IEEE PES Energy Development and Power Generation Committee

Joint Meeting of the Wind and Solar Power Plant Interconnection and Design Subcommittee and Plant Interconnection Working Group

Chairman: Tom Key
Vice Chair: Jens Boemer
Secretary: Nath Venkit

Subcommittee Website:
http://sites.ieee.org/pes-edpgcom-wsppidsc/

Date: **Wednesday July 19, 2023**
Time: **1:00 – 3:00pm EDT**
Location: IEEE PES 2023 Orlando General Meeting

Today's Agenda

1. Welcome and Introductions
   - Review and approval of minutes from July 2022
2. Power Plant Design WG Report (IEEE 2760, 2778, WG plans)
3. Plant Interconnection WG Report—Distribution-Connected Resources (IEEE 1547, .2, .3, .9, .10, Open DER Model)

5-min BREAK

4. Plant Interconnection WG Report—Bulk System-Connected Resources (2800, P2800.2, NERC IBR Standards, GPS-T)
5. Coordination Report (P2882, RSICC, T&D DRI-WG, P1729)
6. Old Business (panels and papers at this 2023 Orlando GM)
7. Future Meeting and Session Plans (2024 tutorials, panels, papers)
8. Review Action items
9. Adjourn

Approval of minutes from July 2022

- Virtual meeting held July 2022 (minutes attached to invite).
- Any corrections or additions? Speak up or put in chat.
- Motion to approve and a second.
- Assumed to be affirmative unless:
  - voice corrections or additions?
  - chat corrections or additions?

2. Power Plant Design WG Report —Chair Loren Powers, Doug Price covering – 10 min

- Update on WG activities
- Task Force on Wind and Solar Plant Grounding Activities
  - IEEE 2760-2020 IEEE Guide for **Wind** Power Plant Grounding System Design for Personnel Safety
  - IEEE 2778-2020 IEEE Guide for **Solar** Power Plant Grounding for Personnel Protection
- Attendance of WG meeting(s) earlier this week
- Hot Topics on Design
- Looking ahead, other WG Activities/Plans 2024

3. Wind and Solar Plant Interconnection WG – Nath Venkit for Jens Boemer

- ***Distribution-Connected*** Inverter Based Resources (DER)
  - 1547 revision plans (scope/timeline/sponsors) – Mamadou Diong (Dominion), via WebEx – 10 min
  - P1547.2 Application Guide, Wayne Stec via WebEx - 5 min
  - P1547.3 Cyber – Janette Sandberg, PGE, Wayne Stec to cover – 5 min
  - 1547.10: Utility Infrastructure DER Gateway (1547.10) – Daniel Freeman (Schneider Electric) via Webex - 10 min
  - Topical Presentation on Interconnection, Open DER Model, Yiwei Ma (EPRI) – 10 min

P1547 Revision Update

Mamadou Diong, P1547 WG Chair

10 min

IEEE P1547 REVISION - PAR

Scope

This standard establishes criteria and requirements for interconnection of distributed energy resources (DER) with electric power systems (EPS) and associated interfaces. The standard includes general interconnection technical specifications and performance requirements , reactive power capability and voltage/power control requirements, response to Area EPS abnormal conditions, power quality, islanding, DER on distribution secondary grid/area/street (grid) networks and spot networks, interoperability, information exchange, information models and protocols, test and verification requirements .This revision incorporates updates from previous errata, one previous amendment and also includes updates to requirements based on industry feedback.

Purpose

Stakeholders include electric power system owners, planners, designers , and operators; electricity consumer; equipment manufacturers; system integrators; distributed energy resource personnel; energy efficiency and demand response personnel; regulatory and government bodies ; electric utilities (transmission & distribution), independent system operators, regional transmission organizations, and bulk power system operators and planners.

IEEE P1547 REVISION – PAR (CONTINUED)

Need for the Project	This revision is needed to consolidate previous errata, amendment and incorporate lessons learned from adoption to date .The revision will include consideration of update and improvement of all clauses and annexes including normative references and definitions.
Stakeholders for the standard	Stakeholders include electric power system owners, planners, designers , and operators; electricity consumer; equipment manufacturers; system integrators; distributed energy resource personnel; energy efficiency and demand response personnel; regulatory and government bodies ; electric utilities (transmission & distribution), independent system operators, regional transmission organizations, and bulk power system operators and planners.

IEEE P1547 – REVISION TO IEEE STD. 1547-2018

Initial Focus of this Revision towards IEEE 1547-2025

- Integrate 2020 amendment
- Fixes from 1547 adoption
- Fixes from UL 1741 SB revisions
- Promote selected P1547.9 guidance to requirements
- Fixes for V2G commissioning procedures (as it pertains to the base 1547 standard and not 1547.1)
- Promote selected P1547.3 guidance to requirements
- Add recommended DER settings file format based on EPRI working group recommendations
- Remove barriers for GFM identified by UNIFI et al.

DER EXISTING AND NEW DEFINITIONS - OVERVIEW

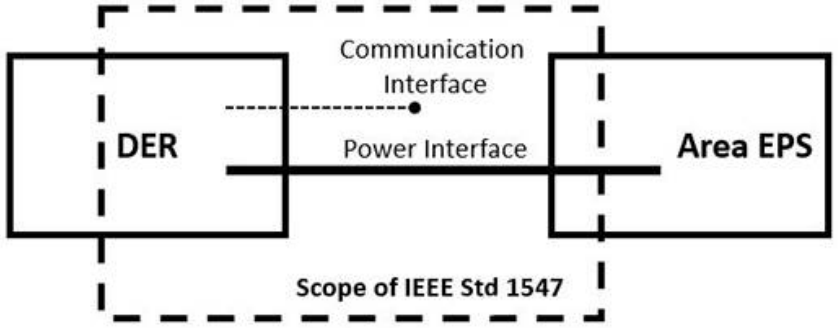
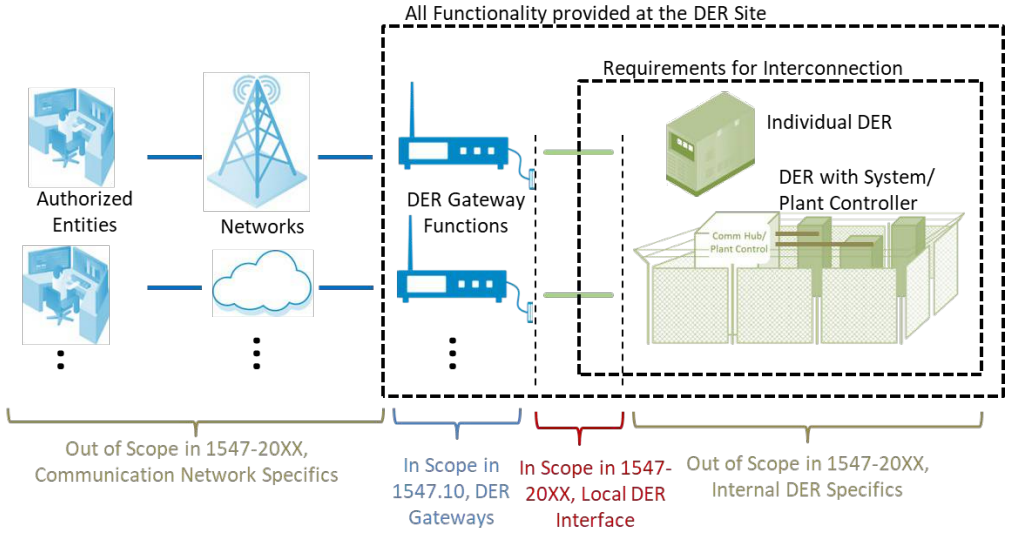


Figure 1—Scope of this standard



P1547.10 Figure—
Potential scopes of IEEE 1547-2018 and P1547.10

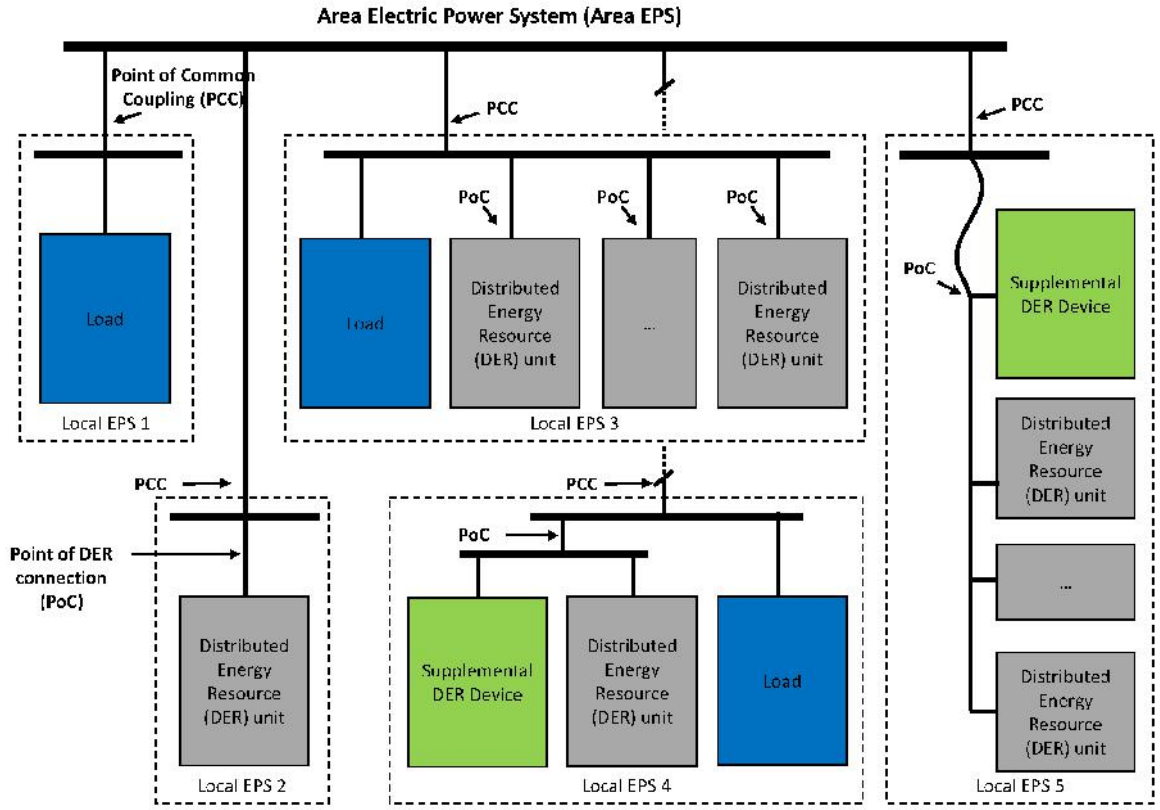


Figure 2—Relationship of interconnection terms

GRID FORMING OBSTACLES—UNIFI PRESENTATION AT P1547 WG MEETING (VIRTUAL), JULY 10-11, 2023

✓Brief overview about UNIFI consortium and overall scope
- focus on grid-connected GFM technology in P1547
- clarify that islanded GFM will be addressed in the recently approved P1547.4 (Mike Ropp)

✓Detailed review of UNIFI scope related to
1) identification of potential barriers in 1547
2) identification of potential gaps in 1547
3) Identification of potential issues from GFM

✓Presentation of one finding (to date) for 1) identification of potential barriers in 1547

✓ Outlook with mentioning of IEEE 2800-2022 requirements that may address some of the gaps identified in 2)

➢Next steps:
1. coordination with and future contributions to responsible Subgroups (SG2, SG3, SG5, others?);
2. goal to present a summary and redlines addressing barriers identified in 1) at the October WG meeting

SUBGROUP STRUCTURE AND MAILING LISTS

P1547 REV Working Group	Mamadou Diong (Chair) Christopher Lee (Secretary)	Jens Boemer (SC21 Stds Coordinator)	P1547REVWG@LISTSERV.IEEE.ORG	**Click here to sign up for the P1547rev listserver**

P1547 REV Subgroup	Overseeing WG Officers / SG Leads	Subgroup Facilitator(s)	Subgroup Mailing List (ListServ)	Sign-Up Link
#1 – Overall Document	Mamadou Diong Christopher Lee (Alternate)	Jens Boemer Daniel Freeman	STDS-P1547REVWG-SG1@LISTSERV.IEEE.ORG	**Click here to sign up for SG1 listserver**
#2 – Normal conditions, voltage regulation	Aminul Huque Chris Lee (Alternate)	Peter Evans Fares Al Jajeh	STDS-P1547REVWG-SG2@LISTSERV.IEEE.ORG	**Click here to sign up for SG2 listserver**
#3 - Abnormal conditions, ride through	Chris Lee Mike Ropp (Alternate)	Sean Carr Mark Smith	STDS-P1547REVWG-SG3@LISTSERV.IEEE.ORG	**Click here to sign up for SG3 listserver**

SUBGROUP STRUCTURE AND MAILING LISTS

P1547 REV Subgroup	Overseeing WG Officers / SG Leads	Subgroup Facilitator(s)	Subgroup Mailing List (ListServ)	Sign-Up Link
#4 – Interoperability & Cybersecurity	Janette Sandberg Ben Ealey (Alternate)	Ben Ealey Kevin Whitener Danish Salem	STDS-P1547REVWG-SG4@LISTSERV.IEEE.ORG	**Click here to sign up for SG4 listserver**
#5 - Special Interconnections ***#5.1 Islanding (incl. intentional)?*** ***#5.2 Secondary Networks*** ***#5.2 Storage*** ***#5.3 Vehicle to Grid ?***	Michael Ropp Alternate Needed	Peter Evans Daniel Mungovan John Berdner	STDS-P1547REVWG-SG5@LISTSERV.IEEE.ORG	**Click here to sign up for SG5 listserver**

SUBGROUP STRUCTURE AND MAILING LISTS

P1547 REV Subgroup	Overseeing WG Officers / SG Leads	Subgroup Facilitator(s)	Volunteers / Contributors	Sign-Up Link
#6 – Modeling & simulation - Assigned its lead items - Completed its prioritization but given the new nature of content this is somewhat different - Has its own spreadsheet - Did not submit redlines yet	Aminul Huque Michael Ropp / Jeannie Piekarz (Alternate)	John Berdner Yiwei Ma	STDS-P1547REVWG-SG6@LISTSERV.IEEE.ORG	**Click here to sign up for SG6 listserver**
#7 – Test Specifications & Requirements	Andy Hoke (Vice-Chair) Aminul Huque (Vice-Chair)	Shazreen Meor Danial Fares Al Jajeh	STDS-P1547REVWG-SG7@LISTSERV.IEEE.ORG	**Click here to sign up for SG7 listserver**

SUBGROUP STRUCTURE AND MAILING LISTS

P1547 REV Subgroup	Overseeing WG Officers / SG Leads	Subgroup Facilitator(s)	Subgroup Mailing List (ListServ)	Sign-Up Link
#8:Power Quality	Dan Sabin Dave Mueller (Alternate)	Dave Mueller Aaron Anaya	STDS-P1547REVWG-SG8@LISTSERV.IEEE.ORG	**Click here to sign up for SG8 listserver**

Appendices	Responsible Subgroups
#9.1 Bibliography	SG1 - Overall Document
#9.2 DER Performance category assignment	SG1 - Overall Document
#9.3 Intentional Islands	SG5 - Special Interconnections
#9.4 Communications/information	SG4 - Interoperability + cybersecurity?
#9.5 Ridethrough	SG3 - General Reqs - abnormal conditions
#9.6 Testing and Verifications	SG7 - Test Specifications & Requirements
#9.7 Power Quality	SG8 - Power Quality
#9.8 Illustrative Figures (Clause 4-6)	SG3 - General Reqs - abnormal conditions
#9.9 International practices 50 Hz System	SG1 – Overall Document

TASK FORCES AND MAILING LIST

P1547 REV WG MAILING LIST AT P1547REVWG@LISTSERV.IEEE.ORG

P1547 REV Task Force	Overseeing WG Officers / TF Leads	Task Force Facilitator(s)	Subgroup Mailing List (ListServ)	Sign-Up Link
TF-1 - Rotating Machines	Michael Ropp Alternate Volunteer Folder lead Needed	Marcelo Algrain Alternate Facilitator Needed	STDS-P1547REVWG-TF1@LISTSERV.IEEE.ORG	**Click here to sign up for TF1 listserver**
TF-2 – Electric Vehicles to Grid	Michael Ropp Alternate Volunteer Folder lead Needed	Peter Evans John Berdner	STDS-P1547REVWG-TF1@LISTSERV.IEEE.ORG	**Click here to sign up for TF2 listserver**

IEEE P1547/.X WORKING GROUPS
PLANNING OF FUTURE MEETINGS

Proposal for full WG meetings in 2023 following April Meeting:

3rd Full WG meeting in in Wilsonville, OR – Fall 2023

- To be hosted by PGE – Kevin Whitener (Point of Contact)
- Dates: Oct 2-5, 2023 – Confirmed
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a)

Proposal for full WG meetings in 2024:

1st Full WG meeting – Hybrid / FULLY VIRTUAL ? (Pending Final Decision)

- Dates: March 4-8, 2024
- Alternative Date: March 11-15, 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

2nd Full WG meeting in Andover, MA – Summer 2024 ? (Tentative)

- To be hosted by Schneider Electric – Dan Sabin is POC (To be confirmed)
- Proposed dates and time for future (full) WG meeting: identification of potential conflicts in Summer of 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

3rd Full WG meeting in Atlanta, GA / Mid-West – Fall 2024 (Tentative)

- To be hosted by NERC / TBD – (To be confirmed)
- Proposed dates and time for future (full) WG meeting: identification of potential conflicts in Fall of 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

IEEE SA
STANDARDS ASSOCIATION

IEEE P1547.2-202X

DRAFT GUIDE FOR APPLICATION OF IEEE STD 1547-2018™, IEEE STANDARD FOR INTERCONNECTION AND INTEROPERABILITY OF DISTRIBUTED ENERGY RESOURCES WITH ASSOCIATED ELECTRIC POWER SYSTEMS INTERFACES

Wayne Stec

Chair, IEEE P1547.2 Working Group

IEEE

1547.2 OVERVIEW

IEEE 1547.2:

- **Provides technical background & application details**
- **Characterizes various forms of DER technologies and their associated interconnection issues.**
- **Provides background & rationale of the technical requirements of IEEE 1547-2018.**
- **Provides tips, techniques, and common practices to address issues related to DER project implementation.**

1547.2 CONTENTS

- **General interconnection technical specifications and performance requirements –** Includes Reference Point of Applicability (RPA), Cease to Energize, Inadvertent Energization, Enter Service, Integration with Area EPS Grounding.
- **Reactive Power Capability & Voltage Control**
- **Response to Area EPS Abnormal Conditions –** Includes faults, Voltage & Frequency Ride-Through, and Return to Service After Trip.
- **Power Quality**
- **Islanding**
- **Secondary Networks**
- **Interoperability** - information exchange, information models and protocols
- **Field Verification Requirements** – Includes gap between tye test and installed systems, periodic testing.
- **DER High Penetration**

1547.2 STATUS

- Currently in 2nd Ballot Recirculation – Closes July 24th
- Targeting September 2023 RevCom Submission

THANK YOU!

Please feel free to contact me:

Wayne Stec

stec@distregen.com

317-679-7832

IEEE SA
STANDARDS ASSOCIATION

IEEE 1547.3-2023

GUIDE FOR CYBERSECURITY OF DISTRIBUTED ENERGY RESOURCES INTERCONNECTED WITH ELECTRIC POWER SYSTEMS

A REVISED STANDARD TO ADDRESS CYBERSECURITY WHEN INTERCONNECTING DISTRIBUTED ENERGY RESOURCES WITH ELECTRIC POWER SYSTEMS

Janette Sandberg, P.E.

