IEEE P2800

Draft Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Virtual Working Group Meeting
ConfCall 2 of 3

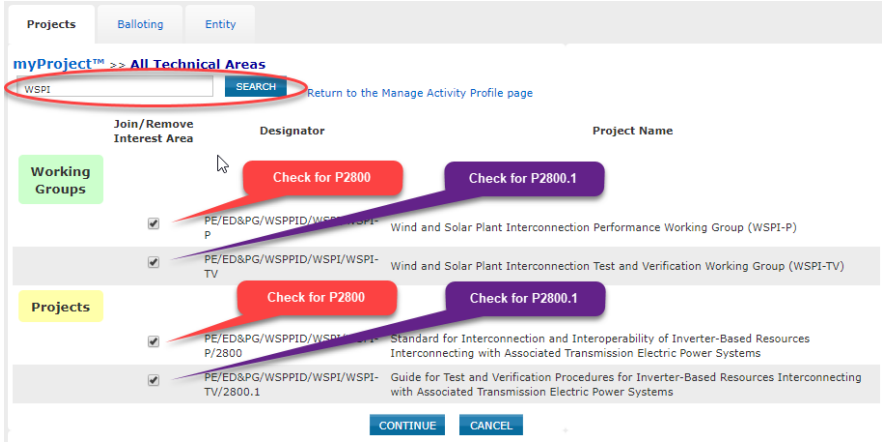
Jens C. Boemer, WG Chair*
Kevin Collins, Bob Cummings, Babak Enayati, Ross Guttromson,
Manish Patel, Chenhui Niu, Vice-Chairs
Wes Baker, Secretary – Diwakar Tewari, Treasurer

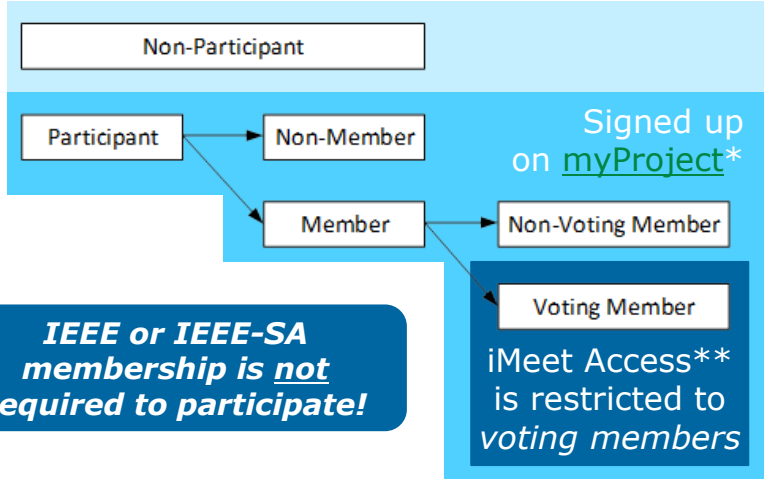
December 6, 2019

*Also Chair of the sponsoring ED&PG Wind and Solar Plant Interconnection Working Group (Link to Website)

How To Log WG Meeting Attendance via IEEE iMAT?

- Anyone with an IEEE account can sign up at https://development.standards.ieee.org/my-site/home to receive P2800 Working Group updates ("Participant").
- Participants can attend WG meetings and log their attendance via https://imat.ieee.org/. Must attend two consecutive meetings to become a "Voting Member", i.e., get access to iMeet and to vote.
- Only IEEE SA members can ballot P2800.

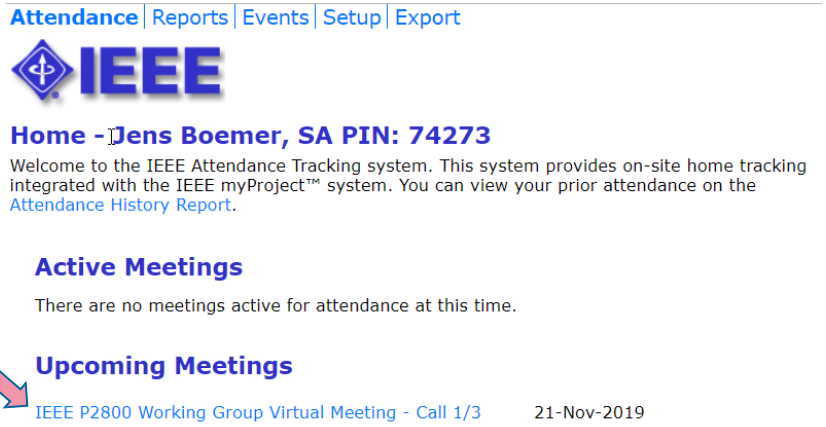


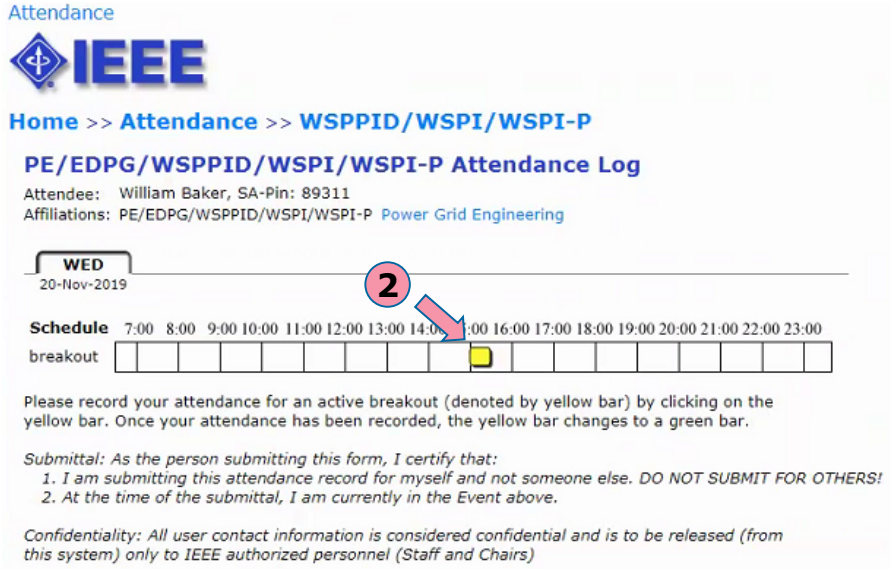


* Log WG Mtg attendance via iMAT (imat.ieee.org)
** Available at https://ieee-sa.imeetcentral.com/p2800-wspi-p

