

IEEE P2800.2 5th Working Group Meeting

ANDY HOKE, P2800.2 WG CHAIR

MANISH PATEL, SECRETARY

JENS BOEMER, BOB CUMMINGS, DIVYA CHANDRASHEKHARA,

JULIA MATEVOSYAN, MAHESH MORJARIA, STEVE WURMLINGER, VICE CHAIRS

April 25-27, 2023

Some content derived from IEEE 2800 WG and Jens Boemer, 2800 WG Chair

Please record your attendance

- Please record your attendance at:
<https://imat.ieee.org/attendance> -> select “EDPG Energy Development & Power Generation”
-> select [PE/EDPG/WSPPID/WSPI/WSPI-TV Attendance](#)
or
<https://imat.ieee.org/wg500900043/attendance-log?d=04/25/2023&p=4318500005&t=500900043>
- **Meeting attendance determines eligibility for WG voting membership**
 - Credit for attendance will be given to those who attend at least 2 of 3 days this week
- In lieu of verbal roll call, **please type your name and affiliation in the chat window**
 - IEEE affiliation FAQs: <http://standards.ieee.org/faqs/affiliation.html>
- Introduce new IEEE Program Manager: Vanessa Lalitte

Acknowledgements and disclaimers

- 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.
- Draft standard disclaimer:
 - P2800.2 is an unapproved draft of a proposed IEEE Standard. As such, the document is subject to change, any draft requirements and figures shown in this presentation may change.
- For those working group members whose effort on the standard was partially or fully supported by the U.S. DOE's National Renewable Energy Laboratory, the following statement applies:
 - This work was supported in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office and Wind Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government.

Agenda

Day 1

- Call to order and welcome
- Roll call and declaration of affiliation
 - (via chat window)
 - Introduce new IEEE program manager: Vanessa Lalitte
- P2800.2 Working Group policies and procedures
- IEEE patent, copyright, and participant policies.
 - Call for potentially essential patents
- Approval of agenda and past minutes
- Subgroup 1: General Requirements
- Subgroup 2: Type Tests
- Role of P2800.2 in IEEE 2800 adoption

Day 2

- External presentation: FGW Presentation – German approach to IBR unit testing and verification
- Subgroup 3: Design Evaluations
- Power Quality Task Force

Day 3

- Subgroup 4: Commissioning Tests and As-built Evaluations
- Subgroup 5: Post Commissioning Model Validation, Monitoring, and Periodic Evaluations
- Summary and next steps

US MT	Tuesday April 25	Wednesday April 26	Thursday April 27
9:00	Introduction	FGW presentation	Subgroup 4 - Commissioning and as-built
	Subgroup 1: Overall document		Subgroup 4 - Commissioning and as-built
10:00	Subgroup 1: Overall document	Subgroup 3 - Design evaluation	Subgroup 4 - Commissioning and as-built
	Subgroup 1: Overall document	Subgroup 3 - Design evaluation	Overflow time
11:00	Subgroup 2: Type tests	Subgroup 3 - Design evaluation	Subgroup 5: Post-commissioning steps
	Subgroup 2: Type tests	Power Quality Task Force	Subgroup 5: Post-commissioning steps
12:00	Subgroup 2: Type tests	Power Quality Task Force	Subgroup 5: Post-commissioning steps
	Role of P2800.2 in 2800 adoption	Power Quality Task Force	Closeout

Working Group Policies and Procedures

- We have the same P&Ps as the 2800 WG, as previously approved by the sponsor, available here:
https://sagroups.ieee.org/2800/wp-content/uploads/sites/336/2020/08/EDPGC-Sponsored-WG-P-and-PV2Jan2020_IEEE-P2800-WG.pdf
 - Introduced at previous WG meetings
 - Link provided in meeting agenda
- Given ~120 WG members total, we have a quorum if 26 members or more are present