Chair, IEEE P1547.3 Working Group

IEEE

SCOPE OF IEEE 1547

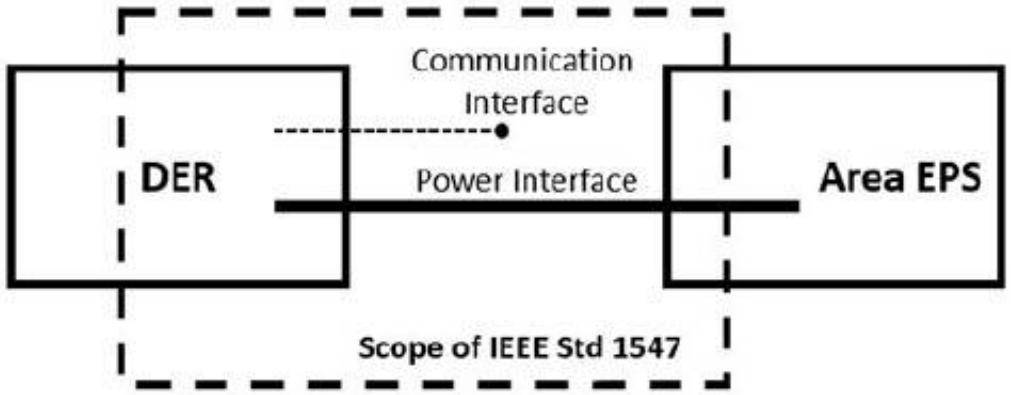


Figure 1 —Scope of this standard

1547-2018 covers the power and communications interfaces between the DER and the Area EPS (distribution system). It sets limits on what the DER can do to the Area EPS, and how the DER should "talk to" the Area EPS.

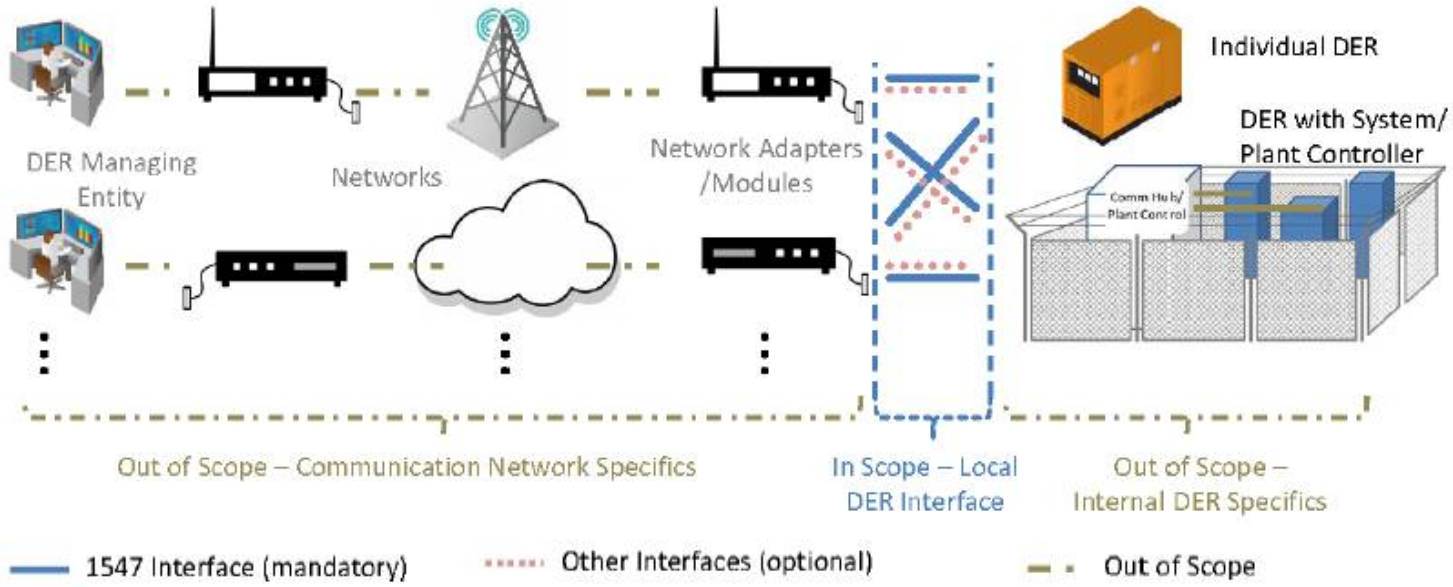


Figure 4 —Control protocol in/out of scope mapping

WHY DOES 1547.3 GUIDE FOR DER CYBERSECURITY EXIST?

- **IEEE Std 1547-2018, introduces interoperability as a technical requirement for DER, with a note that cybersecurity should be addressed.**
- **IEEE Std 1547.3-2007 material had been absorbed into IEEE Std 1547-2018, except for cybersecurity.**
- **"Why not include this as a subclause in IEEE Std 1547.2?"**
- A key reason was that it was desired that cybersecurity-specific aspects draw from the cybersecurity community as much as from the power systems community. Thus, ***1547.3 was co-sponsored by SC21 and the PSSC committee, and had a co-chair from each.***
- For convenience, it was decided to split out into a separate document the guidance for cybersecurity that is specific to DER.

WHAT'S IN 1547.3?

1547.3 focuses on DER cybersecurity. Examples:

- Need for Cybersecurity
- Risk Assessment
- Network Engineering
- Access Control
- Data Security
- Security Management
- Coping and Recovering from Security Events
- Testing and commissioning

WHEN WILL 1547.3 BE OFFICIAL?

Fall 2023.

Dates	Activities	Status
February 26, 2020	P1547.3 WG meeting – WG initiated	Done
June 9-10, 2020, virtual	P1547.3 WG Meeting – WG input on D1.0	Done
Oct 6-7, 2020, virtual	P1547.3 WG Meeting – WG input on D2.0	Done
February 23-24, 2021, virtual	P1547.3 WG Meeting – WG input on D3.0	Done
June 8-9, 2021, virtual	P1547.3 WG Meeting – WG input on D3.0	Done
Oct 13-14, 2021, virtual	P1547. WG Meeting – WG Ballot Draft and WG approval	Done
Q3 2022	P1547.3 To IEEE-SA for ballot	Done
Q3 2023	**IEEE Std 1547.3-2023 Published**	**In Progress**

THANK YOU!

Please feel free to email me with questions:

Janette.Sandberg@pgn.com

P1547.10 Update

Daniel Freeman, P1547.10 WG Secretary (Presenter)
Abrez Mondal, P1547 WG Chair

10 min

Joint Sponsorship & Coordination

IEEE P1547.10

Joint Sponsors

- COM/PLC
- PE/EDPG
- PE/PSCC
- PE/PSRCC
- PE/T&D
- PE/EM
- PEL/SC

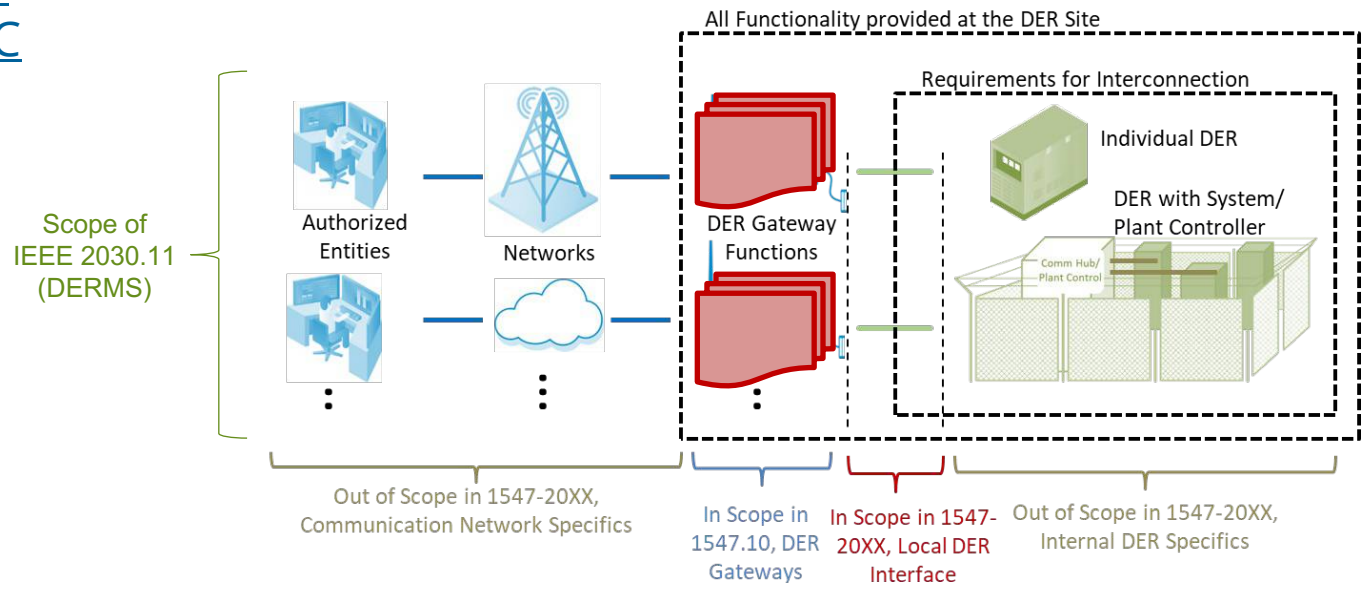
"A DER Gateway is a set of advanced functions such as intelligence, monitoring, control, protocol translation and cybersecurity at the grid-edge, that augments IEEE 1547."

IEEE P1547.10 (DER Gateways)

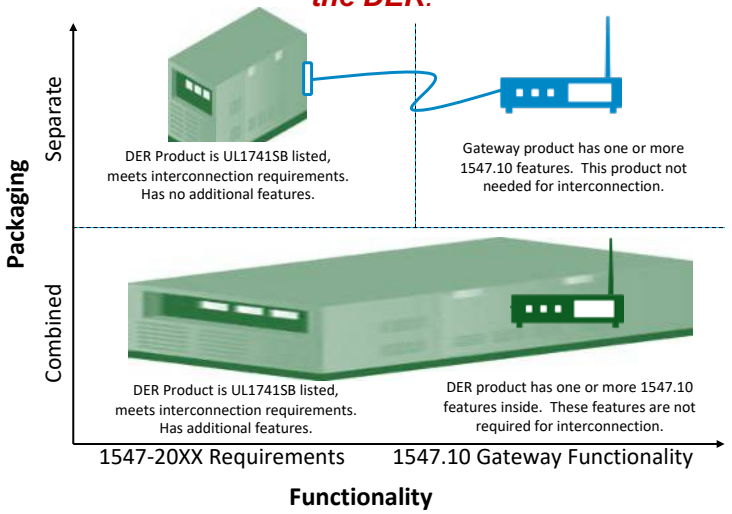
Joint Sponsors

- COM/PLC
- PE/EDPG
- PE/PSCC
- PE/PSRCC
- PE/T&D

DER Gateway Functions: the 'missing link' between IEEE 1547 and IEEE 2030



*DER Gateways are platforms that can use **stand-alone devices** and/or **hardware integrated into the DER**.*



IMPORTANT NOTES

- 1547.10 is a recommended practice
- 1547.10 is dedicated to DER Gateways, and not on interconnection requirements
- December 2024 – Project completion goal

PAR SCOPE

5.2 Scope of proposed standard: This document defines recommended specifications for a Distributed Energy Resources (DER) gateway platform in grid applications across various domains. A description of DER gateway implementation options (local or distributed platform, for legacy or intelligent DERs) is included. Gateway platform functions and communications, including operational procedures and data collection recommendations are described. Recommended procedures for cybersecurity, centralized manageability, monitoring, grid edge intelligence and control, multiple entities management, error detection and mitigation, events tracking and notification, communication protocol translation, and communication network performance monitoring are also described.

5.4 Purpose: The purpose of the project is to create and maintain coherency between P1547/.x, P2030/.x, and other related projects for DER and Distributed Energy Resources Management Systems (DERMS) within the evolving smart grid interoperability reference model (SGIRM) with a focus on Distributed Energy Resources (DER) Gateway Platforms. The recommended practice enables utilities deploying DERMS and other DER integration systems to integrate DER with grid edge intelligence, while DER devices serve their core functions focusing on simplicity, interoperability, and long-term stability.

5.5 Need for the Project: The smart inverter functionalities specified in IEEE 1547-2018, and the associated communication interfaces are not suitable for direct integration with the monitoring and control systems of grid operators. The standard inverter functionalities were designed only to expose the raw, inherent capabilities of the DER, but (intentionally) omitted additional logic or management features because these were believed to vary by utility and region. This gap can be addressed by deploying a DER gateway platform with a range of grid edge-intelligence functions that provides opportunities to improve system functionality as grid needs evolve over time.

PAR EXAMPLE FUNCTIONS

The following provides some example functions for each of the DER Gateway functional categories listed in section 5.2 (Scope of the proposed standard):
FUNCTIONAL CATEGORY: Example Function(s)
* CYBERSECURITY: Transport Layer Security (TLS), Role Based Access Control (RBAC)
* CENTRALIZED MANAGEABILITY: Firmware management, Upgradeability
* MONITORING: Real time status monitoring, Report by exception, Interval data, Lost energy calculation

* GRID-EDGE INTELLIGENCE AND CONTROL: Recurring schedules, New and transparent smart inverter functions handling, Advanced notification and synchronized actions, Smart inverter function implementation for legacy DER, Availability at night and during outages
* MULTIPLE ENTITIES MANAGEMENT: DER providing grid services to multiple entities (local utility, ISO etc.), Command prioritization
* ERROR DETECTION AND MITIGATION: Report unexpected DER settings change, Loss of communication detection and reversion to defaults
* EVENTS TRACKING AND NOTIFICATION: Events and alarms logging and retrieval, Supervision of voltage sags
* COMMUNICATION PROTOCOL TRANSLATION: Translation of messages between DER and upstream managing entity
* COMMUNICATION NETWORK PERFORMANCE MONITORING: Network diagnostics such as detection of packet loss, latency, errors etc.

SUBGROUP STRUCTURE AND MAILING LISTS

P1547.10 Working Group	**Abrez Mondal (WG Chair) Daniel Freeman (Secretary) Yashar Kenarangui, John Berdner (Vice-Chairs)**	STDS-P1547-10@LISTSERV.IEEE.ORG	**Click here to sign up for the P1547.10 listserver**

P1547.10 Subgroup	Overseeing WG Officers / SG Leads	Subgroup Facilitator(s)	Subgroup Mailing List (ListServ)	Sign-Up Link
#1 – Overall Document and General Requirements	**Abrez Mondal**	**Daniel Freeman**	STDS-P1547-10-SG1@LISTSERV.IEEE.ORG	**Click here to sign up for SG1 listserver**
#2 – DER grid-edge Intelligence functions in Gateway	**Yashar Kenarangui**	**Brian Waldron Jedidiah Bartlett**	STDS-P1547-10-SG2@LISTSERV.IEEE.ORG	**Click here to sign up for SG2 listserver**
#3 - Security functions in Gateway	**John Berdner**	**Kiran Thomas**	STDS-P1547-10-SG3@LISTSERV.IEEE.ORG	**Click here to sign up for SG3 listserver**
#4 - Communications	**Yashar Kenarangui**	**Galina Antonova Fares al Jajeh**	STDS-P1547-10-SG4@LISTSERV.IEEE.ORG	**Click here to sign up for SG4 listserver**

IEEE P1547/.X WORKING GROUPS
PLANNING OF FUTURE MEETINGS

Proposal for full WG meetings in 2023 following April Meeting:

3rd Full WG meeting in in Wilsonville, OR – Fall 2023

- To be hosted by PGE – Kevin Whitener (Point of Contact)
- Dates: Oct 2-5, 2023 – Confirmed
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a)

Proposal for full WG meetings in 2024:

1st Full WG meeting – Hybrid / FULLY VIRTUAL ? (Pending Final Decision)

- Dates: March 4-8, 2024
- Alternative Date: March 11-15, 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

2nd Full WG meeting in Andover, MA – Summer 2024 ? (Tentative)

- To be hosted by Schneider Electric – Dan Sabin is POC (To be confirmed)
- Proposed dates and time for future (full) WG meeting: identification of potential conflicts in Summer of 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

3rd Full WG meeting in Atlanta, GA / Mid-West – Fall 2024 (Tentative)

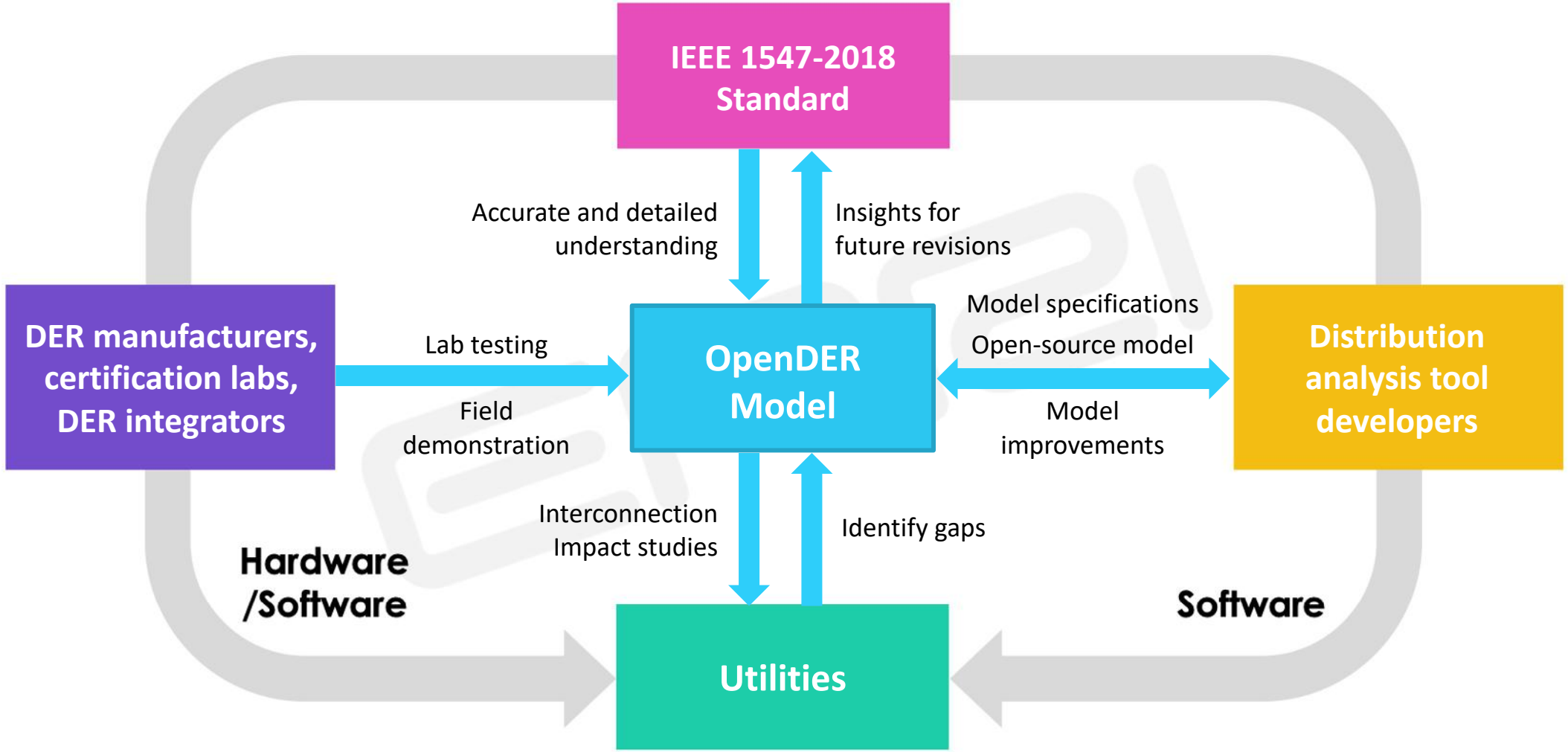
- To be hosted by NERC / TBD – (To be confirmed)
- Proposed dates and time for future (full) WG meeting: identification of potential conflicts in Fall of 2024
- Joint WG Meetings (P1547 Rev, P1547.10, P1547.4, P1547.1a, etc.)