1. On the **myProject™ Home Screen**, select "**Manage Activity Profile**".
2. On the "Manage Activity Profile" Page, **enter "WSPI" into the Search line** and click "Search".
3. **Check the boxes next to the activity you are interested in** (Sponsor, Working Group, Project). Check both the respective working group(s) and project(s).
4. Click "**CONTINUE**"
5. Confirm your interest area and enter your affiliation information.
6. Select from the list or type in your company/organization.
7. Click "**CONTINUE**"

IEEE iMAT


Attendance | Reports | Events | Setup | Export
IEEE
Home - Jens Boemer, SA PIN: 74273
Welcome to the IEEE Attendance Tracking system. This system provides on-site home tracking integrated with the IEEE myProject™ system. You can view your prior attendance on the Attendance History Report.
Active Meetings
There are no meetings active for attendance at this time.
1
Upcoming Meetings
IEEE P2800 Working Group Virtual Meeting - Call 1/3 21-Nov-2019


Attendance
IEEE
Home >> Attendance >> WSPPID/WSPI/WSPI-P
PE/EDPG/WSPPID/WSPI/WSPI-P Attendance Log
Attendee: William Baker, SA-Pin: 89311
Affiliations: PE/EDPG/WSPPID/WSPI/WSPI-P Power Grid Engineering
WED
20-Nov-2019
2
Schedule 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
breakout
Please record your attendance for an active breakout (denoted by yellow bar) by clicking on the yellow bar. Once your attendance has been recorded, the yellow bar changes to a green bar.
Submittal: As the person submitting this form, I certify that:
1. I am submitting this attendance record for myself and not someone else. DO NOT SUBMIT FOR OTHERS!
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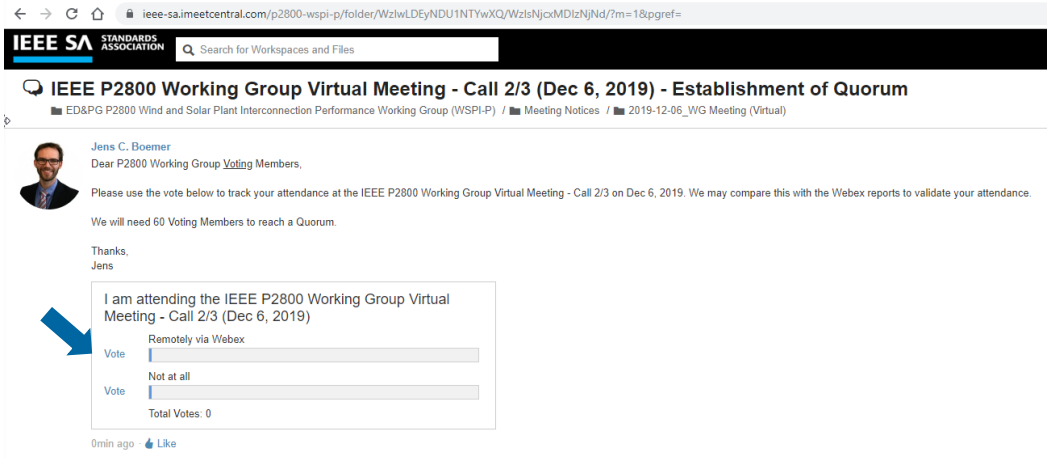

- *Check for quorum*

Meeting Agenda

12/6/19: 12PM-2PM ET / 9AM-11AM PT		
12:00 PM ET	IEEE SA Rules, Standards Classification & Language	J. Boemer
12:10 PM ET	Voltage ride-through capability, cumulative ride-through vs. consecutive ride-through~~, single-pole tripping~~	M. Patel/B. Cummings/ R. Bauer/All
12:50 PM ET	Voltage ride-through performance / verification / modeling	M. Patel/B. Cummings/All
1:30 PM ET	Scoping of protection requirements	B. Enayati/B. Cummings/All
2:00 PM ET	Adjourn	J. Boemer

Meeting Goals

1. Convene Working Group and report on Sub-WGs' progress to date.

2. Discuss latest draft voltage ride-through requirements.

3. Scoping of protection requirements.

IEEE SA Rules,
Standards Classification & Language

Guidelines for IEEE WG meetings

- All IEEE-SA standards meetings shall be conducted **in compliance with all applicable laws**, including **antitrust** and **competition** laws.
  - Don't discuss the interpretation, validity, or essentiality of **patents/patent claims**.
  - Don't discuss specific **license rates, terms, or conditions**.
    - Relative costs of different technical approaches that include relative costs of patent licensing terms may be discussed in standards development meetings.
      - Technical considerations remain the primary focus
  - Don't discuss or engage in the fixing of **product prices, allocation of customers, or division of sales markets**.
  - Don't discuss the status or **substance of ongoing or threatened litigation**.
  - **Don't be silent** if inappropriate topics are discussed … do formally object.

