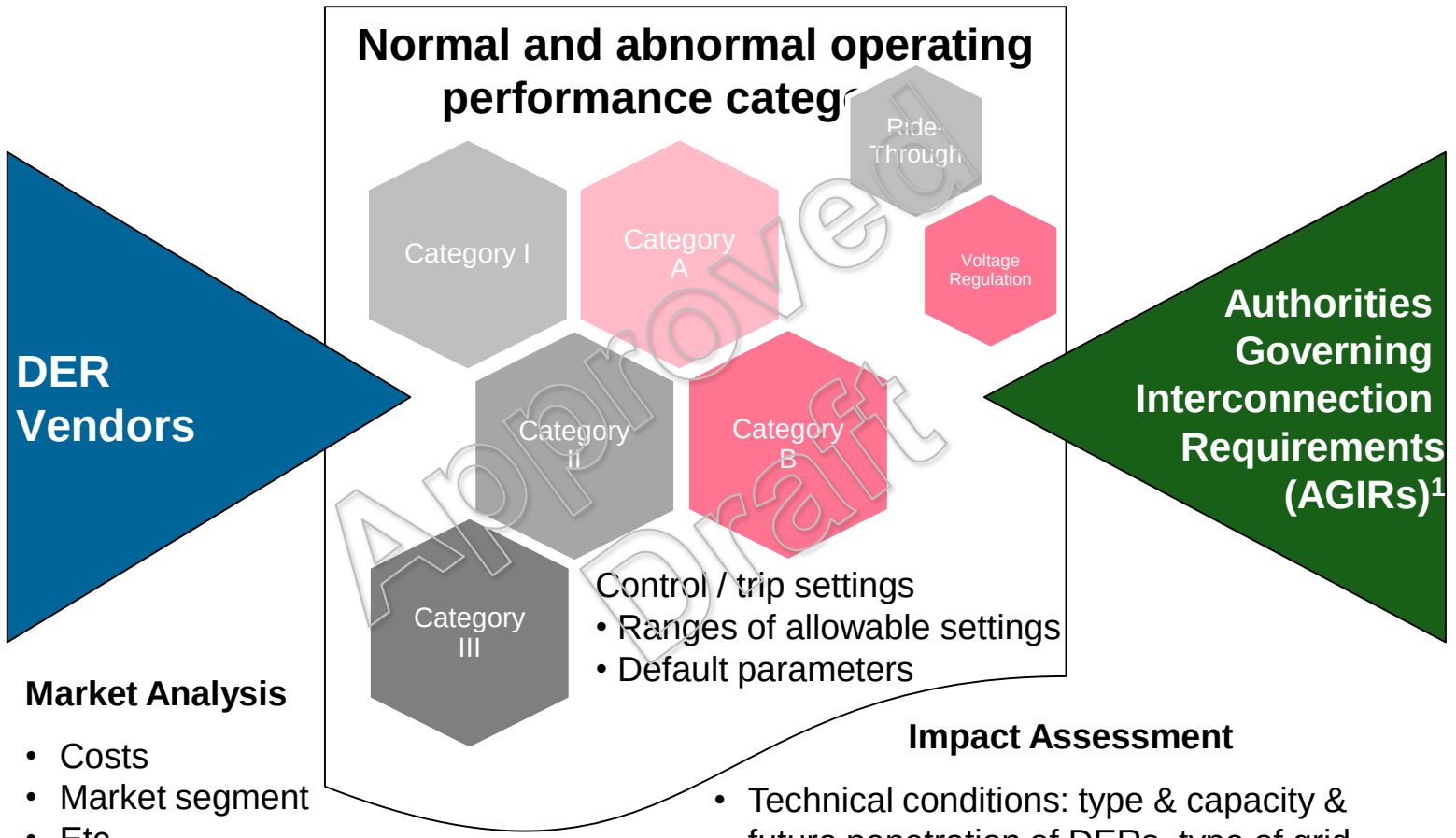
IEEE Std 1547-2018 Performance Categories



Market Analysis

- Costs
- Market segment
- Etc.

Impact Assessment

- Technical conditions: type & capacity & future penetration of DERs, type of grid configuration, etc.
- Non-technical issues: DER use case, impacts on environment, emissions, and sustainability, etc.