OpenDER Model

Yiwei Ma, EPRI and P1547 SG6 Facilitator

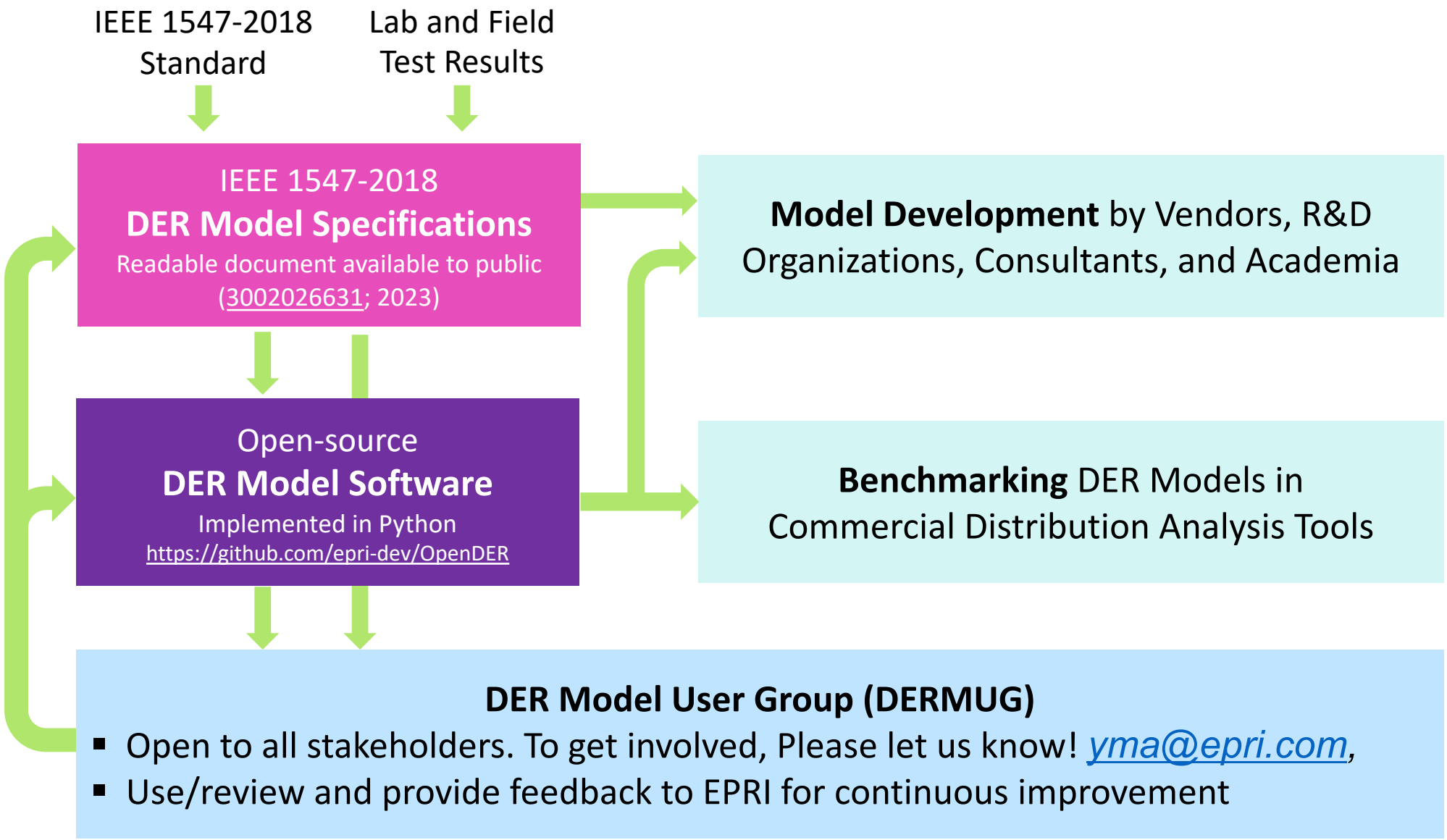
10 min

IEEE 1547-2018 Open-source DER (OpenDER) Model



Harmonizing Understanding of the Standard among all Stakeholders

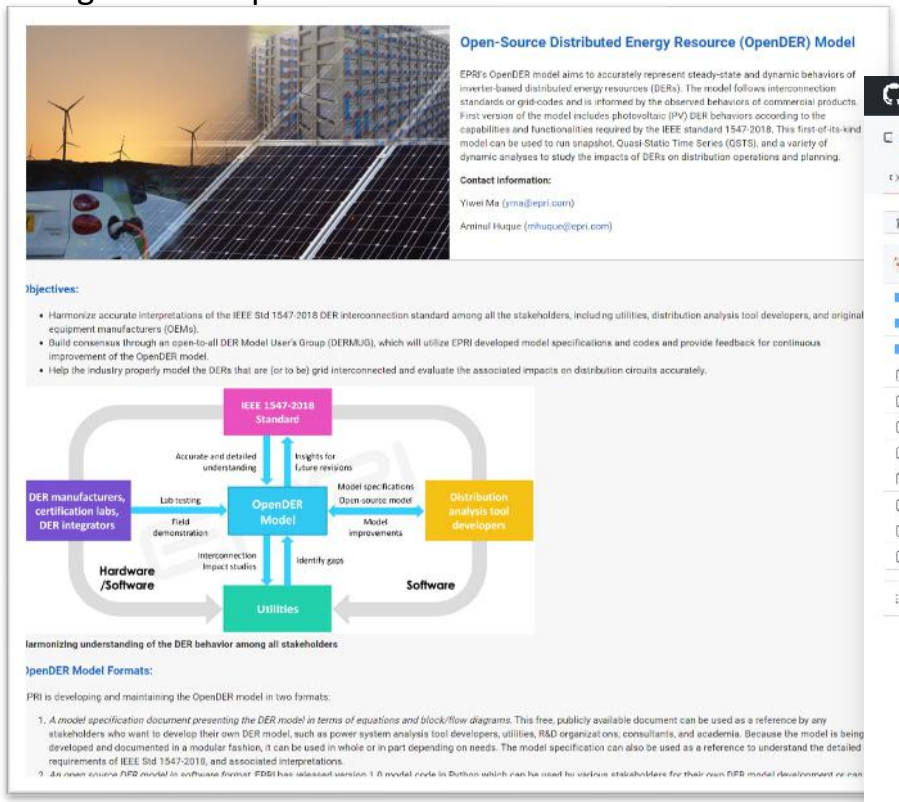
OpenDER Research Outcomes and Usage



Available Resources

Homepage https://www.epri.com/opender

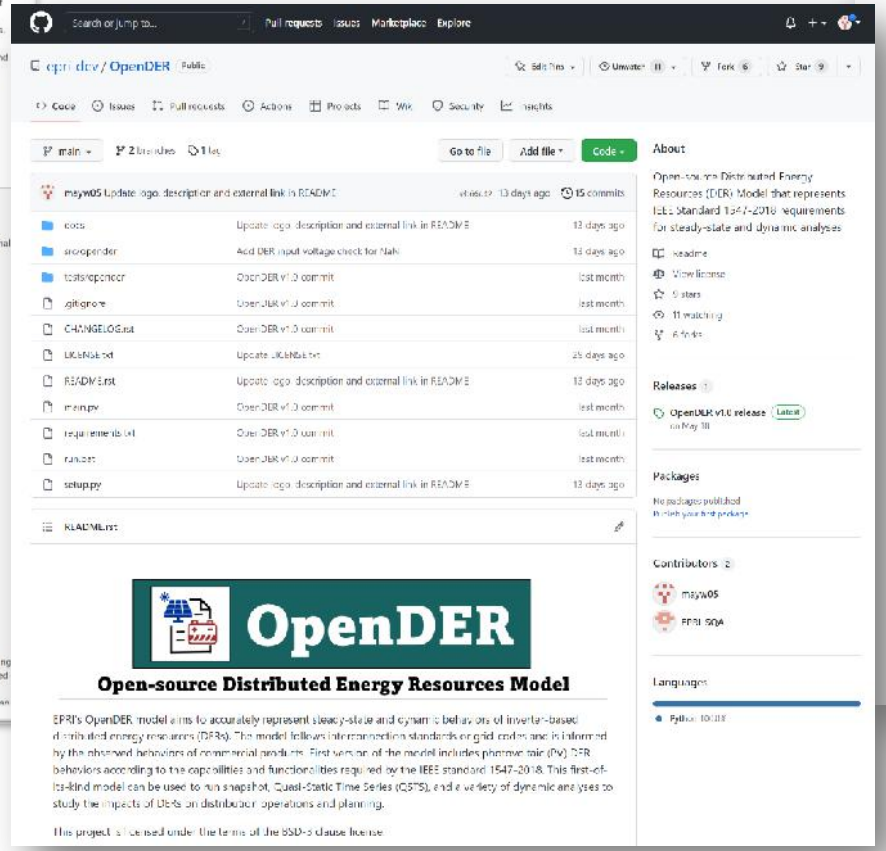
Google: EPRI+OpenDER



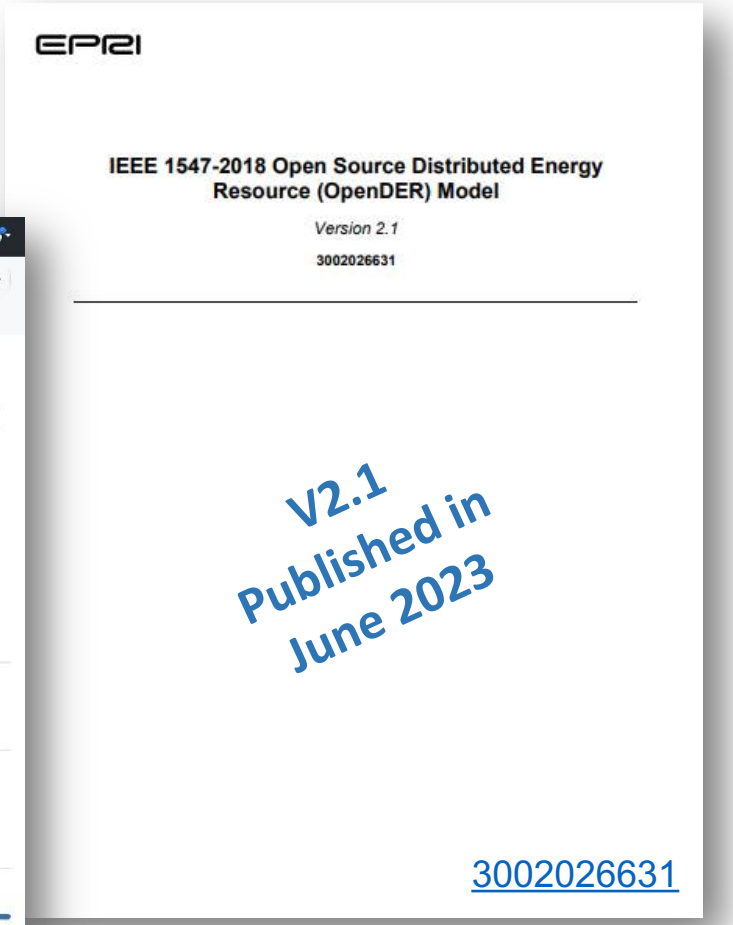
Slides and Recording of DERMUG meetings available for download

Source Code

https://github.com/epri-dev/OpenDER



Model Specification



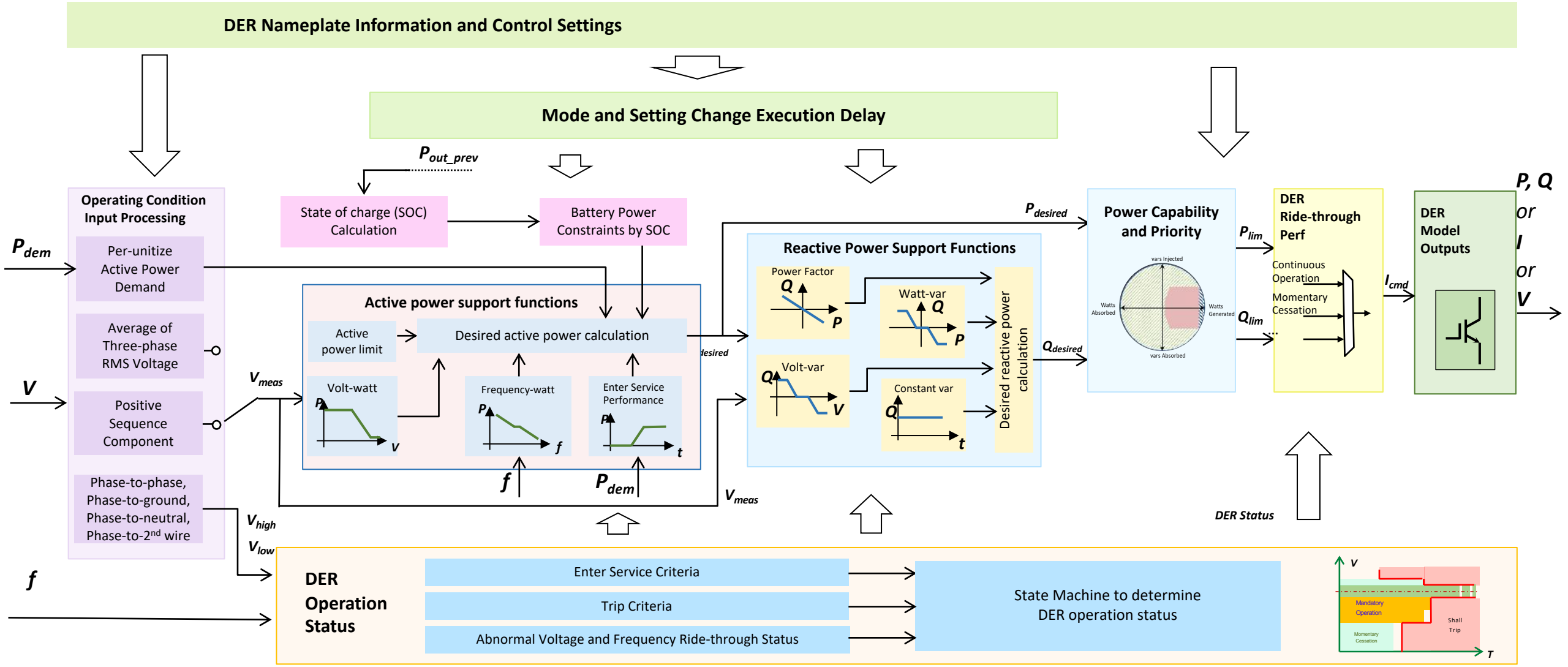
V2.1 Published in June 2023

3002026631

All Publicly Available Materials

OpenDER Model Block Diagrams

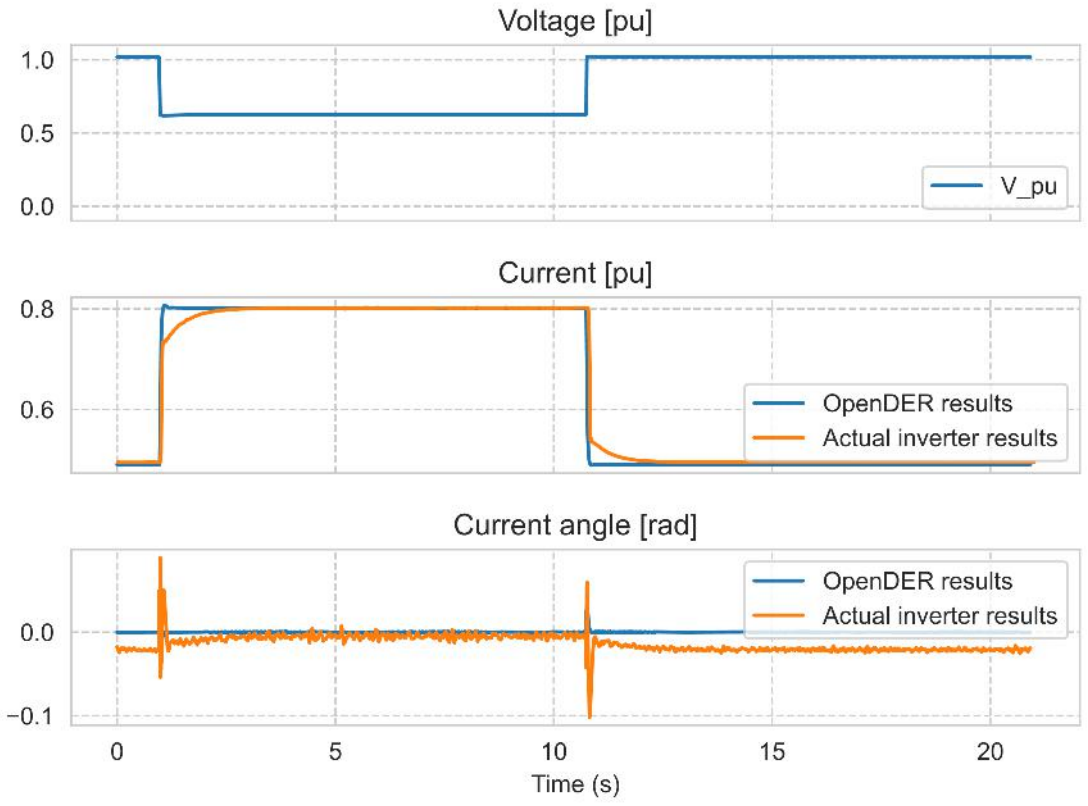
PV or Energy Storage DER, Grid Supp. Functions and Ride-through Perf.