- For more details, see **IEEE-SA Standards Board Operations Manual**, clause 5.3.10 and Antitrust and Competition Policy: What You Need to Know at http://standards.ieee.org/develop/policies/antitrust.pdf

Participants have a duty to inform the IEEE

- Participants shall **inform the IEEE** (or cause the IEEE to be informed) of the **identity of *each* holder** of any **potential Essential Patent Claims**
  - that are **potentially essential to implementation of the proposed standard(s)**
  - of which they are personally aware if the claims are owned or controlled by the participant or the entity the participant is from, employed by, or otherwise represents
- Participants should inform the IEEE (or cause the IEEE to be informed) of the identity of ***any other* holders** of potential Essential Patent Claims
- **Early identification** of holders of potential Essential Patent Claims is **encouraged**
- *At the WG Meeting on Nov 21, 2019, the WG Chair informed the WG that Officers were made aware of 3 potential Essential Patent Claims to date and encouraged WG members to submit others by e-mail.*

Ways to inform IEEE

- Cause an **LOA to be submitted** to the IEEE-SA (patcom@ieee.org); or
- Provide the **chair of this group** with the identity of the holder(s) of any and all such claims as soon as possible; or
- **Speak up now** and respond to this Call for Potentially Essential Patents
- If anyone in this meeting is personally aware of the holder of **any patent** claims that are **potentially essential to implementation of the proposed standard(s)** under consideration by this group and that are not already the subject of an Accepted Letter of Assurance, **please respond at this time** by providing relevant information to the WG Chair

Patent-related information

The patent policy and the procedures used to execute that policy are documented in the:

- *IEEE-SA Standards Board Bylaws*
  (http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#6)
- *IEEE-SA Standards Board Operations Manual*
  (http://standards.ieee.org/develop/policies/opman/sect6.html#6.3)

Material about the patent policy is available at
http://standards.ieee.org/about/sasb/patcom/materials.html

If you have questions, contact the IEEE-SA Standards Board Patent Committee Administrator at patcom@ieee.org

IEEE SA
STANDARDS ASSOCIATION

IEEE SA COPYRIGHT POLICY

NOVEMBER 2019

IEEE

INSTRUCTIONS FOR CHAIRS OF STANDARDS DEVELOPMENT ACTIVITIES

At the beginning of each standards development meeting the chair or a designee is to:

- Show the following slides (or provide them beforehand)
- Advise the standards development group participants that:
- IEEE SA's copyright policy is described in Clause 7 of the IEEE SA Standards Board Bylaws and Clause 6.1 of the IEEE SA Standards Board Operations Manual;
- Any material submitted during standards development, whether verbal, recorded, or in written form, is a Contribution and shall comply with the IEEE SA Copyright Policy;
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- That the foregoing information was provided and that the copyright slides were shown (or provided beforehand).

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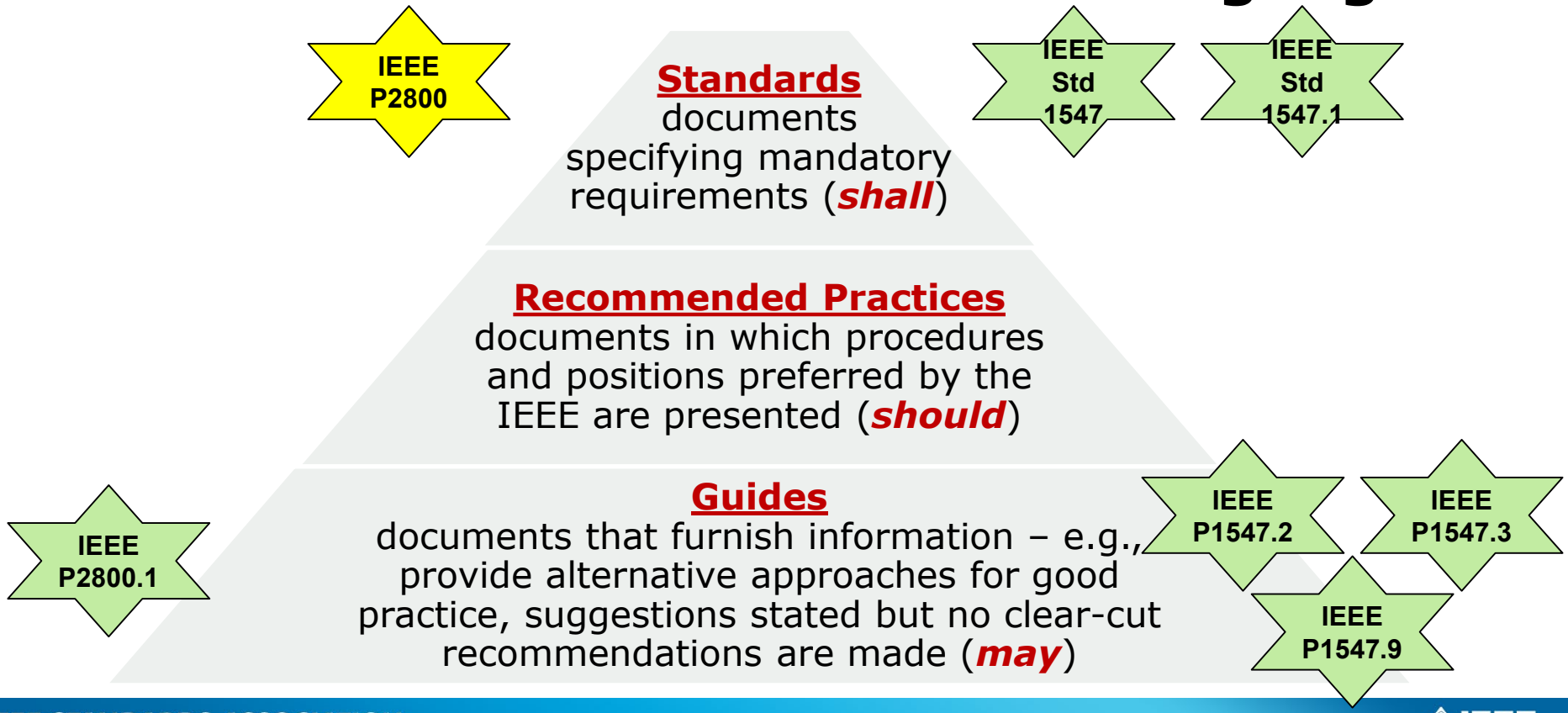
  - http://standards.ieee.org/develop/policies/best_practices_for_ieee_standards_development_051215.pdf
- Distribution of Draft Standards (see 6.1.3 of the SASB Operations Manual)
  - https://standards.ieee.org/about/policies/opman/sect6.html