Stakeholder Engagement

- Area EPS Operators/ Distribution utilities
- Regional reliability coordinator
- DER Operators/ developers
- DER vendors
- Consumers

1 State Regulator, Area EPS or bulk system operator, etc.

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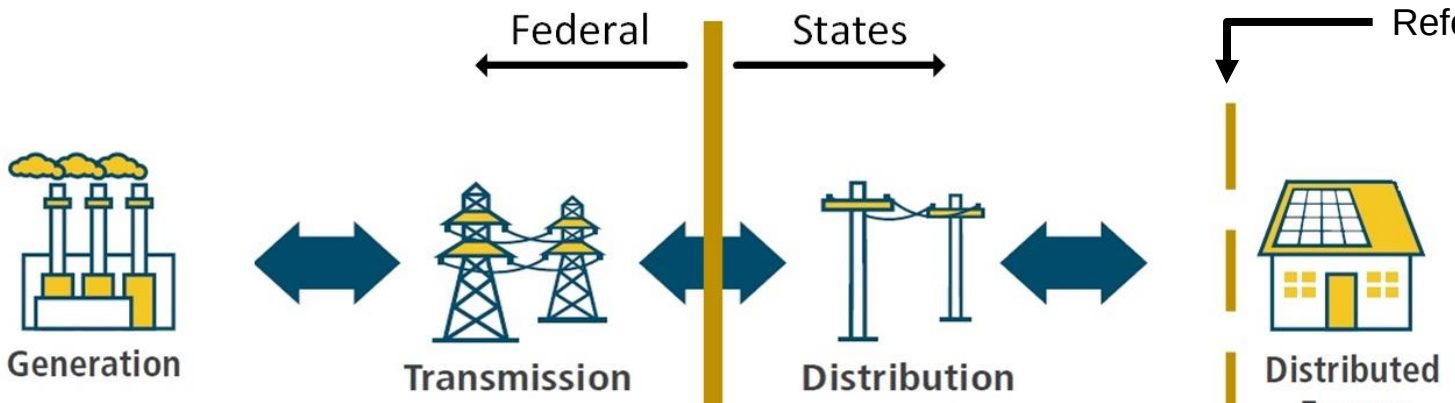
Important terminology and potential new responsibilities



- Federal Energy Regulatory Commission (FERC)
- North American Electric Reliability Corporation (NERC)
- Regional Reliability Coordinator, e.g.:
  - — NERC Reliability Coordinator
  - — NERC Balancing Authority (RTO/ISO)

- Area EPS Operator (distribution utility)
- Authority Governing Inter-connection Requirements (AGIR) (e.g., state regulator)

- Consumer / DER Developer
- DER Operator / Local EPS Operator
- 3rd party test & evaluation entities
- Authority Having Jurisdiction (AHJ) (e.g., local inspectors)

- FERC: Orders regarding Small Generating Facilities
  - — Order No. 827 (reactive power)
  - — Order No. 828 (ride-through) ➔ Transmission Providers to specify "Good Utility Practice" for SGIA
- NERC: Issues reliability guidelines for BPS-connected resources
- Regional Reliability Coordinator:
  - — May recommend technology-specific assignment of abnormal DER performance categories (ride-through)
  - — May recommend technology-specific "preferred" voltage and frequency trip settings

- Area EPS Operator:
  - — May recommend technology-specific assignment of normal DER performance categories (reactive power requirements)
  - — May specify functional settings, e.g., volt/var curve
  - — May recommend / specifies technology-specific "preferred" and "custom" voltage and frequency trip settings
  - — Performs DER interconnection screening
- AGIR:
  - — May assign technology-specific DER performance categories
  - — May specify method for trip settings other than "preferred"
  - — May decide about certification for larger scale DER facilities

- 3rd party test & evaluation entity
  - — Type testing (e.g., by NRTL)
  - — DER evaluation (e.g., by consultant)
  - — Certification, if required
- Authority Having Jurisdiction
  - — Inspects and approves the design and construction of Local EPS

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Application of revised IEEE P1547

What are “ranges of allowable settings”?

- **Definition:** The range within which settings may be adjusted to values other than the specified default settings.
- Used for functional specifications, not for capabilities.
- Default values specify generic settings *that do not harm*.
  - May not be most effective.