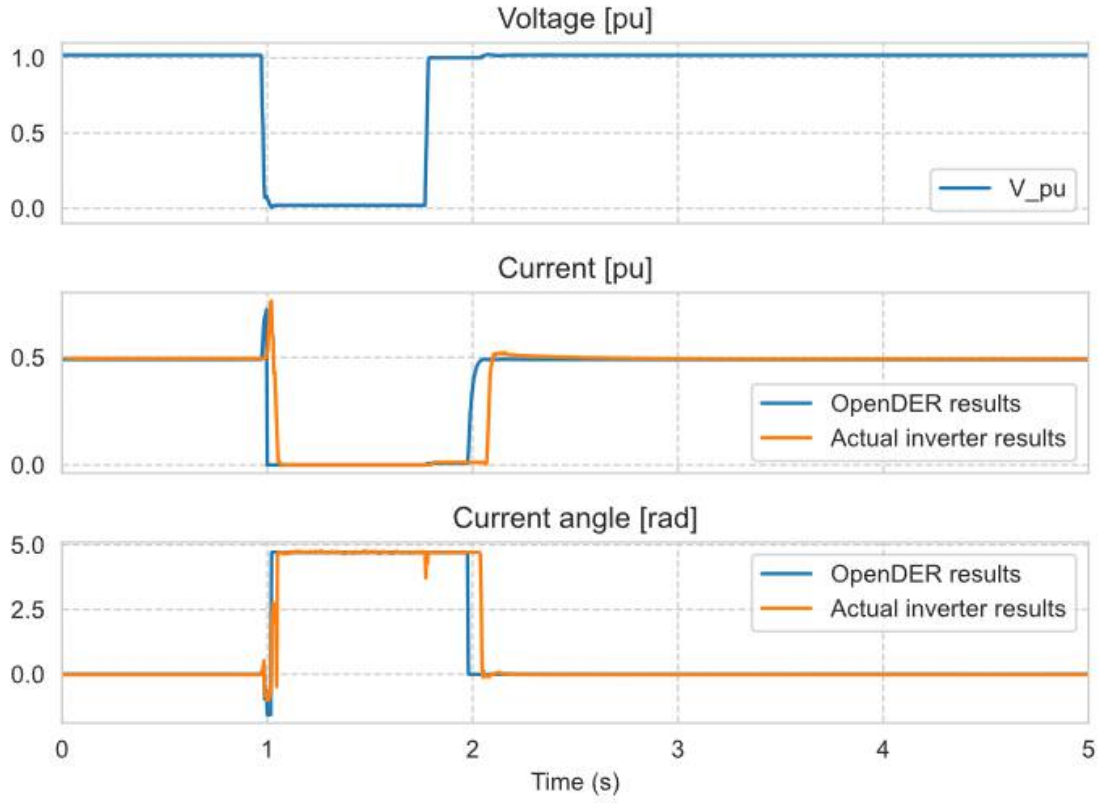
Example Model Validation Results: Voltage Ride-Through

- Inverter is configured with Cat III default trip settings.
- OpenDER fault current magnitude and angle matches inverter's response in "steady-state", with minor inaccuracy when fault begins and ends.

Grid simulator drop voltage to 0.6pu for 9.8s

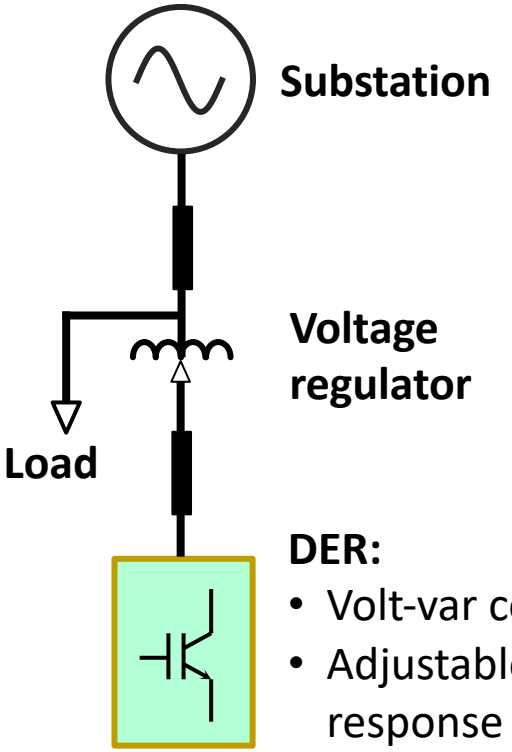


Grid simulator drop voltage to 0pu for 0.8s



Example Application of OpenDER

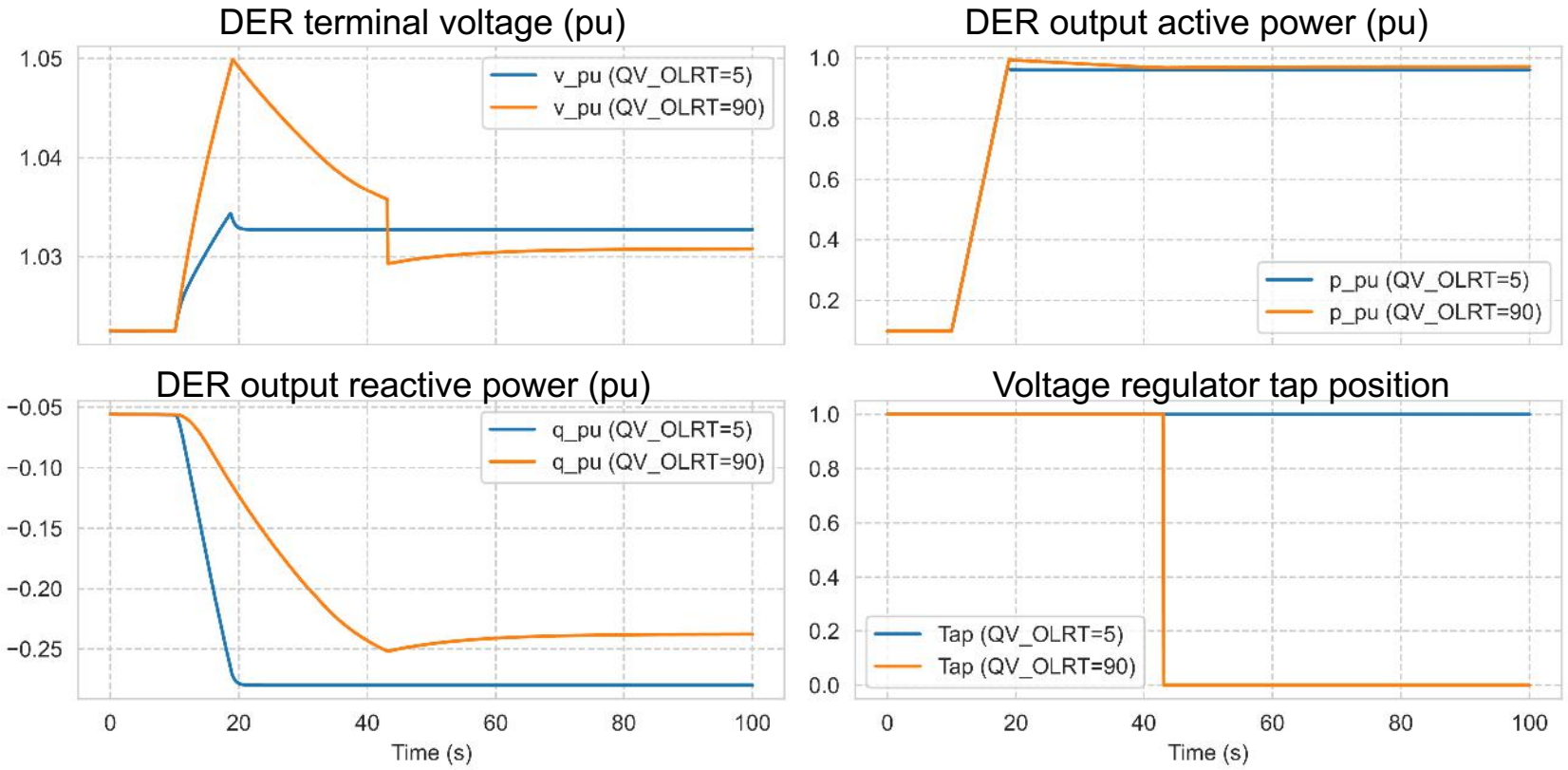
Simulation Circuit



DER:

- Volt-var control
- Adjustable open loop response time (OLRT) of 5s and 90s

Dynamic Simulation Results



DER dynamic performance may impact the wear and tear of distribution equipment – It is important to model DER capabilities and settings accurately in studies

5-MIN BREAK

4. Wind and Solar Plant Interconnection WG – Nath Venkit for Jens Boemer

- ***Bulk System-Connected*** Inverter-Based Resources Activities
  - 2800-2022 Update and adoption status update – Jens Boemer (EPRI)* – 10 min
  - P2800.2 IBR Plant Test and Verification – Andy Hoke (NREL) – 10 min
  - IBR Standards Revision Update, Alex Shattuck (NERC) – 15 min
  - Global Power Systems Transformation Consortium – Jason MacDowell – 5 min

* Presented by Andy Hoke (NREL)

2800-2022 Update and Adoption Status Update

Andy Hoke (NREL), P2800.2 WG Chair (Presenter)
on behalf of Jens Boemer (EPRI), IEEE 2800 WG Chair

10 min

General Disclaimer

The views presented in this presentation are the personal views of the individuals presenting it and shall not be considered the official position of the IEEE Standards Association or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE, in accordance with IEEE Standards Association Standards Board Bylaws 5.2.1.6.

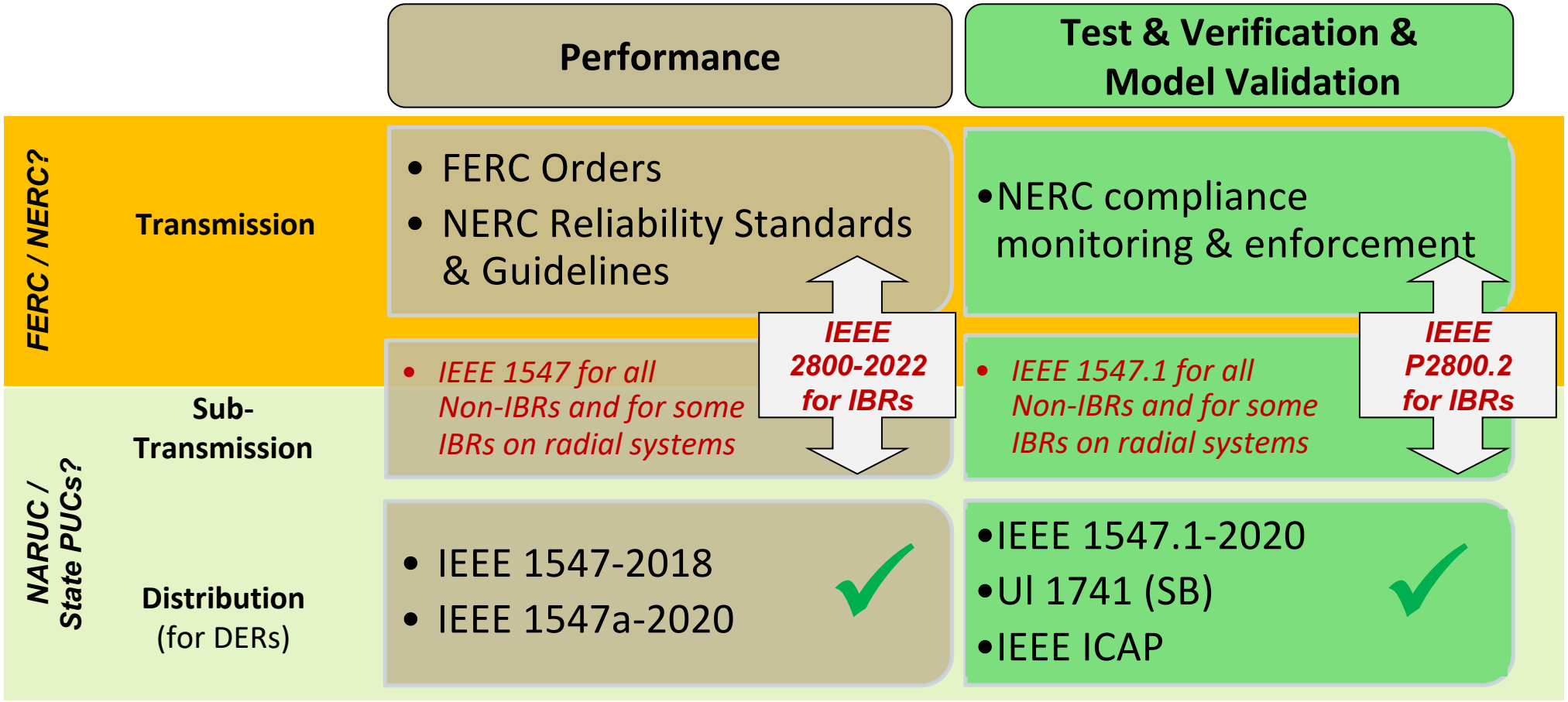
Use of an IEEE standard is wholly voluntary

Summary of IEEE Std 2800

- The standard **harmonizes** Interconnection Requirements for Large Solar, Wind and Storage Plants
- It is a **consensus-based** standard developed by over ~175 Working Group participants from utilities, system operators, transmission planners, & OEMs over 2 years
- It has successfully passed the IEEE SA ballot among 466 SA balloters **(>94% approval**, >90% response rate)
- **Published on April 22, 2022 (Earth Day)**

Scope of IEEE 2800 is limited to IBRs

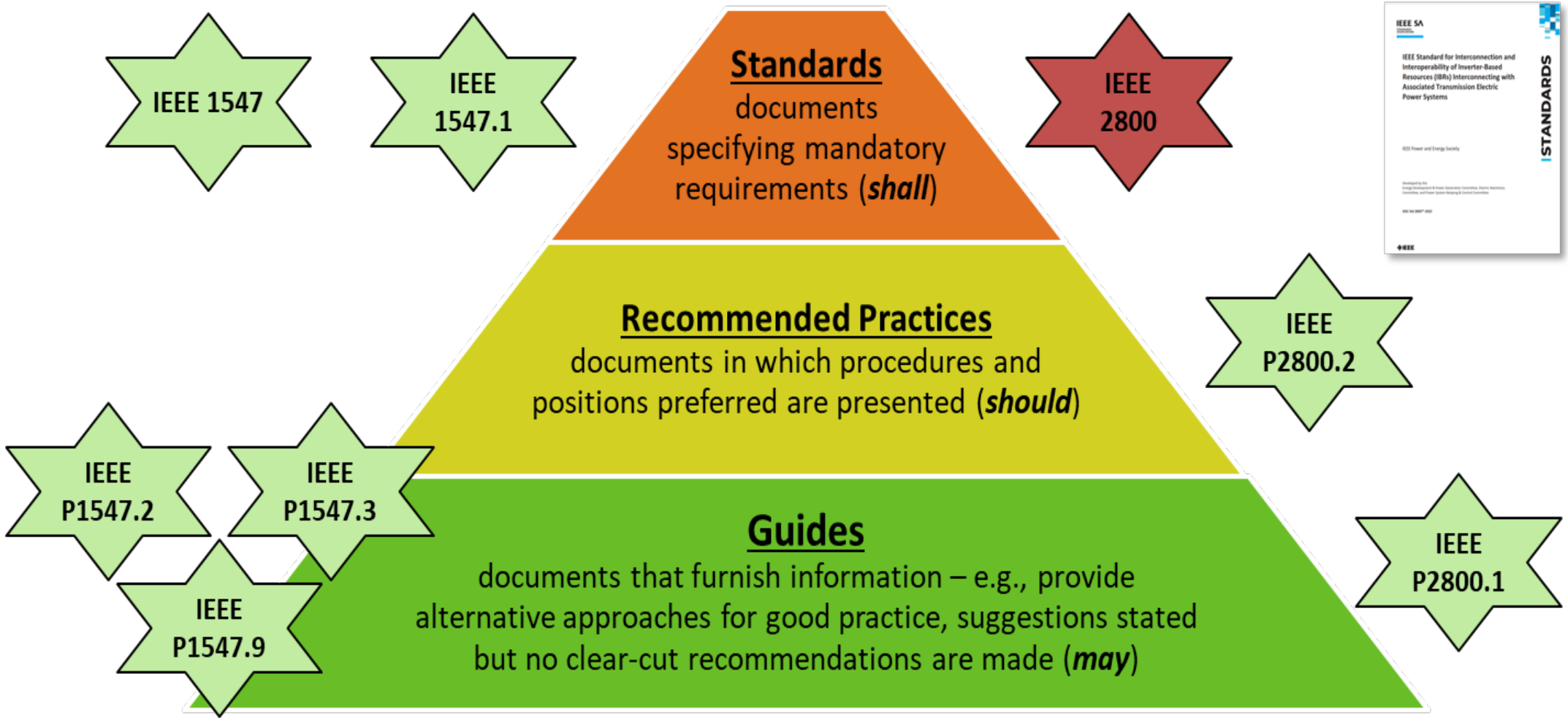
and intentionally overlaps with IEEE 1547 for IBRs connected to *radial* sub-transmission systems.
IEEE standards become mandatory, only when adopted by the appropriate authorities.



IBRs: Inverter-Based Resources

DERs: Distributed Energy Resources

IEEE Standards Classification



General Notes About IEEE 2800-2022

Adoption of IEEE 2800:

- Adoption of IEEE 2800 is not contingent upon publication/adoption of IEEE P2800.2
  - ***In absence of IEEE P2800.2*, IBR owner, TS owner/Operator, OEM etc. could develop their own test and verification procedures.**
- Needs consideration of enforcement date, grandfathering etc.
- Possible adoption methods:
  - Mostly full Adoption by simple reference
  - Full or Partial Adoption, clause-by-clause reference, additional requirements

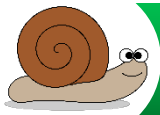
UL Certification:

- Most requirements in IEEE 2800 apply to the IBR plant. UL certification for IBR unit (inverter/WTG) is unlikely.
  - Additional motivation for IEEE P2800.2

Possible IEEE 2800-2022 Adoption Methods

General Reference

- Full adoption of standard by general reference
- Specification of
  - technical minimum capability per IEEE 2800-2022
  - functional settings/ performance (in ranges of available settings)
- Decision whether to specify additional requirements or not
  - e.g., for non-exhaustive reqs.