IEEE Standards Classification & Language



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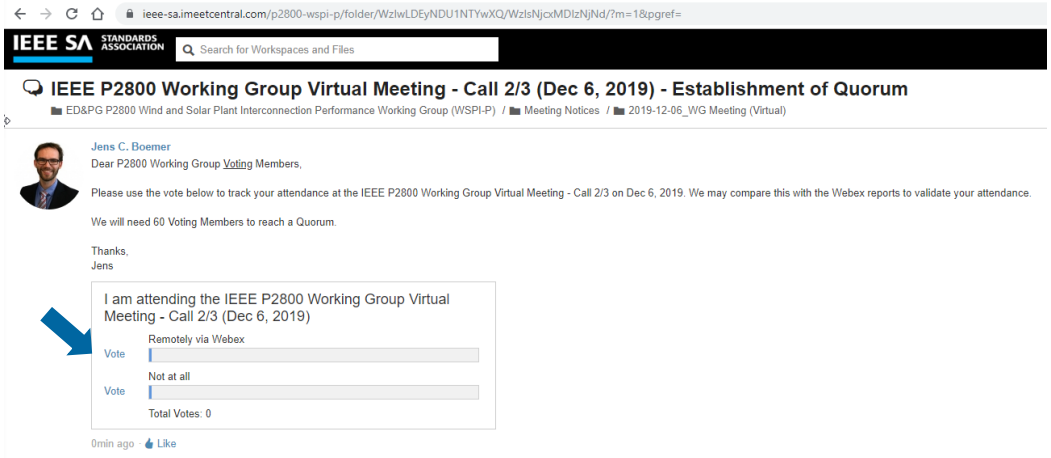


- *Check for quorum*

Previous Meetings' Minutes

- Minutes from the WG Meeting in September 2019 had been posted to iMeetCentral here: https://ieee-sa.imeetcentral.com/p/ZgAAAAAAuc8P
  - *There was no quorum at the Nov 21, 2019, WG Meeting and the minutes remained unapproved.*
  - *Check for approval.*
- Minutes from the Virtual WG Meeting on Nov 21, 2019, had been posted to iMeetCentral here: https://ieee-sa.imeetcentral.com/p/aQAAAAAD_rs6
  - *Check for approval.*
- Motion to approve both minutes.
  - *Check for quorum.*

Review and Approval of Agenda

Refer to Word document on iMeetCentral here:
https://ieee-sa.imeetcentral.com/p/aQAAAAAD_-oG

- *Check for requests for changes of the agenda.*
- *Check for quorum.*

Next Deliverables & Milestones

Deliverable	Due date for SubGroup submissions	Publication date
Draft 1.1 (Annotated)	Oct 31, 2019 (Officer Comments)	Nov 6, 2019 (Posted on iMeet)
WG ConfCall	Nov 21, 2019 – discuss & vote on important decisions, e.g., Definitions	
WG ConfCall	Dec 6, 2019 – discuss & vote on 1-2 important decisions per SubGroup	
WG ConfCall	Dec 17, 2019 – discuss & vote on 1-2 important decisions per SubGroup	
Informal WG Meeting & Voluntary SubGroup Meetings	Jan 13, 2020, 1p-5p ET @2020 IEEE JTCM, Jacksonville, FL (does not count towards WG membership)	
WG ConfCall	Feb 6, 2020* – discuss & vote on 1-2 important decisions per SubGroup	
Milestone: Draft 2 (Complete Draft)	Mar 1, 2020* (SubGroup Input)	Mar 15, 2020* (Posted on iMeet)
WG Meeting	TBD (April 7-9), 2020* (2 ½ days), FirstSolar, Tempe, AZ	
Draft 2.1	April 15, 2020* (SubGroup Posted)	May 1, 2020 (Comments in spreadsheet)
Milestone: Draft 3	June 15, 2020* (Input)	June 30, 2020* (Posted on iMeet)
WG Meeting	TBD (July 14-16), 2020*, Location TBD	
Milestone: WG Vote on Draft 3.x	TBD (July 23), 2020*	
Sponsor Coms Approve WG Draft	August 3-7, 2020 at PES General Meeting, Montreal, Canada	
Initial Ballot	Q3/2020*	
Recirculation	Q4/2020*	
Milestone: Submission to NesCom	Q1/2021*	
Milestone: Publication	Q2/2021*	