Last meeting's minutes

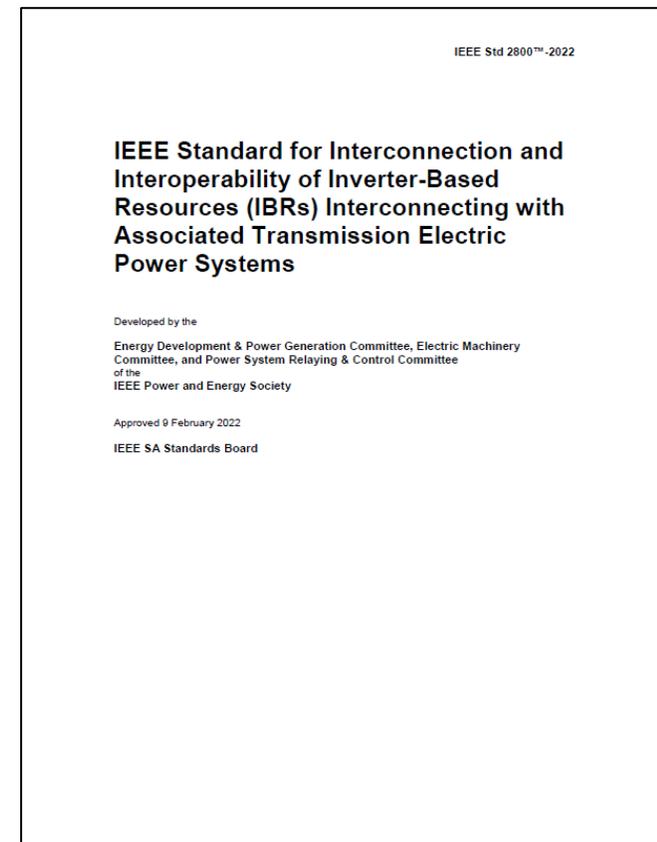
- The minutes of the last WG meeting (December 2022) were posted on iMeet Central shortly after the meeting
- WG members were notified of an opportunity to review the minutes upon posting
- **Call for comments/approval of last meeting minutes**

IEEE patent policy and legal notices

- IEEE Patent Policy
 - <https://development.standards.ieee.org/myproject/Public/mytools/mob/slideset.pdf>
 - **Call for potentially essential patents**
- IEEE Copyright Policy:
 - <https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/other/copyright-policy-WG-meetings.potx>
- IEEE Participant Behavior:
 - <https://standards.ieee.org/wp-content/uploads/import/documents/other/Participant-Behavior-Individual-Method.pdf>
- IEEE Privacy Policy - <https://www.ieee.org/security-privacy.html>
- (Links provided in meeting agenda)

Status of IEEE 2800-2022

- 94% ballot approval. **Published April 22, 2022.**
- Harmonizes interconnection requirements for large solar, wind, and storage plants (and other inverter-based resources)
- A consensus-based standard developed by over ~175 Working Group participants from utilities, system operators, transmission planners, & OEMs over 2+ years
- IEEE standards are **voluntary until adopted by an appropriate entity**. Such entities are encouraged to consider adoption of 2800 to the extent feasible even before IEEE P2800.2 is complete. Many entities have begun adoption process.



Available at
<https://standards.ieee.org/ieee/2800/10453/>

P2800.2 Overview (from PAR)

- Title:
 - Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems
- Scope:
 - Define **recommended practices** for test and **verification procedures to confirm plant-level conformance** of IBRs interconnecting with bulk power systems in compliance with IEEE Std 2800
 - Applies to IBRs in **transmission** and **sub-transmission systems** (both meshed and radial)
 - May also apply to isolated IBRs interconnected to an AC transmission system via dedicated voltage source converter high-voltage direct current (VSC-HVDC) transmission facilities, e.g., offshore wind farms
 - Specifications for the equipment, conditions, tests, modeling methods, and other verification procedures that should be used to demonstrate conformance with IEEE 2800
- Includes:
 - **Type tests** (unit level, not full compliance)
 - **Design evaluation**, including modeling
 - **As-built evaluation** and **commissioning tests**
 - **Post-commissioning model validation, monitoring, periodic tests, and periodic verifications**
- Recommended practice: Uses “should” language, not “shall” language.