Used throughout the standard

- Voltage regulation by
  - 5.3 Voltage and reactive power control
  - 5.4 Voltage and active power control
- Voltage and frequency trip
  - 6.4.1 Mandatory voltage tripping
  - 6.5.1 Mandatory frequency tripping
- Momentary cessation threshold during ride-through (6.4.2.7.3)
- Frequency regulation by
  - 6.5.2.7 Frequency-droop (frequency-power)

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Application of revised IEEE Std 1547

Moving forward…

- Need for a stopgap solution for equipment certification while IEEE P1547.1 is not yet revised.
  - Parts of IEEE Std 1547-2018 with UL 1741 SA-certified “grid support utility interactive” inverters
- Need for education / knowledge transfer prior to opening formal proceedings, targeting
  - distribution and transmission owners.
  - state regulators et al.
- Development of leading practices to apply IEEE Std 1547-2018
  - ISO NE / MA TSRG / EPRI
  - PJM / EPRI
  - MN PUC and others?
  - ➢ IEEE P1547.2 Application Guide for IEEE Std 1547

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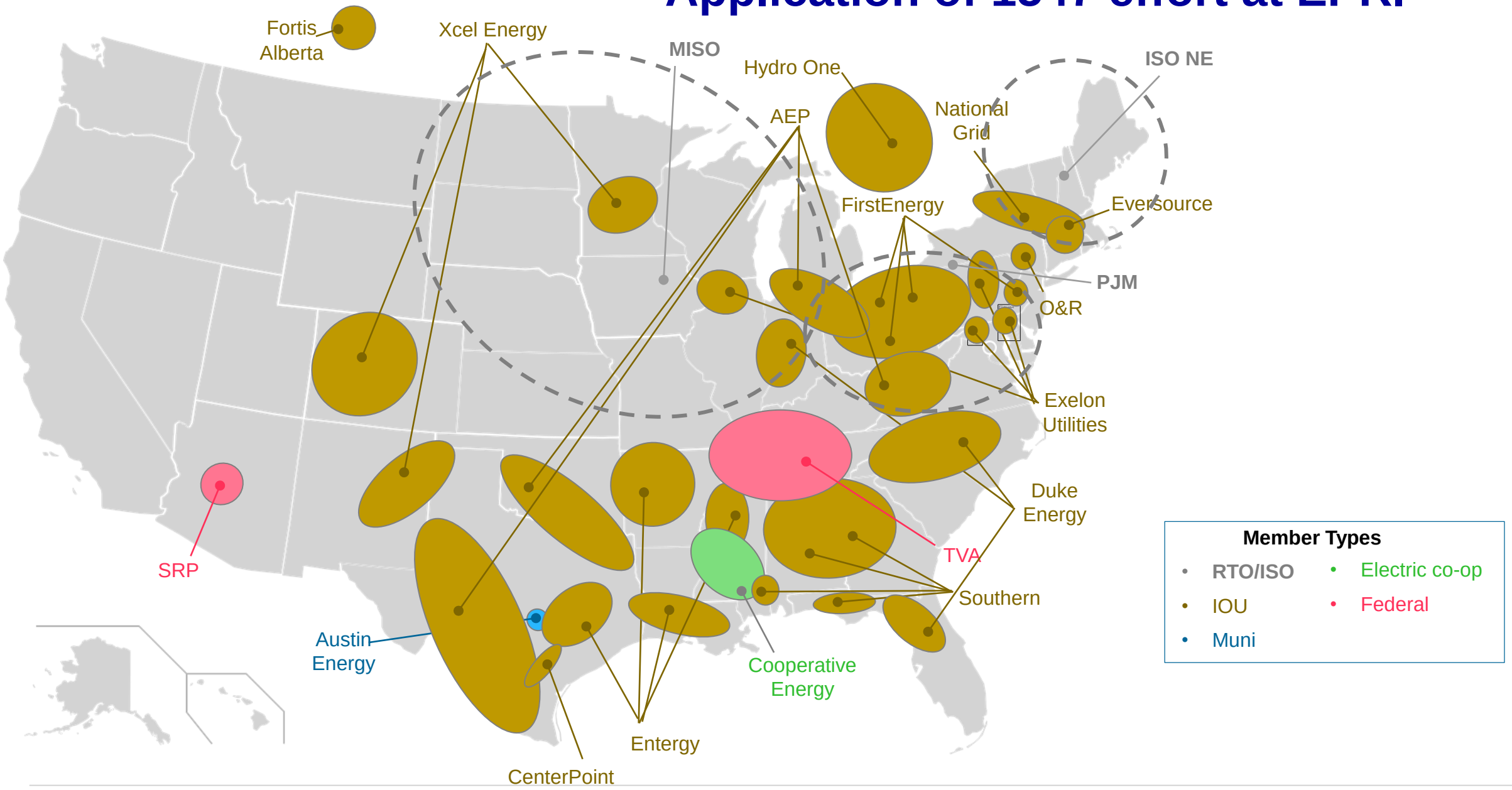
Application of 1547 effort at EPRI



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Comparison of leading practices to apply IEEE Std 1547-2018

ISO NE / MA TSRG / EPRI

- ISO NE desired for interim solution prior to publication of 1547-2018.
  - Developed a 3-step implementation schedule.
- Over 60% of solar PV in New England is/will be installed in Massachusetts.
- The Massachusetts Technical Standards Review Group (TSRG) is an existing group tasked by the state regulator with addressing distribution interconnection issues.