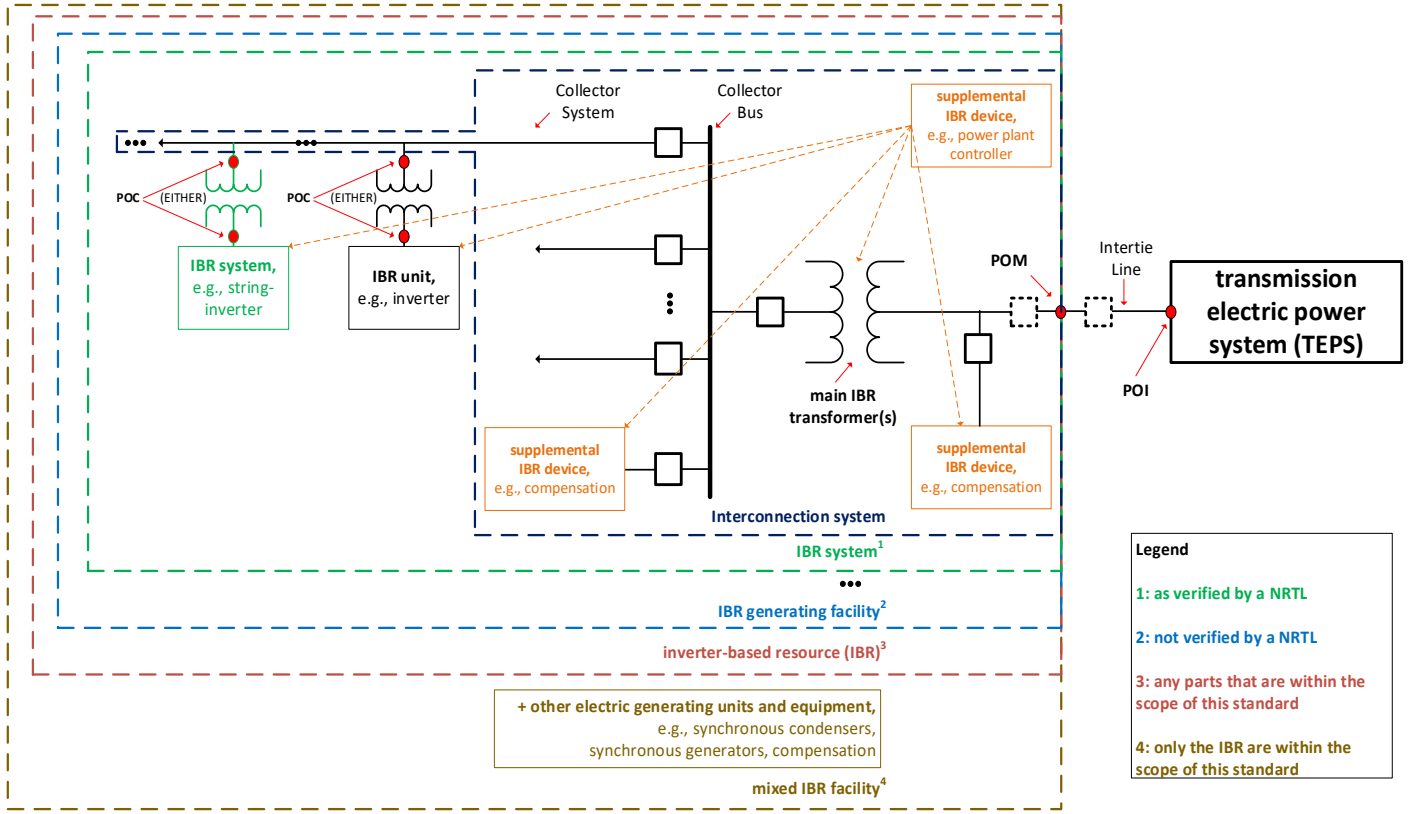
* Tentative dates

Informal WG Meeting at IEEE JTCM in Jacksonville, FL on Jan 13, 2020, 1p-5p

DRAFT AGENDA - Monday, 1/13/2020: 1PM – 5PM		
1:00 PM	Welcome Facility safety and emergency procedures Opening remarks, objectives of this meeting	J. Boemer (remotely)
1:10 PM	Status Update on IEEE P2800	J. Boemer (remotely)
1:20 PM	Status Update on IEEE P2800.1	C. Niu / J. Boemer (remotely)
1:30 PM	Questions & Answers	All (on-site & remotely)
2:00 PM	Joint SubGroup Break-Out (M. Patel, B. Cummings, B. Enayati) • VII. Ride-Through Capability Requirements • VIII. Ride-Through Performance Requirements • IX. IBR Protection	SubGroup VI. Power Quality Break-Out (R. Guttromson) - tentative • Check for confirmation of SubGroup meeting
3:15 PM	Break	
3:45 PM	(cont.)	(cont.)
5:00 PM	Adjourn	

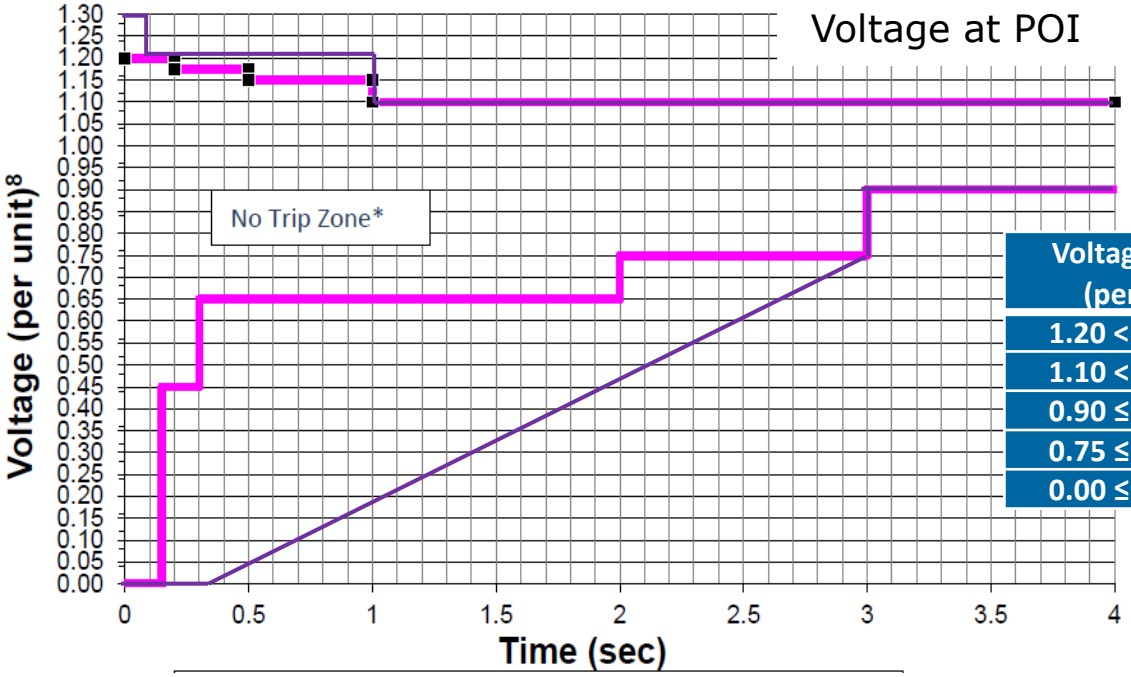
Presentation of definitions developed in SG1+2

- Refer to Word file on iMeet here.
- The updated has been posted to iMeet here.