P2800.2 wants to hear from you

- Several P2800.2 leaders have mentioned that they keep hearing from the same handful of voices
 - This puts us at risk of confirmation bias, or of writing a document that only makes sense to a handful of “experts”
- We want to hear from more of you
- That can be:
 - During this WG meeting
 - Via an email or a call to a WG leader
 - During a subgroup or task force meeting
- The more people we hear from, the better the standard will be



P2800.2 – Relationship to the IBR interconnection process

- Defining (or re-defining) an interconnection process is not in the scope of IEEE P2800.2
- Procedures recommended by P2800.2 are intended to be used as part of an interconnection process:
 - P2800.2 type tests can inform interconnection process
 - P2800.2 design evaluation, commissioning tests, and post-commissioning model validation can occur during interconnection process (along with other steps not in scope of P2800.2)
- In an early meeting, we agreed that in P2800.2, our job is (only) to **write procedures to verify that IBRs conform to IEEE 2800**
 - Important discussions related to interconnection that do not relate to *IEEE 2800 conformance verification* can take place *primarily outside* P2800.2
 - By providing standardized procedures, we are taking a major step to improve the interconnection process (without trying to fix everything)

IEEE P2800.2 Subgroup Scopes

SG 1
Overall document and general requirements

Excerpt of 2800 Table 20: Verification Methods Matrix

Power Quality Task Force

Requirement	RPA at which requirement applies	SG 2	SG 3	SG 4		SG 5				
		Type tests	Design Evals.	Commissioning and As-built		Post-commissioning model validation, monitoring, etc.				
		IBR unit-level tests (at the POC)		IBR plant-level verifications (at the RPA)						
		Type tests ¹⁵²	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	IBR developer / TS owner / TS operator	IBR developer / TS owner / TS operator	IBR developer / TS owner / TS operator	IBR 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	
4.12 Integration with TS grounding	POM	NR	R	R	NR	NR	NR	D	NR	
Clause 5 Reactive Power—Voltage Control Requirements within the Continuous Operation Region										
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 & POM	NR ¹⁵³	R	R	R	R	D	D	D	
6.2 Fast Frequency Response (FFR)	POC & POM	R ¹⁵⁴	R	R	R	R	D	D	D	
Clause 7 Response to TS abnormal conditions										
7.2.2 Voltage disturbance ride-through requirements	POC ¹⁵⁵ & POM ¹⁵⁶	R	R	R	NR	R	R	D	D	
Clause 8 Power quality										
8.2.2 Rapid voltage changes (RVC)	POM	NR	R	R	R	D	R	D	D	
8.2.3 Flicker	POM	NR	NR	NR	R	D	R	N/A	D	
8.3.1 Harmonic current distortion	POM	R ¹⁵⁷	R	R	R	D	R	N/A	D	
8.3.2 Harmonic-voltage distortion	POM	D	D	D	D	D	D	D	D	
8.4.1 Limitation of cumulative instantaneous over-voltage	POM	R	R	R	NR	NR	R	NR	NR	
8.4.2 Limitation of over-voltage over one fundamental frequency period	POM	D	R	R	NR	NR	R	NR	NR	

Subgroup 1 material – Clause 1 (Overview)

- Moved language on collaboration between parties to clause 1.5 and edited language. (Previously in Clause 4)
 - Removed suggested language related to “trial operation”
- Edited language allowing alternate verification procedures for technologies not explicitly considered in 2800. Maintains intent while adding converter-interfaced hydro as another example.

Subgroup 1 material – Definitions

- Brought in several definitions from 2800
- Edited definition of *conformity assessment* to align with ISO-IEC 17000.
- “Finalized” definitions of *model validation*, *model benchmarking*, and *model verification*
- Minor edits to other definitions

Subgroup 1 material – Flow chart edits

- Type tests: changed “tests passed” to “tests completed”
- Commissioning tests:
 - Changed “plant placed in service” to “IEEE 2800 conformity verification process is complete”
 - With note “Additional conformity verification occurs when plant is in service”
 - Added “If plant does not meet IEEE 2800 requirements, it should be considered that the cause could be outside the plant”
- Post-commissioning:
 - Added “If plant does not meet IEEE 2800 requirements, it should be considered that the cause could be outside the plant”

Subgroup 1 material – **New subclause 4.4**

- Title: “Requirements for which no verification procedure is provided”
- Lists 2800 requirements where one might expect to find a verification procedure, but where none is provided
 - Eight tables of requirements with reasons why no procedure is provided for each requirement
- P2800.2 lets appropriate party decide if any verification procedure is needed, and what it should be

Potential new material: **Data handoffs flowchart**

- Guides handoff of information between all steps of design, testing, verification and conformity assessment relative to IEEE 2800 requirements
- Jason MacDowell will share draft flow chart
- May appear in future P2800.2 draft