Detailed Reference

- Full or partial adoption of std
- Clause-by-clause references
- Any additional requirements

Benefit: *Consistency to standard*

Risk: *Fragmentation of requirements, certification challenges, additional costs*

Full Specification

- All on the left
- Clause-by-clause own language
- Any additional requirements

Benefit: *No need to buy standard*

Risk: *Inconsistencies to standard and fragmentation of requirements, certification challenges, additional costs*

Source: EPRI (2023)

Possible IEEE 2800-2022 Adoption Methods

General Reference

- Florida Power and Light (FPL)
- Salt River Project (SRP)

Detailed Reference

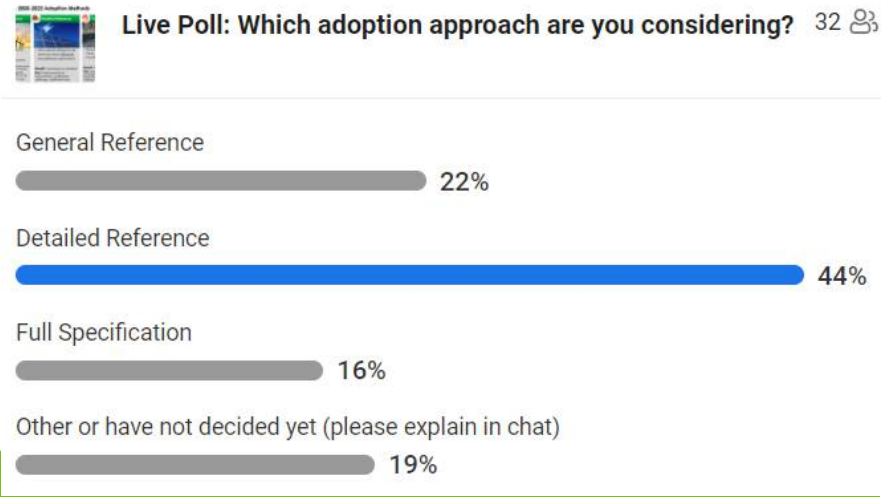
- Duke Energy
- ISO New England
- MISO
- New York ISO
- Southern Company

Full Specification

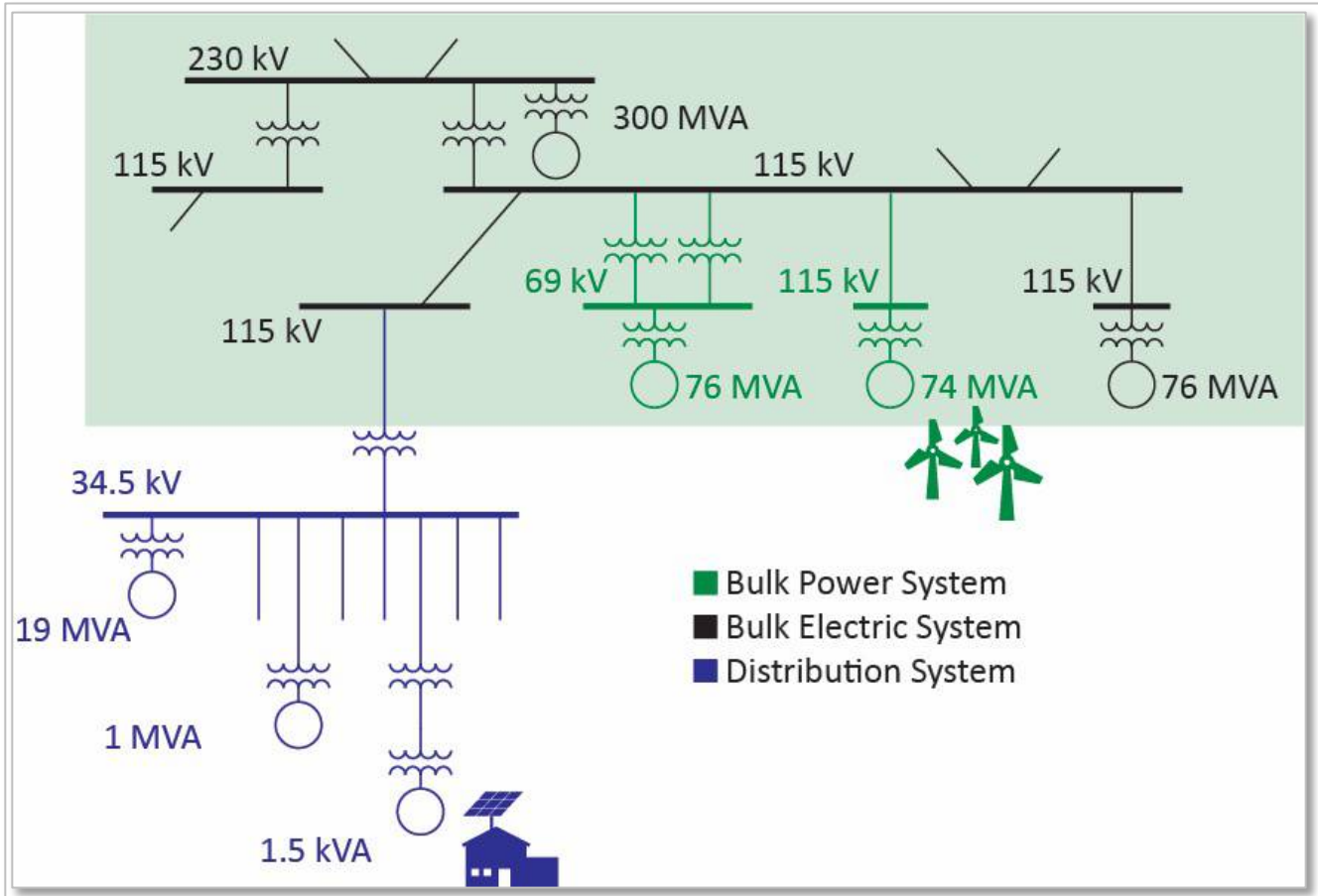
- ERCOT
- Ameren IL

- Other utilities/ISOs considering IEEE 2800-2022 adoption: SPP, TVA, BPA, Long Island Power Authority

Source: EPRI (2023)



NERC Perspective on IEEE Standards Applicability



IEEE 2800-2022

- Inverter-based resources
- Covers all BPS and BES
  - Transmission-level
  - Subtransmission-level

IEEE 1547-2018

- All power-producing resources
- Distribution-level

Source: Quick Overview of DERs, IBRs, IEEE Standards, and Other References. Presentation by Ryan D. Quint, NERC, at CanREA HUB Summit (January 2023)—*slightly modified, used with permission.*

Delineation line is between "bulk power system" and distribution system.
But what if some 34.5 kV is subtransmission as for certain co-ops?

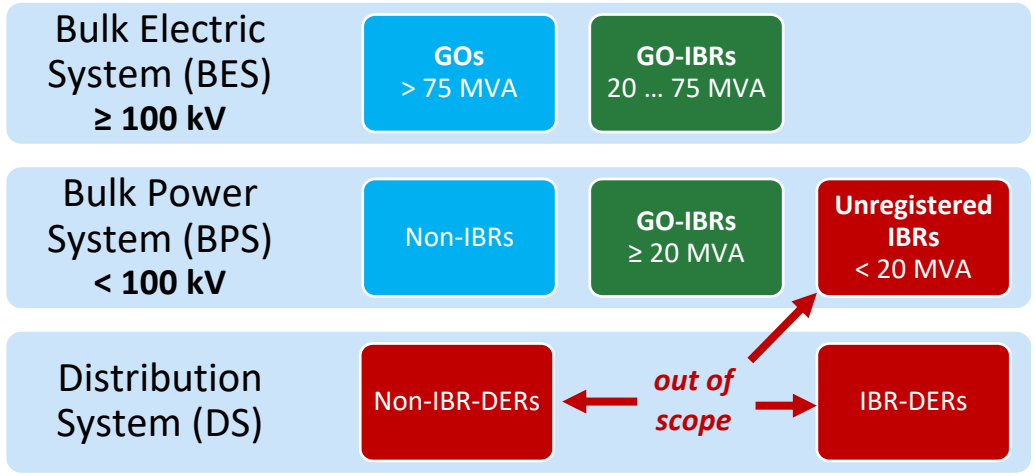
Illustration of IEEE Stds 2800 and 1547 Scope & Limitations

<table>
<tr><th>System Level</th><th>Resource Type</th><th>Networked/Meshed</th><th>Radial</th></tr>
<tr><td rowspan="2">Transmission</td><td>IBR</td><td>IEEE 2800-2022</td><td>IEEE 2800-2022</td></tr>
<tr><td>Non-IBR</td><td></td><td></td></tr>
<tr><td rowspan="2">Subtransmission</td><td>IBR</td><td>IEEE 2800-2022</td><td rowspan="2">Intentional Overlap
↓
<u>IEEE 2800/1547</u></td></tr>
<tr><td>Non-IBR</td><td>Gap? →</td></tr>
<tr><td rowspan="2">Distribution</td><td>IBR</td><td rowspan="2">IEEE 1547-2018
↓
Clause 9 (DER on distribution secondary grid/area/street (grid) networks and spot networks)</td><td rowspan="2">IEEE 1547-2018</td></tr>
<tr><td>Non-IBR</td></tr>
</table>

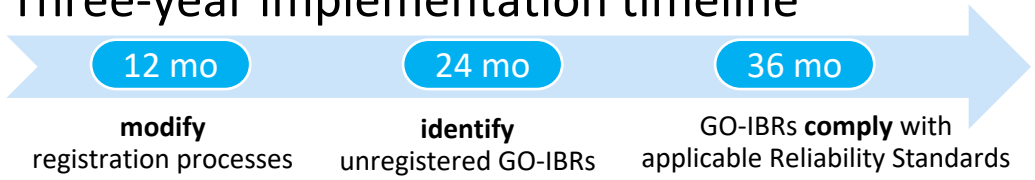
IEEE 1547-2018 could apply to all subtransmission-connected Non-IBRs(?) and to some IBRs on radial systems

FERC Order on IBR Registration (RD22-4-001)

- Issued May 18, 2023 (link)
- Approves NERC's Registration Work Plan for BPS-Connected IBRs
- Goal is to **identify and register** owners and operators of "**unregistered IBRs**"



- Three-year implementation timeline



183 FERC ¶ 61,116
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Willie L. Phillips, Acting Chairman;
James P. Danly, Allison Clements,
and Mark C. Christie.

North American Electric Reliability Corporation Docket No. RD22-4-001

ORDER APPROVING REGISTRATION WORK PLAN

(Issued May 18, 2023)

1. On February 15, 2023, and as amended on March 13, 2023, the North American Electric Reliability Corporation (NERC), the Commission-certified Electric Reliability Organization (ERO), submitted its compliance filing in accordance with the Commission's order[1] directing NERC to submit a plan describing how it will identify and register owners and operators of inverter-based resources (IBR) that are connected to the Bulk-Power System,[2] but that are not otherwise required to register with NERC under its bulk electric system (BES) definition[3] (referred to as "unregistered IBRs" throughout this order). In its filing, NERC includes its work plan, white paper, and communication plan.

[1] *N. Am. Elec. Reliability Corp.*, 181 FERC ¶ 61,124 (2022) (IBR Registration Order).

[2] The Bulk-Power System is defined in the Federal Power Act (FPA) as "facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof), and electric energy from generating facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy." 16 U.S.C. § 824o(a)(1).

[3] NERC's Commission-approved BES definition is a subset of the Bulk-Power System and defines the scope of the Reliability Standards and the entities subject to NERC compliance. *Revisions to Elec. Reliability Org. Definition of Bulk Elec. Sys. & Rules of Proc.*, Order No. 773, 141 FERC ¶ 61,236 (2012), *order on reh'g*, Order No. 773-A, 143 FERC ¶ 61,053 (2013), *rev'd sub nom. People of the State of N.Y. v. FERC*, 783 F.3d 946 (2d Cir. 2015); NERC, *Glossary of Terms Used in NERC Reliability Standards*, 5-7 (updated Mar. 29, 2022), https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf (NERC Glossary).

IEEE P2800.2

Recommended Practice for Test & Verification Procedures for IBRs interconnecting with BPS

Andy Hoke, WG Chair (Presenter)
Manish Patel, Secretary
Jens Boemer, Bob Cummings, Divya Chandrashekhara,
Julia Matevosyan, Mahesh Morjaria, Steve Wurmlinger, Vice Chairs

10 min

General Disclaimer

The views presented in this presentation are the personal views of the individuals presenting it and shall not be considered the official position of the IEEE Standards Association or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE, in accordance with IEEE Standards Association Standards Board Bylaws 5.2.1.6.

Use of an IEEE standard is wholly voluntary

P2800.2 Summary

Title: Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

Scope:

- Defines recommended practices for test and verification procedures that should be used to confirm plant-level conformance of IBRs interconnecting with bulk power systems in compliance with IEEE Std 2800.
- Applies to IBRs interconnected to transmission and sub-transmission systems
- May also apply to isolated IBRs that are interconnected to an alternating current (AC) transmission system via dedicated voltage source converter high-voltage direct current (VSC-HVDC) transmission facilities, e.g., offshore wind farms
- Includes specifications for the equipment, conditions, tests, modeling methods, and other verification procedures that should be used to demonstrate conformance with IEEE 2800

P2800.2 Summary

Includes:

- Type tests
  - unit level, not full compliance with 2800 though
  - Test results are used to validate unit level model
- Design evaluation using verified plant model
  - includes procedures to validate unit level model
- As-built evaluation and commissioning tests
- Post-commissioning model validation, monitoring, periodic tests & verifications

- **Recommended Practice**: uses “should” language, not “shall” language
  - In recognition that prescribing uniform procedures across all IBR types and interconnecting locations would be very challenging.

Motivation for IEEE P2800.2

IEEE 2800 contains capability & performance requirements for IBRs, and a **table** of **methods to verify each requirement**

- Details of verification methods **not** included

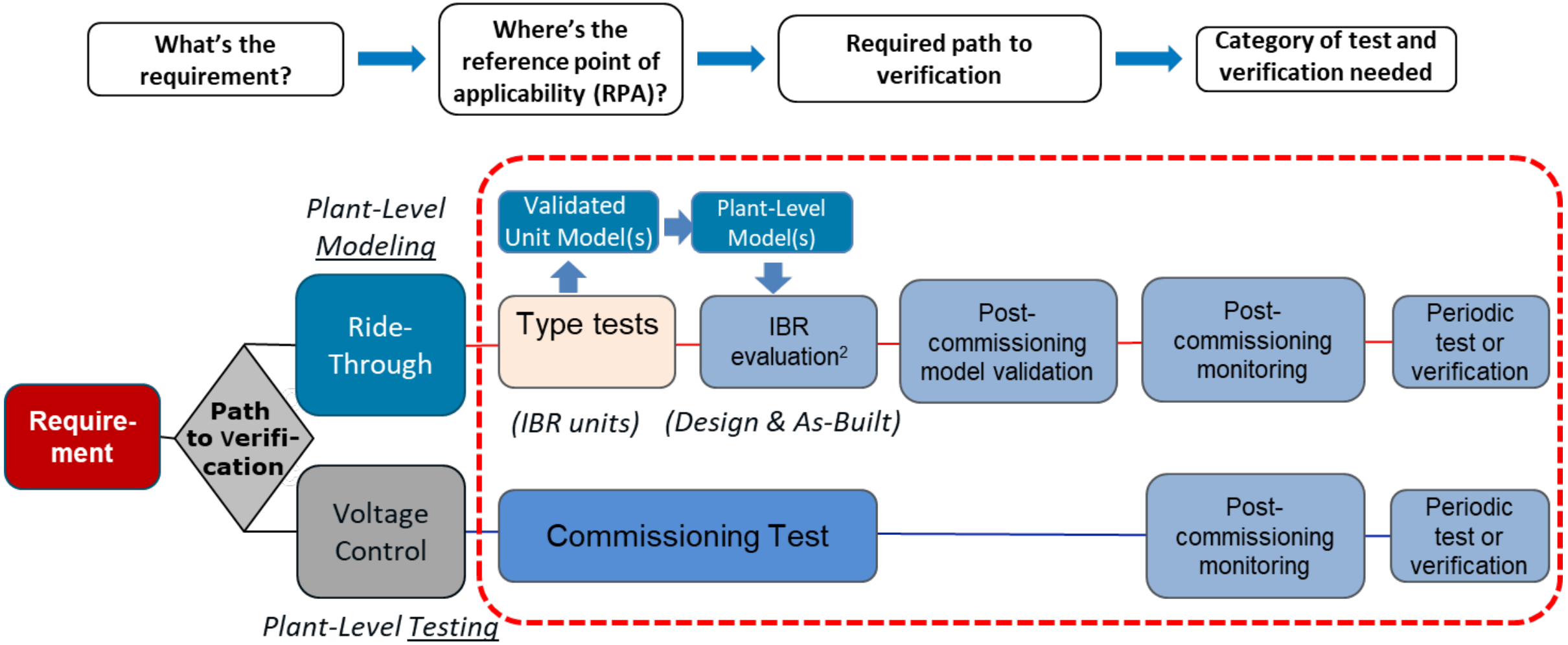
P2800.2 to develop recommended practice for test and verification procedures for IBRs

https://standards.ieee.org/ieee/2800.2/10616/

https://sagroups.ieee.org/2800-2/

Requirement	RPA at which requirement applies	*IBR unit*-level tests (at the POC)	*IBR plant*-level verifications (at the RPA)						
		Type tests[157]	Design evaluation (including modeling)	As-built installation evaluation	Commissioning tests	Post-commissioning model validation	Post-commissioning monitoring	Periodic tests	Periodic Verification
		Responsible Entity							
		IBR Manufacturer	Developer /TS owner/TS operator	Developer /TS owner/TS operator	Developer /TS owner/TS operator	Developer / IBR Operator /TS owner/TS operator	IBR Operator /TS owner/TS operator	IBR operator /TS owner/TS operator	IBR operator /TS owner/TS operator
6.1 Primary Frequency Response (PFR)	POC & POM	NR[158]	R	R	R	R	D	D	D
6.2 Fast Frequency Response (FFR)	POC & POM	R[159]	R	R	R	R	D	D	D
Clause 7 Response to TS abnormal conditions									
7.2.2 Voltage disturbance ride-through requirements	POC[160] & POM[161]	R	R	R	NR	R	R	D	D
7.2.3 Transient overvoltage ride-through requirements	POM	R	R	R	NR	R	R	D	D
7.3.2 Frequency disturbance ride-through requirements	POM	R	R	R	NR	R	R	D	D
7.4 Return to service after IBR plant trip	POM	refer to line entries for 4.10 (Enter service)							

Test & Verification Framework



Overview of conformity assessment steps in IEEE P2800.2

Type Tests

Lab or field tests of individual IBR unit for model verification

IBR Unit Model Validation

Based on type test data

IBR Plant Model Development

Based on validated IBR unit model(s) and balance of plant

IBR Plant Design Evaluation

Simulations to assess plant conformity to IEEE 2800

Design Evaluation

Plant construction complete

As-built Installation Evaluation

Verification of installed plant

Commissioning Tests

Partial field assessment of plant performance

Post-commissioning Monitoring

Monitoring of plant performance during grid events

Post-Commissioning Model Validation

Based on commissioning test data

Periodic Tests and Verifications

This is a general diagram of the process. Details are under development in IEEE P2800.2. Some variations are permitted.

IEEE P2800.2 Subgroup Scopes

SG1
Overall document and general requirements

PQ Task Force

Excerpt of 2800 Table 20: Verification Methods Matrix

		SG2 Type tests	SG3 Design Evaluation	SG4 Commissioning Tests and As-built Evaluations		SG5 Post-commissioning Model Validation, Monitoring, and Periodic Testing			
Requirement	RPA at which requirement applies	*IBR unit*-level tests (at the POC)		*IBR plant*-level verifications (at the RPA)					
		Type tests[160]	Design evaluation (including modeling for most requirements)	As-built installation evaluation	Commissioning tests	Post-commissioning model validation	Post-commissioning monitoring	Periodic tests	Periodic verification
		Responsible entity							
		IBR unit or *supplemental IBR device* manufacturer[a]	*IBR developer /TS owner/ TS operator*[a]	*IBR developer /TS owner/ TS operator*[a]	*IBR developer/ TS owner/ TS operator*[a]	*IBR developer/ IBR operator/ TS owner/ TS operator*[a]	*IBR operator/ TS owner/ TS operator*[a]	*IBR operator/ TS owner/ TS operator*[a]	*IBR operator/ TS owner/ TS operator*[a]
5.1 Reactive power capability	POM	R	R	R	R	R	D	D	D
5.2 Voltage and reactive power control modes	POM	D	R	R	R	R	D	D	D
Clause 6 Active-power—frequency response requirements									
6.1 Primary frequency response (PFR)	POC and POM	NR[161]	R	R	R	R	D	D	D
6.2 Fast frequency response (FFR)	POC and POM	R[162]	R	R	R	R	D	D	D
Clause 7 Response to TS abnormal conditions									
7.2.2 Voltage disturbance ride-through requirements	POC[163] and POM[164]	R	R	R	NR	R	R	D	D
7.2.3 Transient overvoltage ride-through requirements	POM	R	R	R	NR	R	R	D	D
7.3.2 Frequency disturbance ride-through requirements	POM	R	R	R	NR	R	R	D	D
7.4 Return to service after IBR plant trip	POM			Refer to line entries for 4.10					
Clause 8 Power quality									
8.1.2 Rapid voltage changes (RVC)	POM	NR	R	R	R	D	R	D	D
8.1.3 Flicker	POM	NR	NR	NR	R	D	R	N/A	D
8.2.1 Harmonic current distortion	POM	R[165]	R	R	R	D	R	N/A	D

IEEE P2800.2 WG Structure/Leaders

Subgroup	Vice Chair	Subgroup Chair(s)
2: Type tests	Steve Wurmlinger Stephen.Wurmlinger@sma-america.com	Pramod Ghimire, Michael Ropp
3: Design evaluations	Jens Boemer j.c.boemer@ieee.org	Andrew Isaacs, Alex Shattuck
4: Commissioning and as-built evaluation	Divya Chandrashekhara DKUCH@orsted.com	Chris Milan, Dave Narang
5: Post-commissioning model validation and monitoring, and periodic tests and verifications	Julia Matevosyan julia@esig.energy	Jason MacDowell, Brad Marszalkowski

Lead subgroup and coordinate with other subgroups

Facilitate subgroup calls

Draft specific verification procedures with subgroup input

Most of the detailed work will occur in the subgroups and task force via periodic calls

Chair	Andy Hoke Andy.Hoke@nrel.gov
Secretary	Manish Patel mpatel@southernco.com
Vice Chair	Bob Cummings
Vice Chair	Mahesh Morjaria

Compile drafts; Lead Subgroup 1 (overall document and general requirements)

Lead overall WG

Power Quality Task Force	
Co-Lead	Eugen Starschich
Co-Lead	David Mueller

Provide input to subgroups on PQ requirements verification

Signup Instructions

Listservs:

- Subgroup 1 (overall document): STDS-P2800-2-SG1
- Subgroup 2 (type tests): STDS-P2800-2-SG2
- Subgroup 3 (design evaluation): STDS-P2800-2-SG3
- Subgroup 4 (commissioning and as-built): STDS-P2800-2-SG4
- Subgroup 5 (post-commissioning): STDS-P2800-2-SG5
- Power quality task force: STDS-P2800-2-PQTF
- Overall P2800.1 listserv: P2800-2 (will be used to communicate meeting dates, agendas, etc.)