Voltage Ride-Through

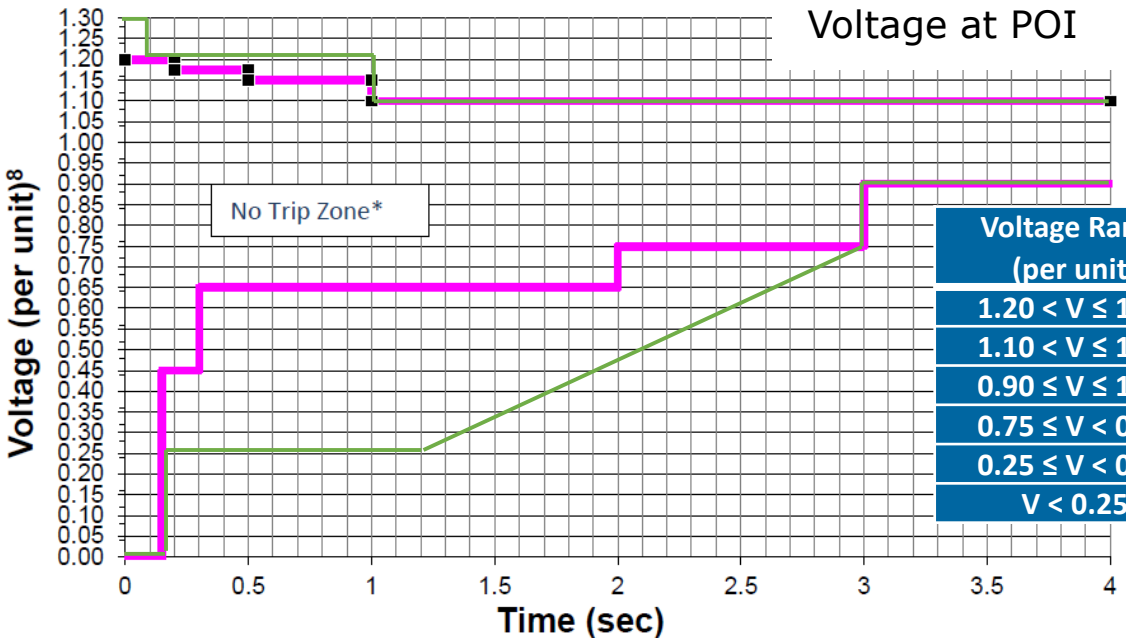
Voltage Ride-Through Capability – PV/BESS



Voltage Range (per unit)	Operating Mode	Minimum Ride-Through Time (seconds)
1.20 < V ≤ 1.30	Mandatory	0.10
1.10 < V ≤ 1.20	Mandatory	1.00
0.90 ≤ V ≤ 1.10	Continuous	Infinite
0.75 ≤ V < 0.90	Mandatory	3.00
0.00 ≤ V < 0.75	Mandatory	0.32 + 3.57 V

Lower of each P-G or P-P voltage relative to system nom. voltage

Voltage Ride-Through Capability – Wind



Voltage Range (per unit)	Operating Mode	Minimum Ride-Through Time (seconds)
1.20 < V ≤ 1.30	Mandatory	0.10
1.10 < V ≤ 1.20	Mandatory	1.00
0.90 ≤ V ≤ 1.10	Continuous	Infinite
0.75 ≤ V < 0.90	Mandatory	3.00
0.25 ≤ V < 0.75	Mandatory	1.20 + 3.6 (V – 0.25)
V < 0.25	Mandatory	0.16

Lower of each P-G or P-P voltage relative to system nom. voltage

Cumulative Time & Consecutive Voltage Disturbances

- Reference to cumulative time is removed from the latest draft of the NERC standard PRC-024.
- The IEEE Standard 1547-2018 specifies ride-through time requirement on a cumulative time duration basis.
- P2800 –
  - Is use of cumulative time necessary?
  - If so, is there any alternative which conveys requirement clearly?
  - How about specifying number of consecutive disturbances in a given timeframe?

Voltage Ride-Through Performance Requirements

- NERC IRPTF Guideline recommended following:

Applicable when in Mandatory Operation Region

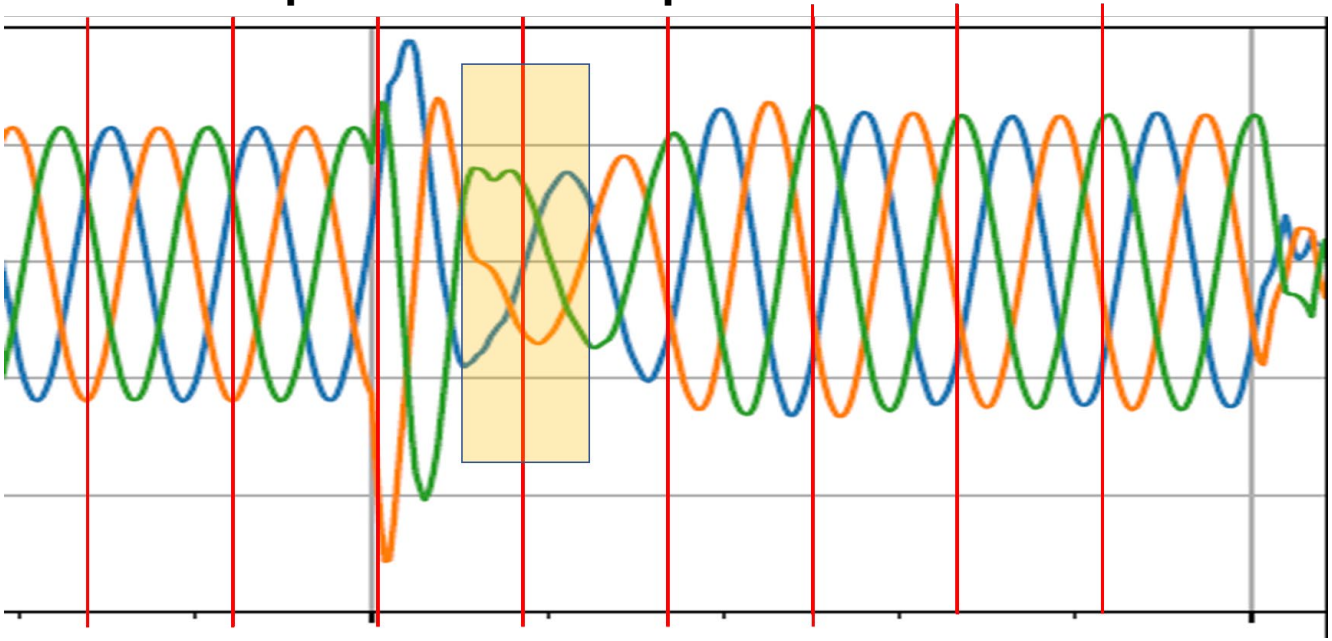
Table 3.2: Large Disturbance Reactive Current-Voltage Performance		
Parameter	**Description**	**Performance Target**
For a large disturbance step change in voltage, measured at the inverter terminals, where voltage falls outside the continuous operating range, the positive sequence component of the inverter reactive current response should meet the following performance specifications…		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change[56]	< 16 ms*
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90 percent of its final value	< 100 ms**
Overshoot	Percentage of rated reactive current output that the resource can exceed while reaching the settling band	Determined by the TP/PC***

From inverter control's perspective, there is no difference between large system disturbance and a fault condition.

Not acceptable from protection perspective

Fault Example 1: Type IV WTG

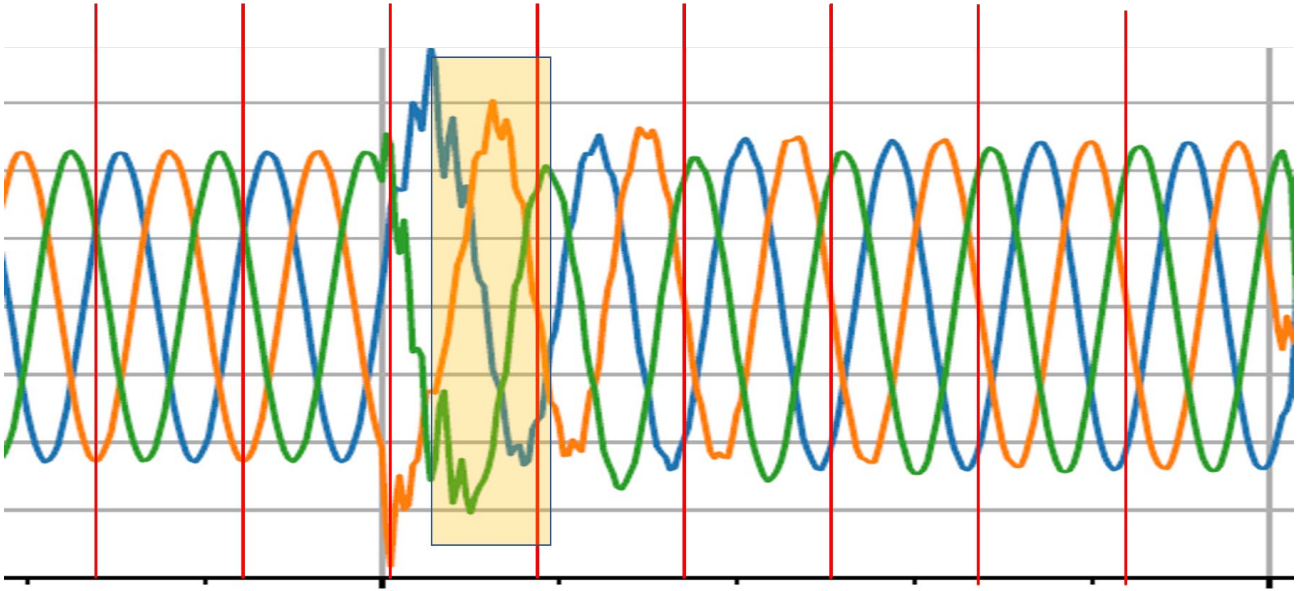
Response for a three-phase fault at the POI



Phase shift (active to reactive current) is occurring in highlighted box, i.e., phase shift is complete within 1.5 cycle from initiation of fault.

Fault Example 2: PV Solar

Response for a three-phase fault at the POI



Phase shift (active to reactive current) is complete in one (1) cycle.
New steady state value within 2.0 cycles.

Voltage Ride-Through Performance Requirements – Fault Response

No specification for current magnitude

Time required (1 cycle DFT) to extract phasor quantities (active, reactive, positive, negative sequence currents etc.) is included in times specified in this table.

Between initiation of a fault and a rise of current to 90% of the final value.

	Type III WTG	Type IV WTG, PV, BESS
Response Time	NA[1]	<=~2.5 cycles (<=40 ms)
Settling Time	<=6.0 cycles (<=100 ms)	<=~4.0 cycles (<=65 ms)

Note 1: Induction Gen, response based on machine parameters, during crowbar action frequency may be different from system frequency

Slower response may be allowed with mutual agreement between area EPS and the resource owner.