Next steps in SG1

- Address topics that cut across multiple subgroups
- Develop any general content needed (Clause 4)
- Incorporate definitions and references as they arise in other subgroups
- WG priority is filling in the details of the conformity assessment procedures in Clauses 5-10 (i.e., SG2-SG5, PQ Task Force)

Subgroup 1 – Overall document: Logistics

- Plan
 - Biweekly meetings (as needed), Mondays, 10am Mountain Time
- Leads
 - Andy Hoke (andy.hoke@nrel.gov)
 - Manish Patel (mpatel@southernco.com)
- How to get involved, join listserv, send an email message to listserv@listserv.ieee.org
 - In first line of email body, write: **SUBSCRIBE STDS-P2800-2-SG1 <Your Name>**
 - For example, “**SUBSCRIBE STDS-P2800-2-SG1 Andy Hoke**”

10 minute break – Back at 20 minutes past hour

- Subgroup 2 (Type Tests) continues next

- Reminder: record your attendance in iMat:

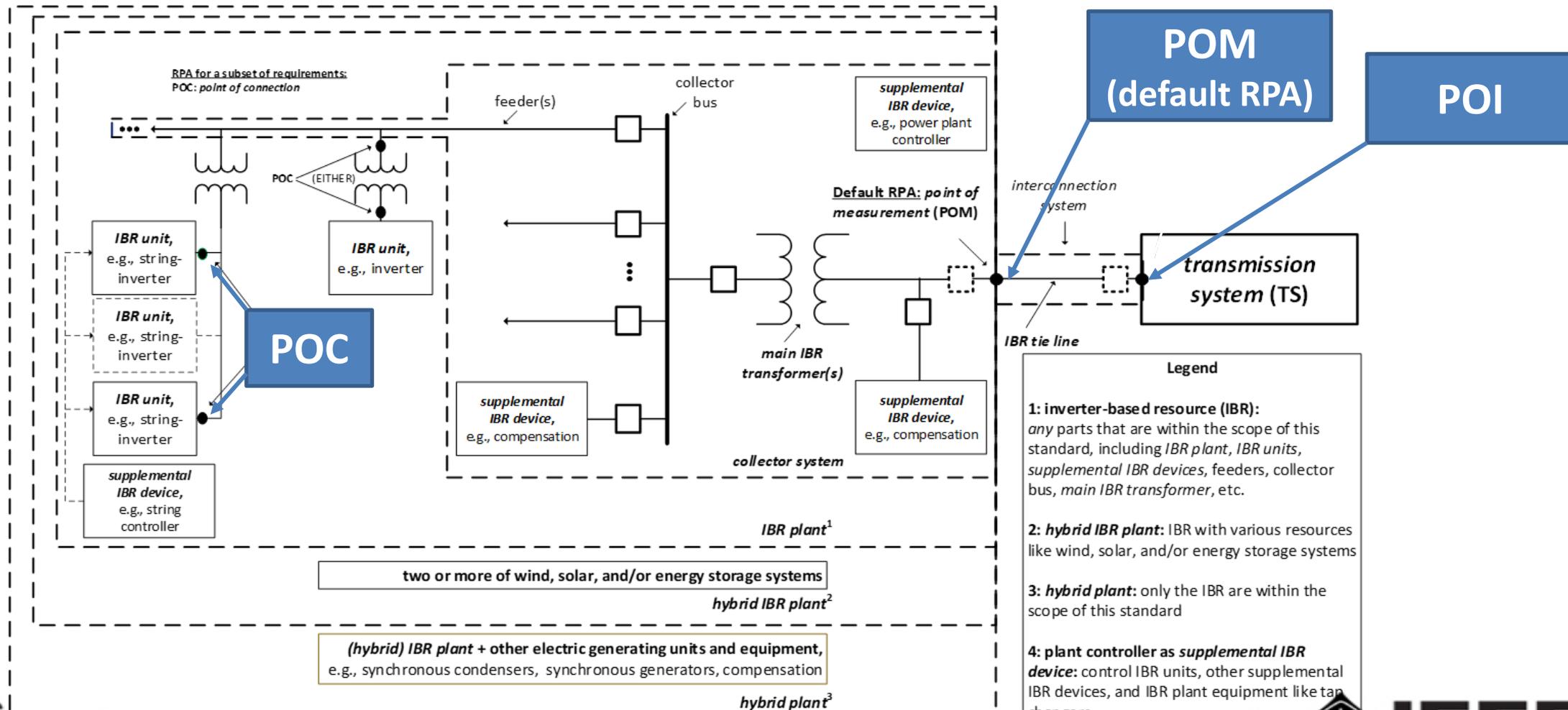
<https://imat.ieee.org/wg500900043/attendance-log?d=04/26/2023&p=4318500005&t=500900043>