- **Approach:** worked with MA TSRG without need for additional regulatory proceedings in MA
  1. Started discussions with MA TSRG in early 2017
  2. Completed ISO NE Source Requirement Document (SRD) in February 2018
  3. Future: Work with utilities, regulators, munis, and co-ops in each state to implement the ISO-NE SRD

PJM / EPRI

- PJM recognizes that 1547-2018 establishes an explicit role for entities like PJM.
- Most DER is under local jurisdiction, and PJM has very limited authority.
- PJM desires for new requirements in 1-2 yrs

- **Approach:** create technical consensus prior to entering regulatory proceeding
  1. Preliminary technical trial workshop (Feb 28)
  2. Regular phone calls
  3. Workshop with all PJM members (T and D)
  4. Ongoing collaboration
  5. 2019: Final Documentation of Consensus Ride Through and Trip Parameters
  6. 2019+: PJM Rules + Distribution utility discussions under local regulation

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Lessons learned (so far) from leading adoption activities

ISO NE / MA TSRG / EPRI

1. Certification with UL 1741 (SA) offers a practical stopgap solution until IEEE 1547.1 will be updated.
   - ➢ Need to develop a “source requirements document” (SRD) as basis for UL certification.
2. A SRD that diverges from IEEE Std 1547-2018 triggers lengthy discussions with stakeholders
   - ➢ Changed draft SRD to be consistent with new 1547 half-way through the process.
3. DER manufacturers desire for a single set of functional parameters in a standardized form
   - – e.g., voltage and frequency trip
   - – can be implemented via inverter software profiles

PJM / EPRI

1. Regulatory references to IEEE Std 1547 differ between states and may determine adoption approach
   - – Some refer implicitly without specific reference to version and publication date.
   - – Others refer explicitly to a specific version and publication date. Choosing trip settings within IEEE 1547**a** ranges may eliminate the need to revise state regulations.
2. Consensus on single set of “preferred” ride through and trip parameters requires involvement of T and D planning engineers.
3. Creation of a technical consensus among key stakeholders prior to entering regulatory proceeding is very effective.

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Conclusions

- IEEE P1547 will help standardize “smart DERs” and accelerate state of the art. It can provide **high value** to the power industry.

- IEEE P1547 Working Group aspired to specify **safe, reliable,** and **cost-effective** new interconnection and interoperability **requirements** for DERs.

- Specification of **test and verification** requirements is under way in P1547.1.
  - Interim solution for inverter certification via UL1741-SA
  - ➢ *Interested utilities can be supported by EPRI in applying new standards.*

- IEEE P1547 and P1547.1 will provide a widely-accepted **technical basis for regulatory proceedings** that can be **flexibly** adjusted to regional differences.
  - ➢ *Action required from state regulators, et al. !!!*

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Together…Shaping the Future of Electricity

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Why IEEE Std 1547-2018?

- Defines and standardizes "**smart DERs**" across the industry.

- Attempts to specify **safe, reliable,** and **cost-effective** new interconnection and interoperability **requirements** for DERs.

- Provides a widely-accepted **technical basis** for update of **utility interconnection agreements** and related **regulatory proceedings** that can be **flexibly** adjusted to regional differences.

➢ Value provided:

- ✓ avoid lengthy discussions with various stakeholders;
- ✓ avoid necessity to specify technical requirements;
- ✓ account for regional differences;
- ✓ accelerate regulatory proceedings;
- ✓ mitigate technical risks.

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Difference between Capability & Utilization/Provision

- Capabilities and functions which utilization/provision may **impact DER owners**:
  - Reactive power exchange
  - Active power curtailment
  - Head-room to provide frequency response

- Capabilities and functions which utilization/provision may **impact distribution utilities**:
  - Voltage Ride-Through with extended voltage trip settings
  - Frequency Ride-Through with extended frequency trip settings

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