To Join a Listserv:

- Send an email message to listserv@listserv.ieee.org
  - In first line of the email body, write: ***SUBSCRIBE <list name> <Your Name>***
  - For example, “SUBSCRIBE STDS-P2800-2-SG1 Andy Hoke”

General Info

Target Dates:

- WG approved draft by Q1 2024
- IEEE SA Ballot: Q2, 2024 – Q1, 2025
- Publication: Q1-Q2, 2025

Next WG Meeting:

- Virtual meeting scheduled for August 29-31, 2023

Call for Participation:

- Please consider joining the WG and SGs of your interest to help develop P2800.2

Contacts

P2800.2 WG

Andy Hoke,
Andy.Hoke@nrel.gov
Manish Patel,
mpatel@southernco.com

https://sagroups.ieee.org/2800-2/
https://standards.ieee.org/ieee/2800.2/10616/

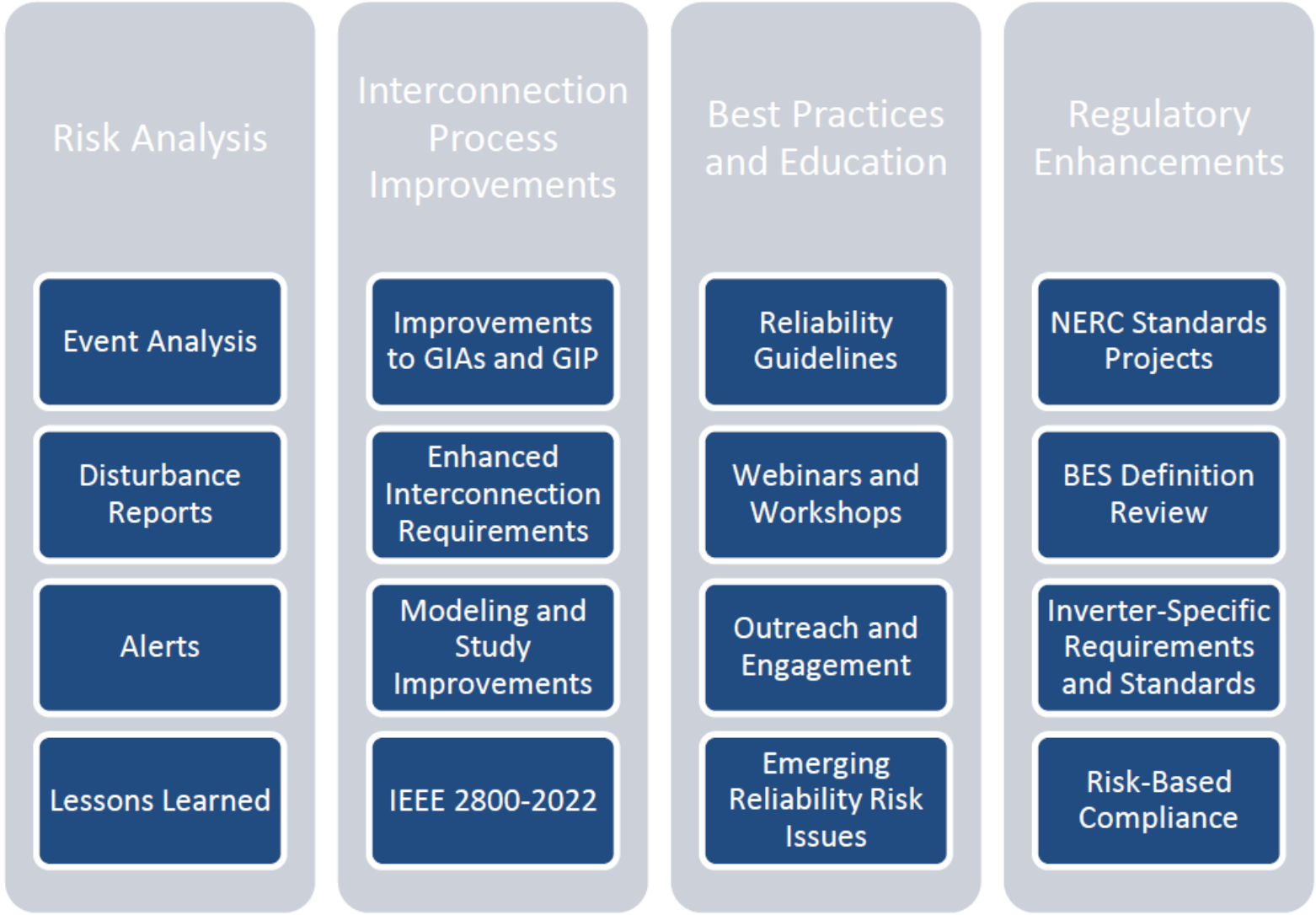
IEEE 2800-2022 is available at:

- https://standards.ieee.org/project/2800.html
- https://ieeexplore.ieee.org/document/9762253/

IBR-Specific Standards Enhancements

Alex Shattuck – Senior Engineer - Engineering and Security Integration, NERC

NERC IBR Strategy



NERC IBR Strategy

NERC Disturbance Reports

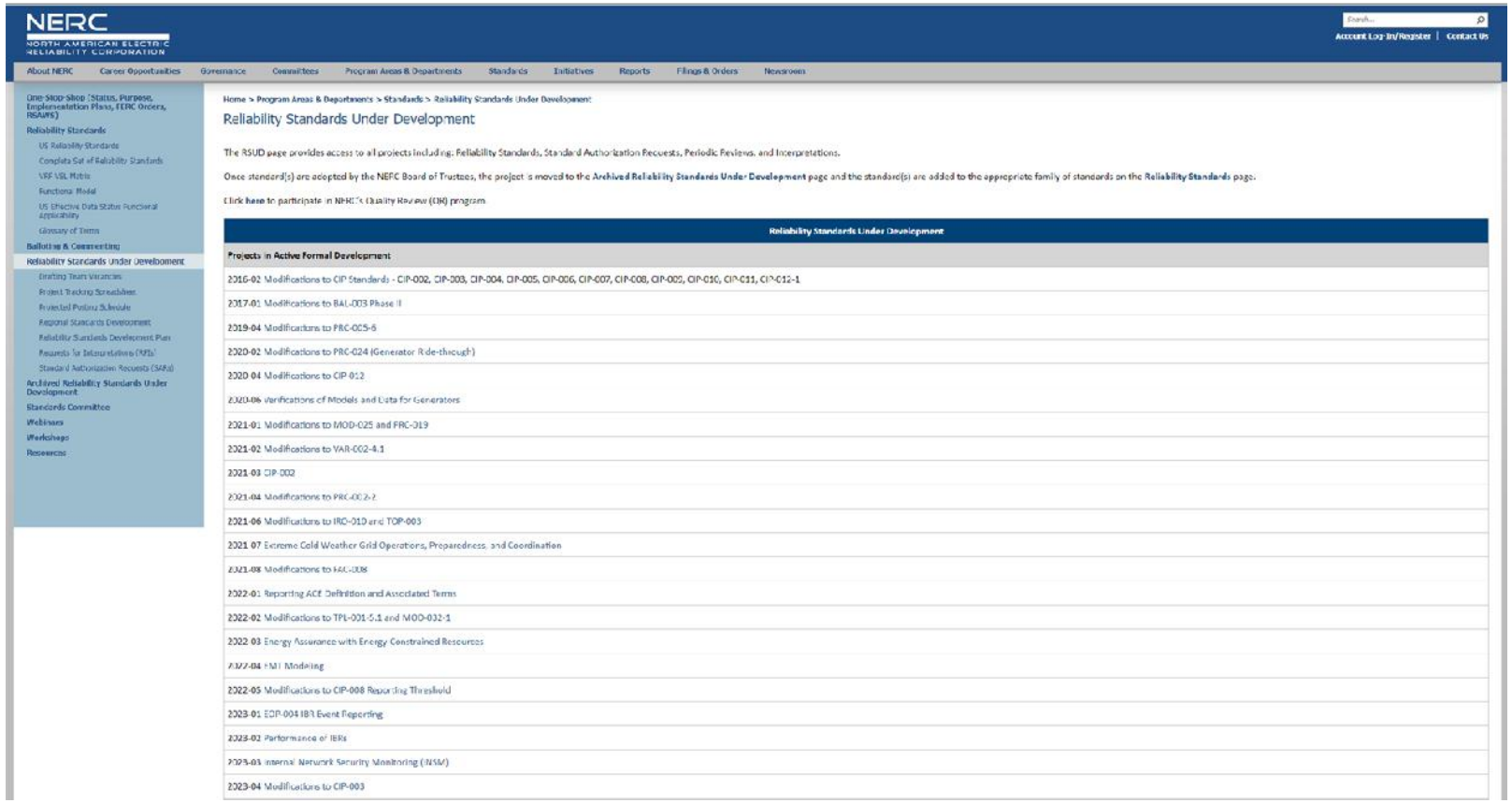
Planned Upcoming Reports:

- BESS-Related Events in California in 2022
- Texas Wind Event in 2022
- Solar PV-Related Event in Utah in 2023

https://www.nerc.com/pa/rrm/ea/Pages/Major-Event-Reports.aspx

Standards Under Development

Projects and Current Drafts Located on NERC Website



[Reliability Standards Under Development (nerc.com)]

FERC NOPR RM22-12-000

NERC Actions

- NERC has responded to FERC NOPR RM22-12-000 with a work plan:
  - To develop new or modified Reliability Standards that address the following reliability gaps related to inverter-based resources
  - Data sharing
  - Model validation
  - Planning and operational studies
  - Performance requirements

Standards Process at 10,000 ft

Short Overview of NERC Standards Drafting

- The standard drafting process starts with a Standard Authorization Request (SAR).
  - SAR can be written by any person or organization by submitting a SAR form.
  - SAR define an Industry Need (what Bulk Electric System benefit does the proposed project provide).
  - SAR must be presented to, and accepted by the NERC Standards Committee.
- Once a SAR is accepted, drafting team members are nominated through the nomination form.
  - Drafting team members are selected from the nominees.
- Standards drafting process begins and the drafting team:
  - Responds to comments on the SAR.
  - Creates draft language.
  - Responds to comments that come from the balloting process.
- Standard is deemed complete after posting responses to all comments and conducting a final ballot. After a final ballot, Standards must be approved by the NERC Board and filed with FERC (or provincial government)

Project 2020-04

IBR Ride Through

- **Background:**
  - **Standard(s) affected:** PRC-024
  - Retire PRC-024-3 and replace it with a performance-based ride-through standard that ensures generators remain connected to the BPS during system disturbances.
  - Focus is on the generator protection and control systems that can result in the reduction of disconnection of generating resources.
- **Industry Need:**
  - Mitigate the ongoing and systemic performance issues identified across multiple Interconnections and across many disturbances analyzed by NERC and the Regions.
  - Issues have been identified in inverter-based resources as well as synchronous generators, with many causes of tripping entirely unrelated to voltage and frequency protection settings as dictated by the currently effective version of PRC-024.
- **Current Status:**
  - No Drafts

Project 2020-06

Verifications of Model and Data for Generators

- **Background:**
  - **Standard(s) affected:** MOD-026 and MOD-027
  - Revisions needed to clarify the applicable requirements for synchronous generators and to require sufficient model verification to ensure accurate generator representation in dynamic simulations.
- **Industry Need:**
  - Accurate model response is required for engineers to adequately study system conditions and it is crucial that all parameters in a model be verified in some way.
  - Will help fill current gaps as a significant number of modeling parameters are not verified in the typical verification tests currently used to comply with MOD-026 and MOD-027
- **Current Status:**
  - MOD-026-2 Draft 3

Project 2021-01

Modifications to MOD-025 and PRC-019

- **Background:**
  - **Standard(s) affected:** MOD-025 and PRC-019
  - MOD-025: To address issues regarding verification and data reporting of generator active and reactive power capability. Current time of work vs value of data is not sufficient.
  - PRC-019: Address numerous issues to make the standard inclusive of all generating resources.
- **Industry Need:**
  - MOD-025: To provide more useful data through verification activities performed by equipment owners.
  - PRC-019: Standard addresses important reliability need for protection coordination and clarity is needed to ensure requirements are inclusive of all generating resources.
- **Current Status:**
  - MOD-025-3 Draft 2
  - PEC-019 Draft 2

Project 2021-02

Modifications to VAR-002-4.1

- **Background:**
  - **Standard(s) affected:** VAR-002
  - To address ambiguities of voltage and reactive resource Requirements concerning dispersed power producing resources.
- **Industry Need:**
  - Reactive support and voltage control are Essential Reliability Services and thus, clarity on the applicability of requirements to IBR is essential with the current grid transformation.
- **Current Status:**
  - VAR-002-5 Draft 2

Project 2021-04

Modifications to PRC-002 Phase II

- **Background:**
  - **Standard(s) affected:** PRC-002
  - To modify the requirements to ensure adequate data is available and periodically assessed to facilitate the analysis of BES disturbances, including in areas of the Bulk Power System (BPS) that may not be covered by the existing requirements.
- **Industry Need:**
  - Location requirements and associated periodic assessments need to be revised such that required data is available for the purposes of post-mortem event analysis and identifying root causes of large system disturbances.
- **Current Status:**
  - PRC-002-4 Final Draft

Project 2022-02

Modifications to TPL-001 and MOD-032

- **Background:**
  - **Standard(s) affected:** TPL-001 and MOD-032
  - Clarifications needed “to address terminology throughout the standard that is unclear with regards to inverter-based resources“
  - Enhancements to MOD-032 to include “data requirements and reporting procedures” for Distributed Energy Resources
- **Industry Need:**
  - Transmission planning and modeling requirements are essential to the reliability of the BPS, thus clarity on the applicability of requirements to IBR is essential with the current grid transformation.
- **Current Status:**
  - MOD-032 Draft 2
  - TPL-001 No Drafts

Project 2022-04

EMT Modeling

- **Background:**
  - **Standard(s) affected:** FAC-002, MOD-032, and TPL-001
  - To include Electromagnetic Transient (EMT) model and studies in planning-related NERC Standards to ensure reliable operation of the BPS moving forward.
- **Industry Need:**
  - Currently a reliability-related need and benefit by ensuring TPs and PCs have the models and tools necessary to adequately conduct reliability assessments under increasing levels of inverter-based resources. This requires the collection of EMT models by applicable entities and TPs and PCs to conduct EMT studies where needed.
- **Current Status:**
  - No Drafts

Project 2023-01

EOP-004 IBR Event Reporting

- **Background:**
  - **Standard(s) affected:** EOP-004
  - Enhancements focused on ensuring timely reporting by industry to the Electric Reliability Organization (ERO) Enterprise through reporting of events involving inverter-based resources (IBRs)
- **Industry Need:**
  - Reporting of generation loss events, per the current EOP-004, uses relatively large size thresholds more suitable for synchronous generation; however, NERC and the Regional Entities have analyzed multiple widespread solar PV loss events (some also involving other generation losses as well) across a large number of resources that did not meet the current EOP-004 criteria.
- **Current Status:**
  - No Drafts

Project 2023-02

Performance of IBRs

- **Background:**
  - **Standard(s) affected:** PRC-004
  - Multiple NERC disturbance reports have identified the undesired performance of bulk power system (BPS)-connected inverter-based resources (IBRs) during grid faults, and have elaborated on the systemic and significant BPS reliability risks that this undesired performance can pose.
- **Industry Need:**
  - Addresses the reliability-related need and benefit by requiring analysis and mitigation of unexpected or unwarranted protection and control operations from inverter-based resources following the identification of such a performance issue.
  - The location requirements and associated periodic assessments need to be revised. These revisions are necessary so that required data is available for the purposes of post-mortem event analysis and identifying root causes of large system disturbances.
- **Current Status:**
  - No Drafts

Global Power Systems Transformation Consortium

Jason MacDowell – 5 min


GLOBAL PST
CONSORTIUM

GPST Foundational Pillars Drive Change

1. System Operator Research & Peer Learning

ESIG

Perform cutting edge applied research to create novel system operator solutions and globally disseminate and infuse new insights through peer learning

2. System Operator Technical Assistance

NREL Transforming ENERGY

Provide implementation support to scale established best practice engineering and operational solutions

3. Foundational Workforce Development

Imperial College London

Build the inclusive and diverse workforce of tomorrow through enhanced university curriculum and technical upskilling for utility and system operator staff

4. Localized Technology Adoption Support

IEEE Advancing Technology for Humanity

Adapt modern power system technologies to individual country contexts through testing programs and standards development activities

5. Open Data and Tools

VTT

NREL Transforming ENERGY

Support rigorous planning, operational analysis and enhanced real-time system monitoring through open data and tools

CORE TEAM – All Core Team members contribute to all activity pillars

olade · NREL Transforming ENERGY · EPRI Electric Power Research Institute · ESIG · IEEE Advancing Technology for Humanity · DTU · Fraunhofer CINES · CSIR · Imperial College London · VTT

REGIONAL LEADS – Coordinate regional peer learning networks and country-level TA delivery efforts for Africa, Asia, and Latin America and the Caribbean

ASEAN Centre for Energy (ACE) · olade Organización Latinoamericana de Energía · CSIR Touching lives through innovation

INTERIM SECRETARIAT – Work program coordination, partnerships and support, outreach, etc.