Subgroup 2

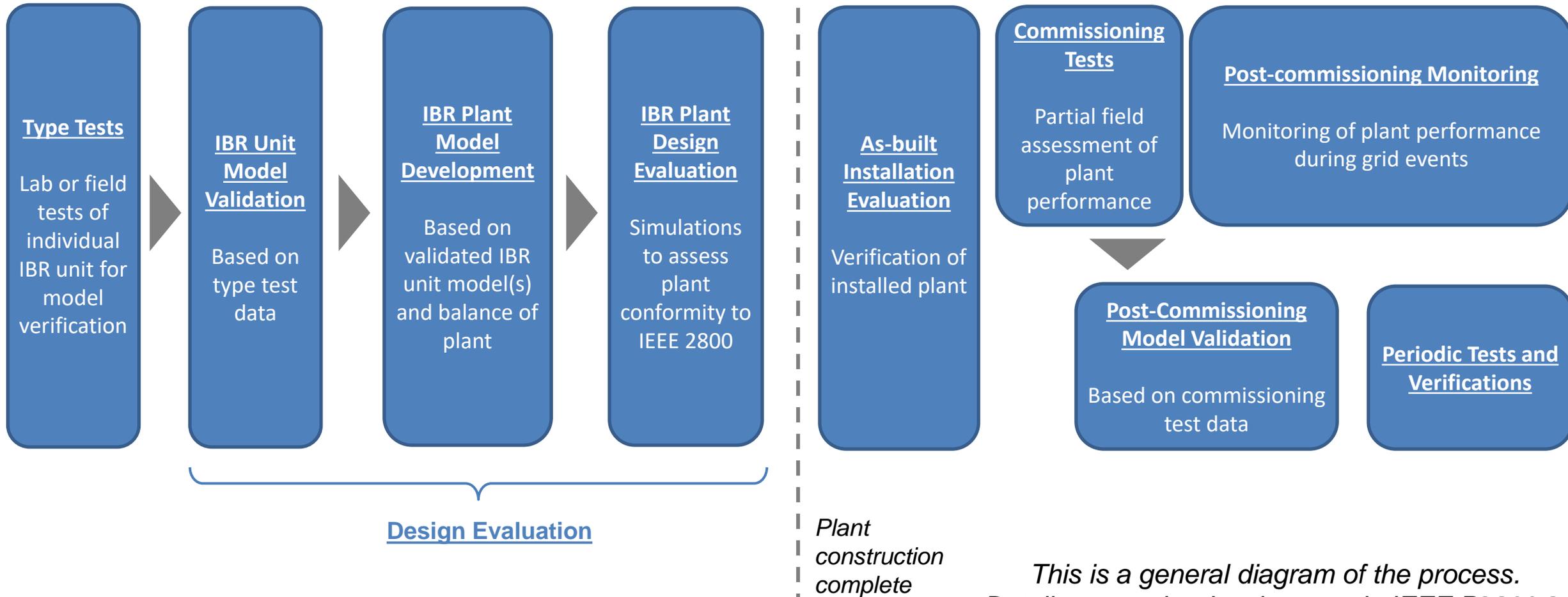
- Discussion led by Steve Wurmlinger, Pramod Ghimire, Mike Ropp

Role of P2800.2 in IEEE 2800 Adoption

Almost all requirements of IEEE 2800 apply at Point of Measurement (POM) by default



Overview of conformity assessment steps in IEEE P2800.2



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

Equipment certification?

- Almost all requirements in IEEE 2800 apply to the IBR plant (not the inverter/WTG)
- The type tests in IEEE P2800.2 do not generally have pass/fail criteria.
 - Instead, they generate data (e.g. test waveforms) to validate the unit-level model.
- Certification of inverters/WTGs to 2800 or P2800.2 by a Nationally Recognized Test Laboratory (NRTL, e.g. UL) appears unlikely
- Even “self-certification” of inverters/WTGs is not really possible because compliance is at the plant level
- Therefore an “IEEE 2800 *certified* inverter/WTG” probably will not exist
 - Instead, inverters/WTGs could perhaps be considered “2800 compatible” if 2800 requirements have been taken into consideration so that they can be used to build a 2800-compliant plant.
- This is different from the IEEE 1547/1547.1/UL 1741 paradigm on the distribution system, where pass/fail type tests and NRTL certification play a large role in conformity assessment

What is the required inverter/WTG capability for 2800 compliance?

- There are many ways to comply
- For example, an inverter could have limited reactive power capability, but still comply with 2800 if the plant designer includes appropriate supplemental equipment
- Even with ride-through capability, the required inverter-level capability is not defined by 2800 because the voltage that each inverter sees is not the same as the voltage the plant sees (and the 2800 requirement is at the plant level)
- Therefore, **OEMs and plant designers will need to work together to decide how to achieve plant-level compliance**
- This flexibility is intentional. 2800 does not want to tell anyone how to design a plant. It just specifies minimum performance capabilities for the plant. It is up to the plant designer to decide how to achieve them.

What can I do to prepare for 2800?

- OEM
 - Review 2800 requirements. Does product need to be updated to be used in a 2800-compliant plant? May need to work with plant designer(s) to decide.
 - Develop, test, and clearly describe product capabilities that a plant designer can use to build a 2800-compliant plant.
 - Provide unit-level (EMT) model and type test data to verify model
- Plant developer/EPC/consultant/owner
 - Review 2800 requirements. Collaborate with OEMs to identify product capabilities and balance-of-plant needed for plant-level compliance with 2800
 - Develop plant models that can be used to demonstrate conformance with 2800. Models should be based on OEM's validated unit-level model.
- Transmission utility/ISO
 - Work towards adoption of IEEE 2800. Determine specific requirements within range offered by 2800.
 - Determine compliance timeline
 - Keep in mind compliance is at plant level
- All: Join IEEE P2800.2 working group. Help make sure verification procedures work for you.

Adoption of IEEE 2800:

- Adoption of IEEE 2800 is not contingent upon publication/adoption of IEEE P2800.2
 - **In the absence of IEEE P2800.2, IBR owners, TS owners/operators, OEMs, etc. could develop their own test and verification procedures or use existing procedures**
- For systems experiencing IBR ride-through events/problems, some requirements may be higher priority than others (ride through of low voltage, TOV, ROCOF, phase jump)
- Needs consideration of enforcement date, grandfathering etc.
- Possible adoption methods:
 - Full adoption by simple reference
 - Full or partial adoption, clause-by-clause reference, additional requirements
- Many utilities/ISOs are already moving towards adoption

Agenda

- Day 1

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- IEEE patent, copyright, and participant policies.
 - Call for potentially essential patents
- Approval of agenda and past minutes
- Subgroup 1: General Requirements
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- Role of P2800.2 in IEEE 2800 adoption

- Day 2

- External presentation: FGW Presentation – German approach to IBR unit testing and verification
- Subgroup 3: Design Evaluations
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- Day 3

- Subgroup 4: Commissioning Tests and As-built Evaluations
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Welcome to Day 2 of IEEE P2800.2 WG meeting

- Please record your attendance at:

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FGW TR8 presentation: Grid code conformity assessment

3 minute break – Back 5 minutes past hour

- Subgroup 3 (Design Evaluation) continues next

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Subgroup 3 – Design Evaluations

5 minute break – Back 40 minutes past hour

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Power Quality Task Force

Excerpt of
2800 Table 20:
Verification
Methods Matrix

**PQ Task
Force**

Requirement	RPA at which requirement applies	SG 2	SG 3	SG 4		SG 5			
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						Post-commissioning model validation	Post-commissioning monitoring	Periodic tests	Periodic verification
						Responsible Entity			
		IBR unit or supplemental IBR device manufacturer	IBR developer / TS owner / TS operator	IBR developer / TS owner / TS operator	IBR developer / TS owner / TS operator	IBR 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
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Subgroup 4 – Commissioning and As-Built

5 minute break – Back 37 minutes past hour

- Subgroup 5 is next
- Reminder: record your attendance in iMat:

<https://imat.ieee.org/wg500900043/attendance-log?d=04/26/2023&p=4318500005&t=500900043>