NREL Transforming ENERGY

IEEE PES Power & Energy Society®

IEEE

Goal Enablers & Implementation

Goals: Operate a 100% IBR Transmission System by 2025 or other regional goals

Enablers to achieve SO goals

- ✓ **Clear definition & adoption of new system needs & services framework**
- ✓ **Advanced techniques to define and ensure resource, energy and flexibility adequacy**
- ✓ **Deployment of advanced technology capabilities (e.g., GFM) to meet grid needs & provide services**
- ✓ **Refined stability tools, models, methods & metrics**
- ✓ **Advanced operational capabilities (e.g., control room of the future)**
- ✓ **DER architecture, operation & impact**

Implement via top projects*

1. System Needs & Services Implementation Council
- NGESO Pathfinder project expansion

2. Resource Adequacy & Integrated Planning Implementation Council
- Next-gen RA & planning tools

3. Grid Forming Inverters: GFM Implementation Council
- GFM field test & demonstrations
- Cross-cutting standards development & technology adoption

4. Stability Tools, Models & Data Implementation Council
- Stability Tools for 100% IBR
- Improved accuracy of phasor and EMT tools & models
- Open-source tool development/data interoperability

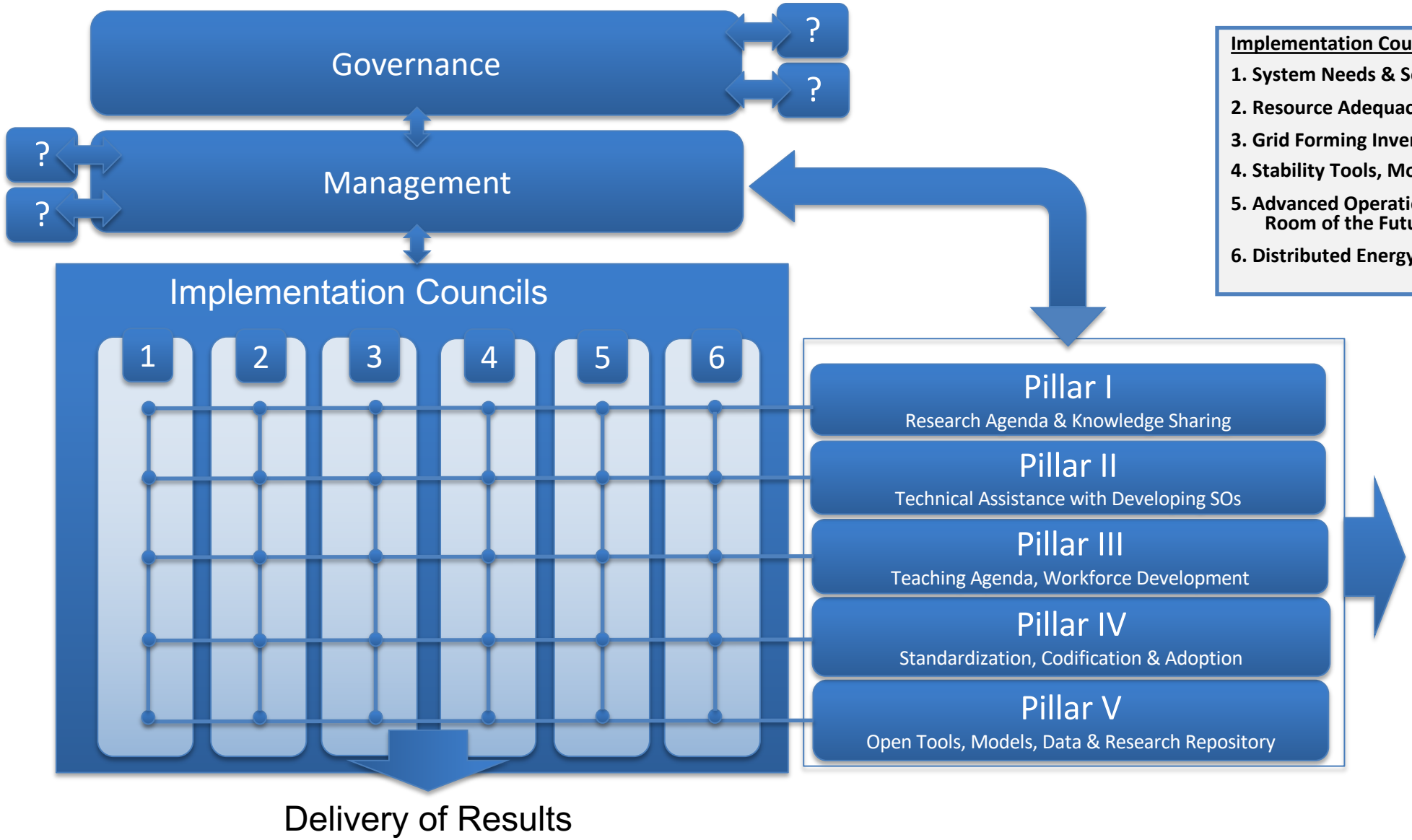
5. CROTF Implementation Council
- Advanced operational capabilities

6. Distributed Energy Resources Implementation Council
- DER system architecture & tool development

Next Gen GPST Structure

Effective & Streamlined:

Enabling SO Goals through Advanced Research, Systems Integration & Technology Deployment



Implementation Councils

1. System Needs & Services
2. Resource Adequacy & Integrated Planning
3. Grid Forming Inverters
4. Stability Tools, Models & Data
5. Advanced Operational Capabilities: Control Room of the Future
6. Distributed Energy Resources

Key GFM Implementation Council Initiatives

PURPOSE - Break the chicken-egg cycle through deployment and commercialization of GFM technology by:

a) identifying GFM features/requirements by system operators
b) supporting technology demonstrations and deploying GFM resources from OEMs
c) GFM resource procurement by developers
d) Standardization, codes and interconnection requirements

METHOD - Cross-pillar I, II and IV collaboration with FSOs, developers, OEMs, software developers, standardizing institutions and other stakeholders

CONFIRMED & POSSIBLE PARTICIPANTS:

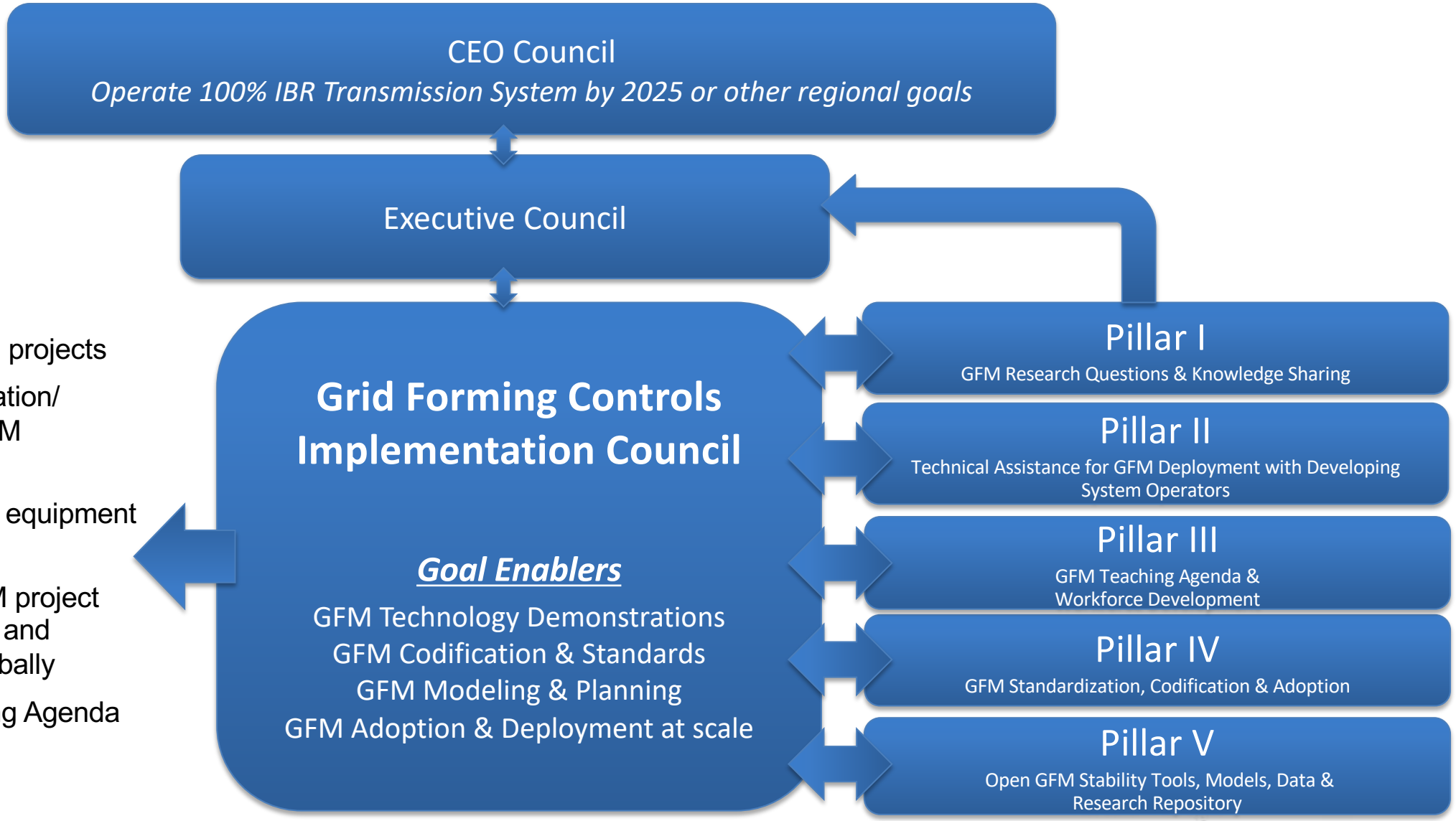
Developers
- ✓ Orstead
- ✓ Enel
- ✓ Invenergy
- ✓ Zenobe
- Nextera
- Iberdrola
- EDF RE
- E.ON
- Acciona

System Operators
- ✓ NG ESO
- ✓ AEMO
- ✓ ERCOT
- ✓ Energinet
- ✓ Eirgrid
- ✓ FinGrid
- ✓ TenneT
- ✓ Amprion
- ✓ Ilia / 50 Hertz
- MISO
- Swissgrid

OEMs
- ✓ GE
- ✓ Smartwires
- ✓ Siemens
- ✓ SGRE
- ✓ Hitachi Energy
- SMA
- Mitsubishi
- Toshiba
- Vestas
- Tesla

Software developers
- DigSilent
- Siemens PTI
- GE
- Manitoba Hydro
- EMTP
- Power World
- PowerTech Labs

Example: GFM Implementation Council



Delivery of Results

- 5 GFM demonstration projects
- Research and codification/ standardization of GFM requirements
- Experience with GFM equipment models
- Dissemination of GFM project experience, modeling and recommendations globally
- Support GFM Teaching Agenda

5. Coordination

- IEEE P2882, Guide for Validation of Software Models of Renewable and Conventional Generators for Power System Studies, Rajesh Nighot (AEMO)
- PES Renewable Systems Integration Coordinating Committee, Sudipta Dutta (EPRI)
- PES T&D Distributed Resources Integration WG, Ben York (EPRI)
- IEEE P1729, Recommended Practice for Electric Power Distribution System Analysis, Tom McDermott (PNNL)

IEEE P2882, Guide for Validation of Software Models of Renewable and Conventional Generators for Power System Studies

WORKING GROUP DETAILS

Society	IEEE Power and Energy Society Learn More >
Sponsor Committee	PE/AMPS - Analytic Methods for Power Systems Learn More >
Working Group	VPSMGCS - Validation of Power System Network Models for Generation Connection Studies Learn More >
IEEE Program Manager	Vanessa Lalitte Contact >
Working Group Chair	Rajesh Nighot

This document provides guidelines for the validation of software models for renewable and conventional generators used for power system studies. For the purposes of this guide, 'validation' is a procedure and set of acceptance criteria that can be used referred by users of the models who may not have intimate knowledge of the models' contents to confirm that the models perform well numerically and provide the intended response(s). The validation procedure can also be used for identifying data errors or inconsistencies before and after assembly of generator software models with the network models. The guide covers generator models that can be either generic or vendor-supplied proprietary models. The guide covers model validation for a broad range of power system analysis such as steady-state, short circuit, harmonic, reliability, motor starting, protection coordination, dynamic stability, Electromagnetic Transients Program (EMTP), and sub-synchronous resonance. The guide also covers the validation of generators and associated equipment models that are integrated with the transmission and distribution networks. The guide does not cover validation procedures methods for developing and testing of generator software models, nor does it cover software model validation of generator software models against field measurements and other types of site or factory tests.

Sponsor Committee	PE/AMPS - Analytic Methods for Power Systems Learn More >
Joint Sponsors	PE/EDPG > PE/EM >
Status	Active PAR
PAR Approval	2020-09-24 >

Renewable System Integration Coordinating Committee

Sudipta Dutta, RSICC Liaison Coordinator (Presenter)
Yingchen Zhang, RSICC Chair

July 19th 2023

IEEE PES General Meeting

RSICC

- The role of RSICC is to serve as a focal point within the Power and Energy Society (PES) for the identification of challenges associated with the integration of renewable energy resources, related energy carriers (storage, fuels, heat) and related electrification applications (transportation, buildings, industry.)
- In 2022, RSICC has focused on PES General Meeting, the RSICC has sponsored two panel session (National Transmission Planning, Grid Forming inverters) also contributed to other panels such as Resource adequacy, Impact of climate change.
- RSICC is leading the drafting of PES road map chapter one – renewable integration.
- Bi-weekly meetings serve as a platform for the contributors to discuss the chapter structure, assign tasks, and track the progress of the project.
- The initial version of draft is ready for review and feedbacks.

Chapter Structure

Current state: *global renewable capacity has reached 3,371 GW by 2022.*

Future state: *Global renewable capacity is expected to increase by almost 2 400 GW (almost 75%) between 2022 and 2027 in the IEA main-case forecast.*

Types of renewables: *Solar, Wind, Hydropower and pumped storage, Geothermal, Biomass, Ocean energy, Hydrogen, Small modular reactors.*

Introduction: *Climate change, Deep carbonization and Sustainable transition.*

Challenges: *Variability and uncertainty; Grid stability and reliability; Supply chain issue; Decentralization; Market and policy hurdles.*

Solutions: *Uncertainty and risk assessment and management; Transmission system upgrades: Distribution system upgrades; Smart grid technologies; T&D coordination; Market and policy enhancement*

Contributors and Progress

- Collaborative effort involving experts from ***utilities, ISOs, standards-making organizations, electrical and electronic manufacturing industry, national labs, and universities***.
- List of contributors: Yingchen Zhang, Bruce kraemer, Mark Siira, Eduardo Bettoni, Gary Hoffman, Rudi Schubert, George Becker, Hong Chen, Junbo Zhao, Anamika Dubey, Rui Yang, Elina Spyrou, Mengmeng Cai, Suman Debnath, Sudipta Dutta, Bendong Tan, Ketian Ye.
- Bi-weekly meetings serve as a platform for the contributors to discuss the chapter structure, assign tasks, and track the progress of the project.
- The initial version of draft is ready for review and feedbacks.

Distributed Resources Integration Working Group (DRI-WG), Ben York EPRI

- Under the T&D Subcommittee…active since 2001
- Mission is DER interaction with distribution system planning, operations, protection, etc.
- Going through a bit of refocusing process after leadership changes
- Website: https://site.ieee.org/pes-dri/

IEEE SA
STANDARDS ASSOCIATION

IEEE P1729

RECOMMENDED PRACTICE FOR ELECTRIC POWER DISTRIBUTION SYSTEM ANALYSIS

2023 GENERAL MEETING UPDATE

CHAIR – THOMAS.MCDERMOTT@PNNL.GOV

VICE CHAIR – MOEINI.ALI@HYDROQUEBEC.COM

SECRETARY – MIKE HANESTAD (MIKEH@RLC-ENG.COM)

IEEE LIAISON – VANESSA LALITTE, V.LALITTE@IEEE.ORG

TF CHAIR (HCA) – DAVE TURCOTTE

TF CHAIR (DYN) – BOB KERESTES

Documents at: https://ieee-sa.imeetcentral.com/p1729/

JULY 17-20, 2023

IEEE

REVISED PAR TO REMOVE VOLTAGE LEVELS

1.1 Scope

This document defines recommendations for steady-state, event-based, probabilistic, stochastic, and dynamic analysis of electric utility power distribution systems. Industrial and commercial power distribution systems, harmonic analysis, and electromagnetic transient analysis are all excluded.

1.2 Purpose

Many commercial software products and academic research projects continue to use analysis methods appropriate for transmission systems, but not for distribution systems. Many research papers submitted for publication still address questions that have been well-settled by previous work. The purpose of this Recommended Practice is to focus research attention on areas where legitimate needs exist, to identify methods that should not be used in software products, and to provide guidance on the application of new analysis methods to electric utility distribution systems.

Timeline – WG approval for first ballot round by December 2024

https://standards.ieee.org/ieee/1729/11171/

OUTLINE OF THE THIRD DRAFT ON JULY 12 (D3.2), 57 PAGES

1 - Overview
- 1.1 - Scope
- 1.2 - Purpose
- 1.3 – Word Usage

2 – Normative References

3 – Definitions, acronyms, and abbrev.
- 3.1 - Definitions
- 3.2 – Acronyms and abbreviations

4 – Recommendations for Test Feeders
- 4.1 Selection of Test Feeders to Use
- 4.2 Method of Reporting Results
- 4.3 Method of Developing New Test Feeders
- 4.4 Recommendations for Researchers
- 4.5 Recommendations for DSAT Providers
- 4.6 Recommendations for DSAT Users
- 4.7 Rec. for Data Exchange Formats

5 – Hosting Capacity Analysis
- 5.1 – Input Parameters
- 5.2 – Hosting Capacity Analysis Evaluation Metrics
- 5.3 – Evaluation Methods
- 5.4 – Evaluation Processes
- 5.5 – Evaluation Methodology
- 5.6 – Evaluation Results
- 5.7 – Result Presentation
- 5.8 – Limitations to Hosting Capacity

6 – Distribution System Dynamic Analysis
- 6.1 – Solution Details
- 6.2 – Modeling & Equipment Considerations
- 6.3 – Applications
- 6.4 – Test Systems
- 6.5 – Aggregating DER for BES
- 6.6 – Summary of Dynamic Studies

A – Bibliography

B – Hosting Capacity Examples

C – Dynamic Analysis Examples

IMPORTANT DEFINITIONS

Bulk electric system (BES): is defined at the national or international level. For example, in the United States and Canada, the BES includes grid infrastructure at 100 kV or higher, including connected generation rated 20 MVA or higher for individual units, or 75 MVA or higher for aggregate generation, also including any looped circuits rated 50 kV or higher.