Subgroup 5 – Post-Commissioning Model Validation, Performance Monitoring, and Periodic Tests

Wrap-up and Next Steps

- Please join any subgroup or task force aligned with your interest/knowledge
 - Join listserv, and send a note to the lead so they are aware
- Consider volunteering to draft procedures/content in that subgroup – that's how we move this forward

To get involved in IEEE P2800.2:

- To join Working Group:
 - If have attended two WG meetings and want to be a WG member, email Manish Patel: Mpatel@southernco.com; CC Andy.Hoke@nrel.gov
 - If not, attend two meetings and request membership
- Join listserv for any subgroup or task force of interest
- WG member iMeet site: <https://ieeesa.imeetcentral.com/p2800-2/home>
 - Contains draft documents, subgroup documents, references, etc
- Public website: <https://sagroups.ieee.org/2800-2/>

Related international standards update

- Four FGW (German interconnection-related documents) are now available to WG on [iMeet site](#), for use (only) in P2800.2 development. (Thank you Jens for arranging!)
 - FGW TG 3
 - FGW TG 4
 - FGW TG 8 - Certification of the electrical characteristics of power generating units and systems in low-, medium-, high- and extra-high voltage grids – Rev 9 (01.02.2019) / EN
 - FGW TG 9 - Determination of high frequency emissions from renewable power generating units – Rev 1 (18.04.2016) / EN
- Request from IEEE for various IEC standards is (still) pending.
- If you identify a standard we should refer to, notify the appropriate subgroup/task force lead.

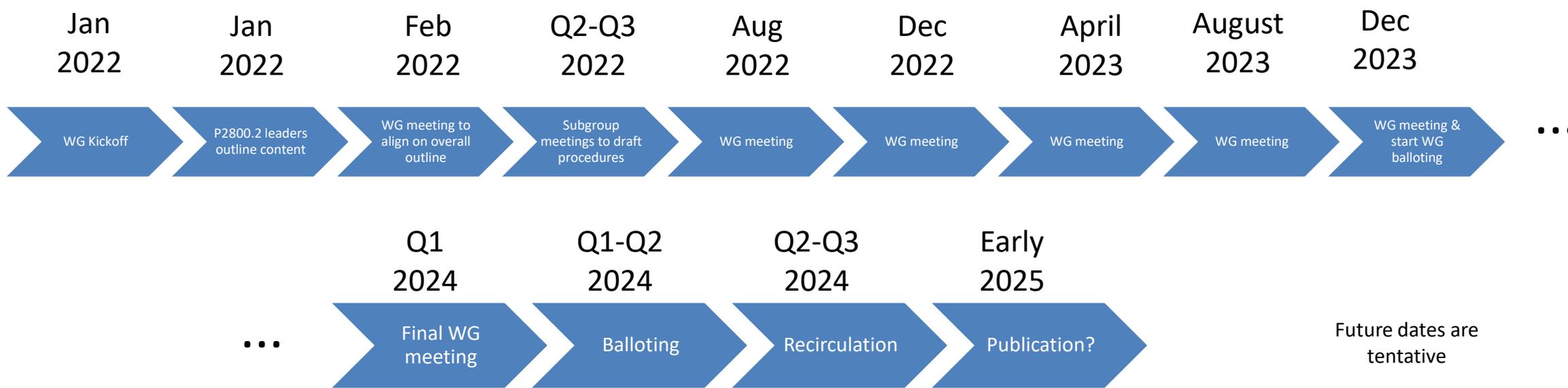
IEEE P2800.2 Email Listservs

- Overall listserv “P2800-2” will be used to communicate meeting dates, agendas, etc.
- Each subgroup and PQ task force each have listserv – sign up to get involved in that group:
 - Overall Working Group: P2800-2
 - 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
- To join a listserv, send an email message to listserv@listserv.ieee.org
 - In first line of email body, write: **SUBSCRIBE <list name> <Your Name>**

For example, “**SUBSCRIBE STDS-P2800-2-SG1 Andy Hoke**”

Future P2800.2 meetings

- **Next meeting: August 29-31, 2023.** Remote, similar structure to this meeting
- Likely subsequent meeting in early December 2023. Aiming for substantial completion.
- Currently still online only
- Will consider in-person meetings with remote option in future



Anticipated Timeline