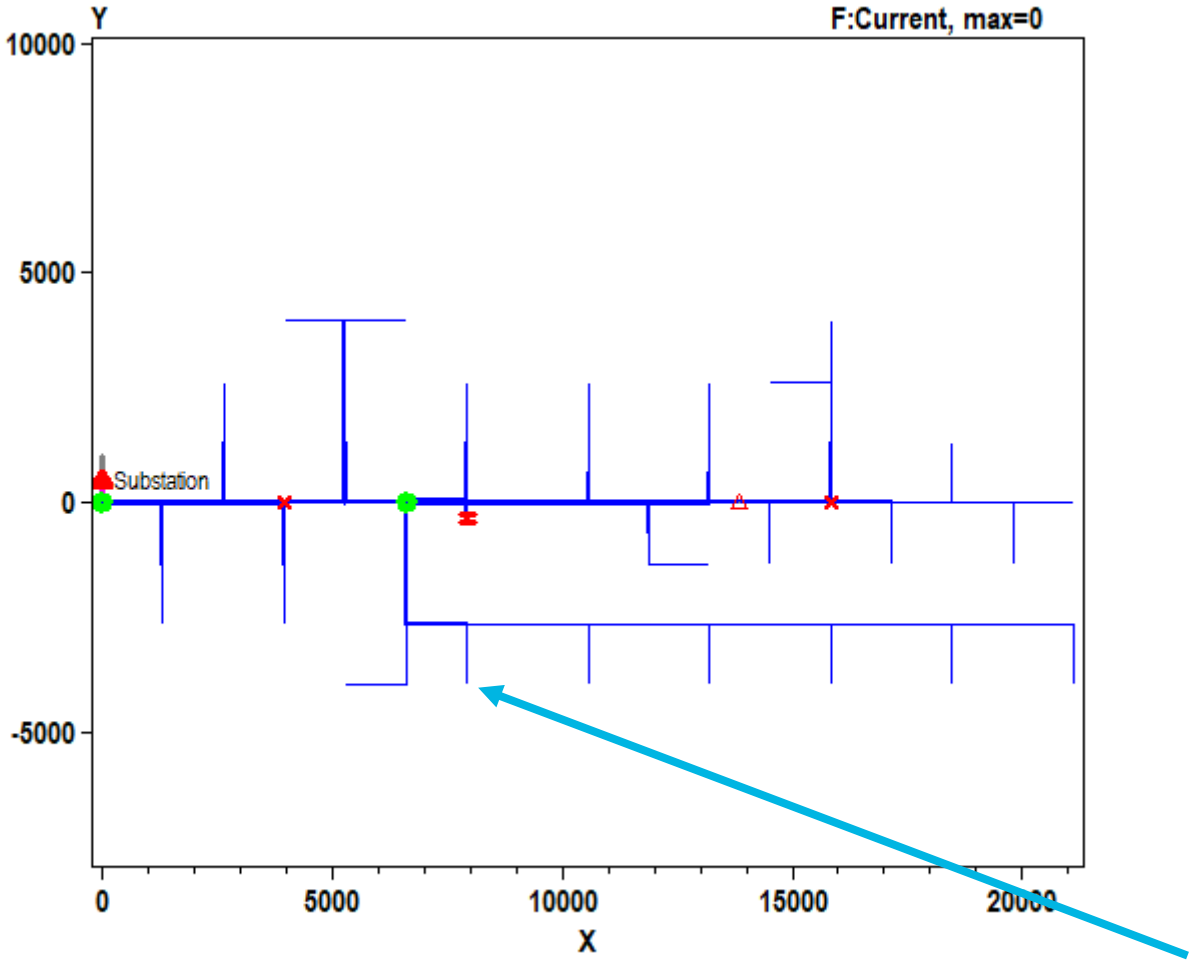
Distribution system: The electric power distribution system, for purposes of analysis, includes all equipment and controls between the Bulk Electric System (BES) and the customer meter. Transformers at the BES boundary are included, either explicitly or as part of a source equivalent. A jurisdiction or utility may define the electric power distribution system differently for other purposes.

Dynamics: time-domain or fast-phasor analysis of machine and inverter-based resource (IBR) behavior on the electric power distribution system, including the effects of phase unbalance and controls, simulated at time steps of 200 microseconds or higher.

Hosting capacity: maximum additional capacity of distributed energy resources (DER) that an electric power distribution system (DS) can accommodate at individual locations using existing power system infrastructure, configuration, and control equipment without adversely impacting reliability, power quality, safety, or the operation of existing or approved connections.

Sub-transmission system: A jurisdiction or utility may define part of the electric power system, between the BES and other parts of the distribution system, as sub-transmission. The lines are typically radial and operate at less than 100 kV. For purposes of analysis, sub-transmission is part of the electric power distribution system. IEEE Std. 2800 may apply to DER connected to sub-transmission systems.

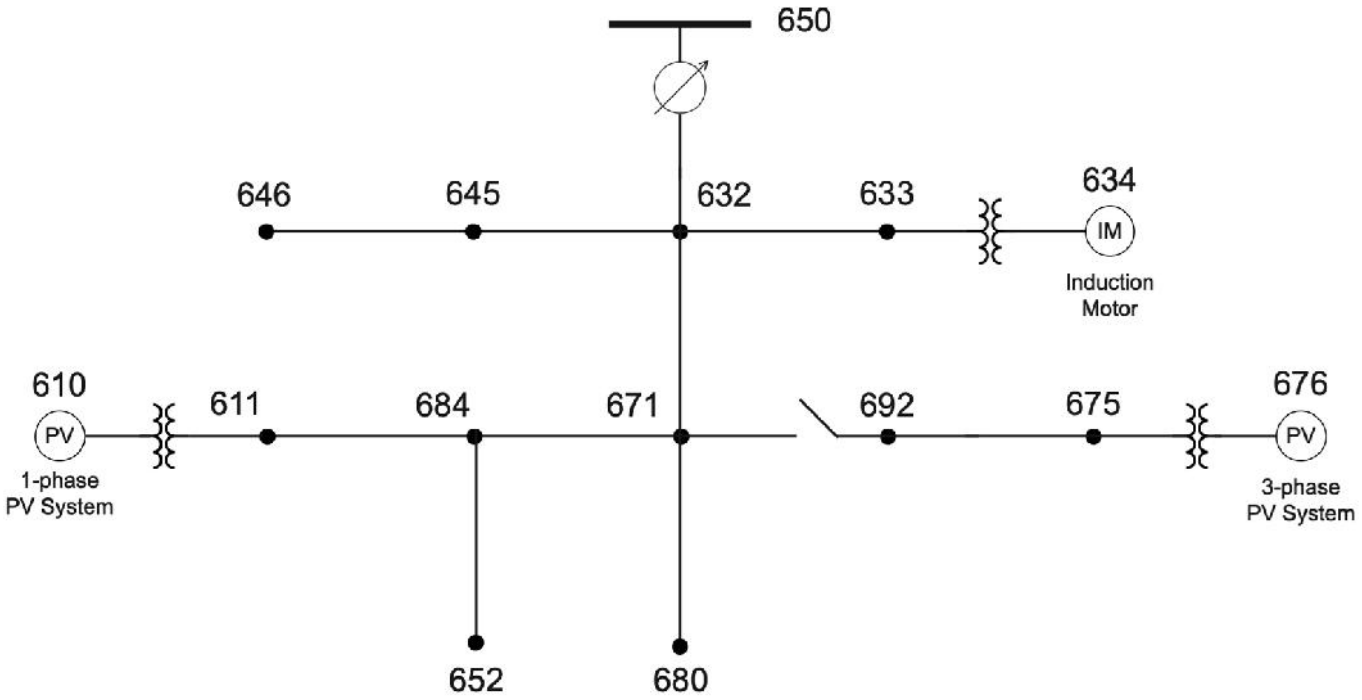
HOSTING CAPACITY TEST FEEDER

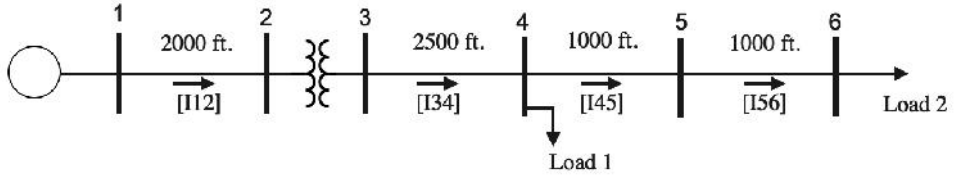


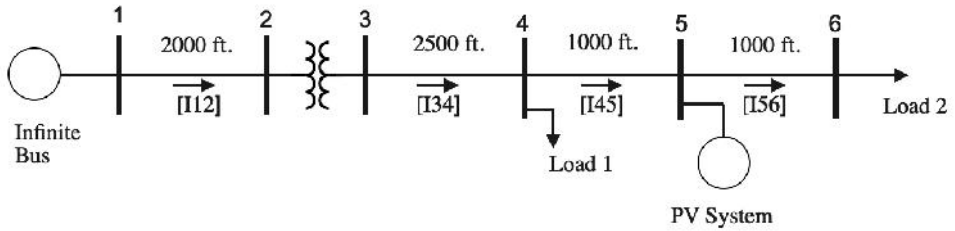
$$d = \frac{|\Delta V|}{|V_T|} = \frac{1}{V_T^2}\sqrt{\left(V_T^2 + R\Delta P + X\Delta Q\right)^2 + \left(X\Delta P - R\Delta Q\right)^2} - 1$$

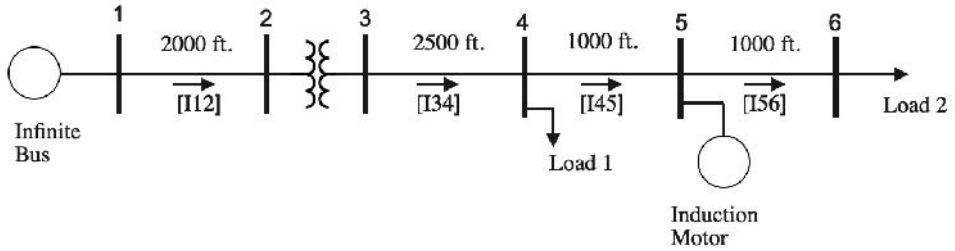
Xfmr MVA	kV	R	X	R [Ω]	X [Ω]
20	12.47	1%	8%	0.0778	0.6220
Linecode	**R/mi**	**X/mi**	**Len [ft]**		
1	0.306	0.6134	6600	0.3825	0.7668
2	1.688	0.839	3960	1.2660	0.6293
3	5.439	0.837	1320	1.35975	0.20925
Z pcc [Ω]				3.0860	2.2273
VT [V]	12470				
ΔP [W]	9.22E+05		Term 1	158346192	
ΔQ [VAR]	0.00E+00		Term 2	2053527.82	
d	**1.84%**		**ΔI [A]**	**42.69**	

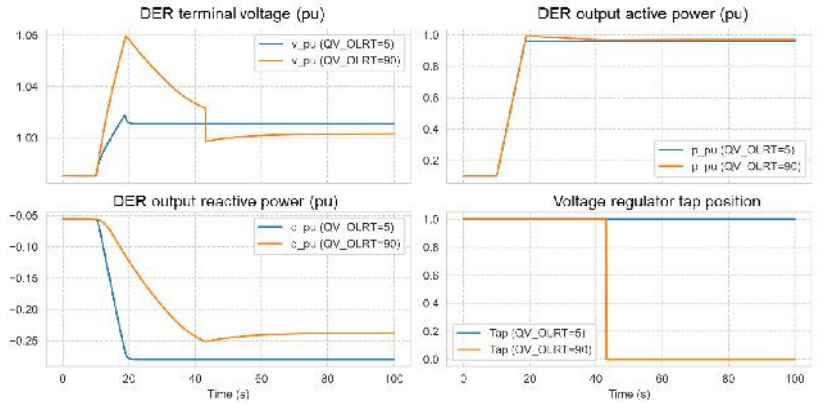
DISTRIBUTION DYNAMICS TEST FEEDERS











https://github.com/rkerestes/IEEE1729DynamicsTF

General Thoughts on Wind/Solar Interconnection for Distribution

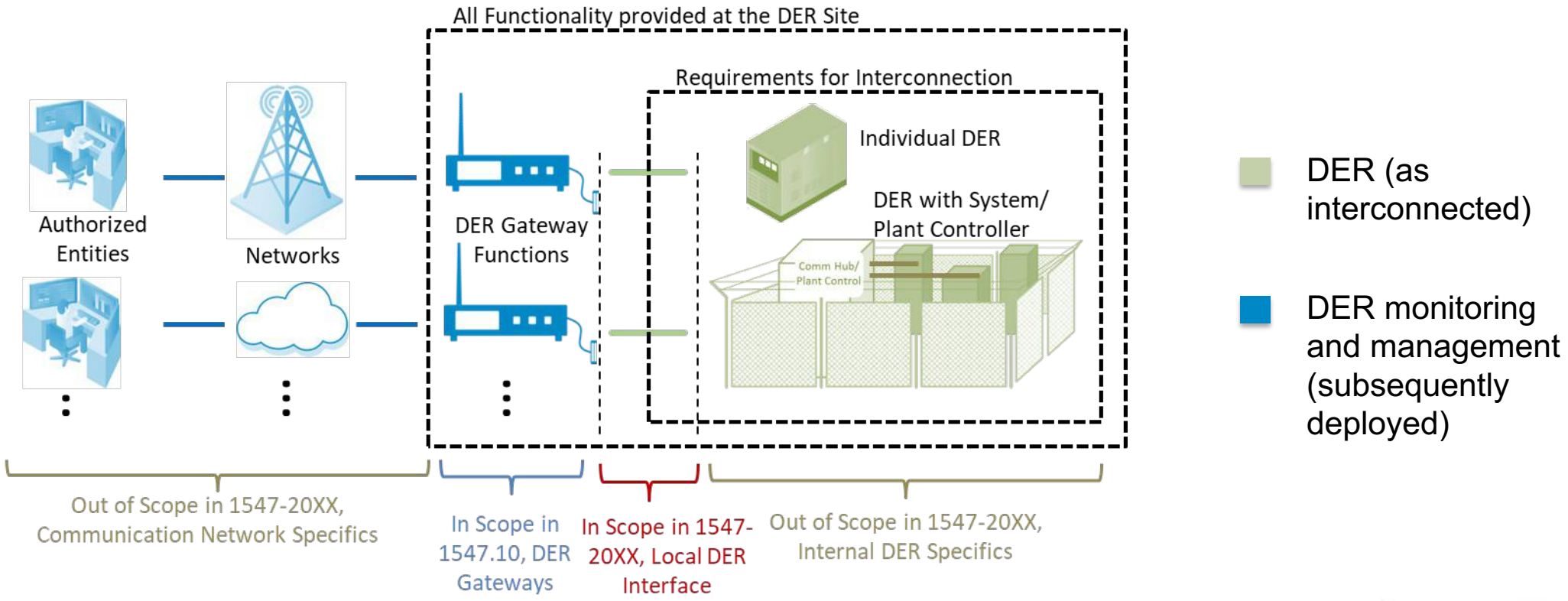
- Minimum capability and performance requirements emerging along IEEE 1547 and IEEE 2800
- Verifying Performance in pre-commissioning plant-level design evaluation important area for improvement of interconnection process, requirements, and verification
- Opportunities for global knowledge exchange, learning, and collaboration

6. Old Business

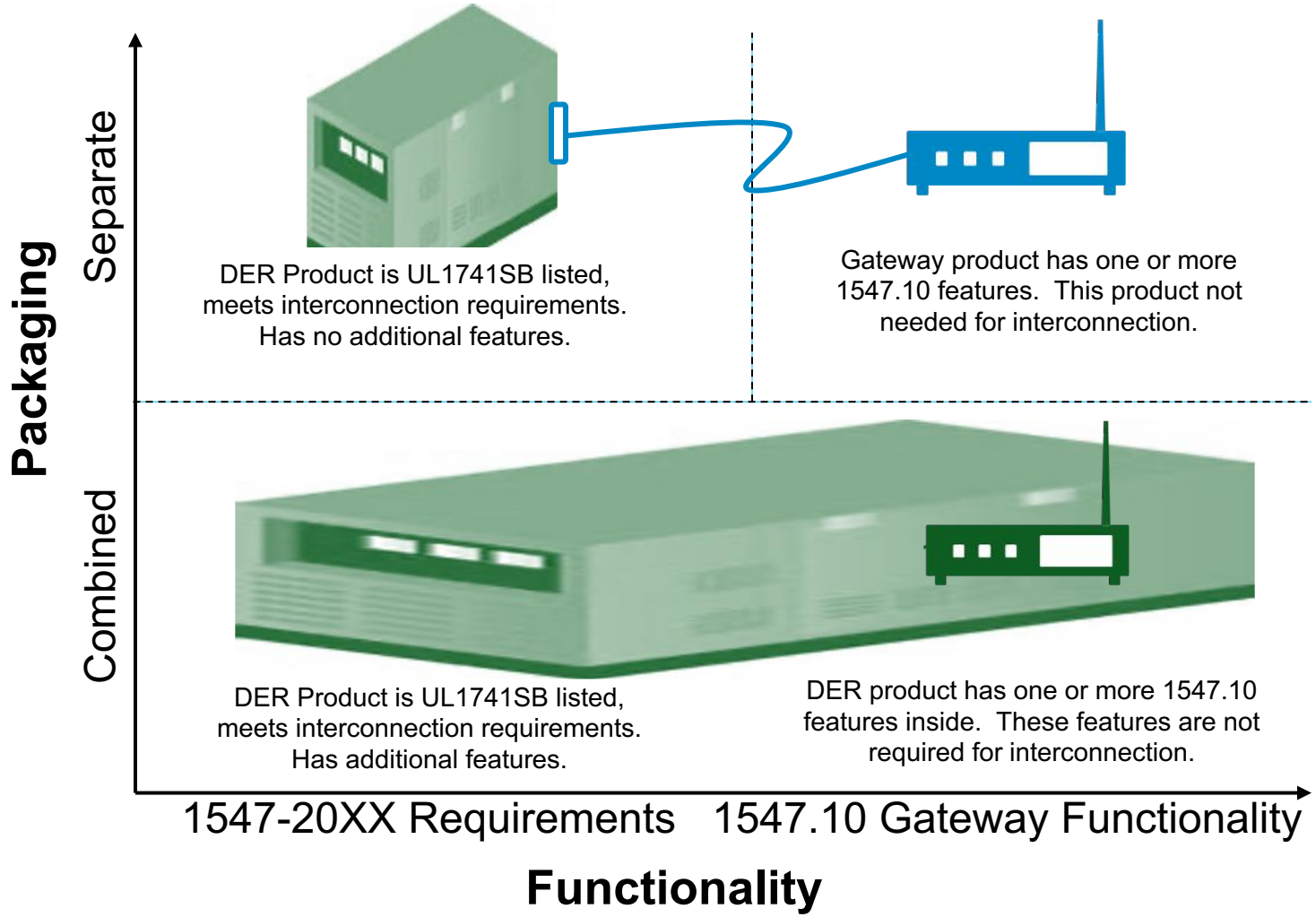
- 2022 PES GM: Questions on the scope of Gateway, P1547.10. Is it only distribution? Is there possible confusion for transmission-connected DER?
  - *Focused on distribution-connected resources*
  - *Augmenting IEEE 1547 (in its published 2018 version)*
  - *Located at DER site but not necessarily integrated into DER*
  - ***See next slide for proposed definition***
- Report on SC sponsored Panels or Papers at 2023 Orlando GM
- Webmaster http://sites.ieee.org/pes-edpgcom-wsppidsc/

P1547.10 Leadership Proposed Definition

A DER Gateway is a <u>set of advanced functions</u> such as intelligence, monitoring, control, protocol translation and cybersecurity at the grid-edge, <u>that augments IEEE 1547</u>.



DER GATEWAY AND THE DER



6. Old Business

- 2022 PES GM: Questions on the scope of Gateway, P1547.10. Is it only distribution? Is there possible confusion for transmission-connected DER?
  - *Focused on distribution-connected resources*
  - *Augmenting IEEE 1547 (in its published 2018 version)*
  - *Located at DER site but not necessarily integrated into DER*
  - ***See next slide for proposed definition***
- Report on SC sponsored Panels or Papers at 2023 Orlando GM
- Webmaster http://sites.ieee.org/pes-edpgcom-wsppidsc/

Report on SC sponsored Panels or Papers at 2023 Orlando GM

- 2023 PES GM Local Chapter Panel “IBR Interconnection with high voltage Transmission networks – Risks, Requirements and Compliance”
- Others?

8. Future Meetings and Sessions Plans

- 2024 IEEE PES Joint Technical Committee Meeting, Jan 7-11, New Orleans, LA
  - No EDPG WSPPID-SC or WSPI-WG meetings planned
  - No EDPG Wind and Solar Plant Design WG meetings planned?
- 2024 IEEE PES General Meeting, July 21-25, Seattle, WA
  - ***See next slide for proposed tutorials, panels, and papers***

Proposals for 2024 IEEE PES General Meeting

2024 Tutorials

- EDPG-sponsored *IEEE 2800 Tutorial—Understanding origin and specifications of technical minimum capability and performance requirements* (joint with PSRC and EMC)

2024 Panels

- EDPG supported panel on *Requirements for fault ride through behavior from future IBRs and protection equipment* (sponsored by PSRC)

2024 Papers

- EDPG supported paper on *IEEE 1547/.2 Application Guidance for Distribution and Bulk System Protection Engineers* (sponsored by SC21)

9. Adjourned 3pm July 19, 2023