Voltage Ride-Through Performance Requirements – Fault Response

- The type and magnitude of current injection shall be dependent on voltage deviation.
- Inject current at same frequency as of terminal voltage
  - Exclusion for type III WTG when crowbar is activated.
- Unbalanced faults & negative sequence current:
  - Inject negative sequence current dependent on negative sequence terminal voltage.
  - Current shall lead the terminal voltage by 90 degrees.

Voltage Ride-Through Performance Requirements – Fault Response

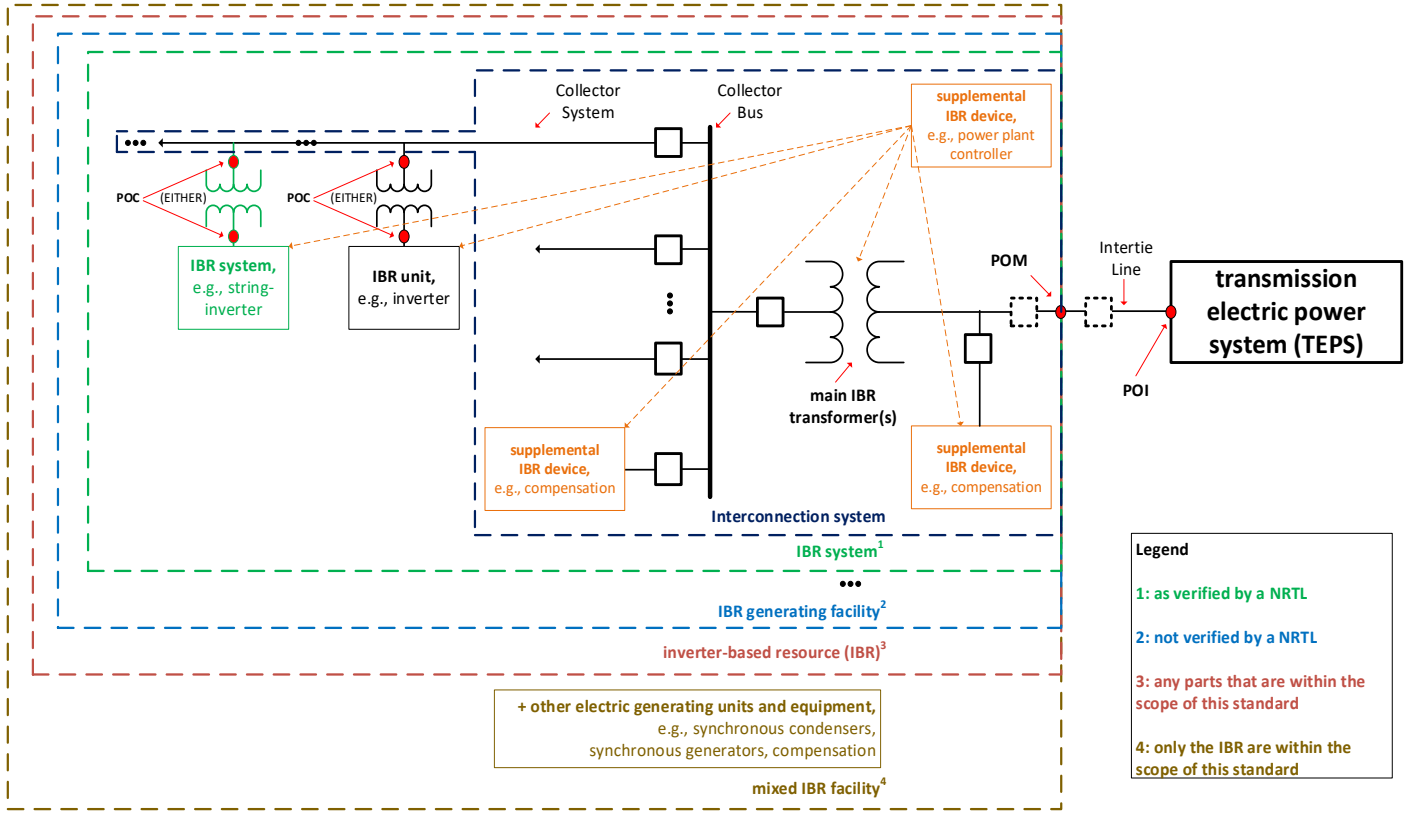
- Unbalanced faults & negative sequence current:
  - Questions:
    - What to do for normal unbalance? Do we need a dead band?
    - Relationship & priority between positive and negative sequence current.

- Upon fault clearance/Return to continuous operation mode:
  - Ramp rate for active power – default & acceptable range
  - Is there a need to specify how quickly reactive current output needs to return to normal?

Voltage Ride-Through Modeling and Verification

Verification of Requirements – *Where?*

- POC
  - Unit
  - System
- POM
  - Generating Facility
- POI
  - Generating Facility



Test & verification requirements in P2800 vs. P2800.1 – *What belongs where?*

	P2800	P2800.1
1) Any **performance requirement** that can be verified with any of the verification methods below*	X	
2) For each performance requirements from 1), specify **which verification method*** shall be used ▪ Current practice for BPS-resources is verification of performance by post-event analysis ▪ SubGroup XI. (Tests and verification requirements) to start with a structure similar to Tables 43 and 44 in IEEE 1547-2018 but need to add additional column(as) as needed. See next slides for details.	X	
3) For each performance requirement from 1), specify guidelines for detailed **verification procedures** (step-by-step instructions) regarding **how** to conduct the required verification method* ▪ SubGroup XI. (Tests and verification requirements) to start with P1547.1 Draft 9.6 (Recirc 2)		X

*** Potential Verification methods**

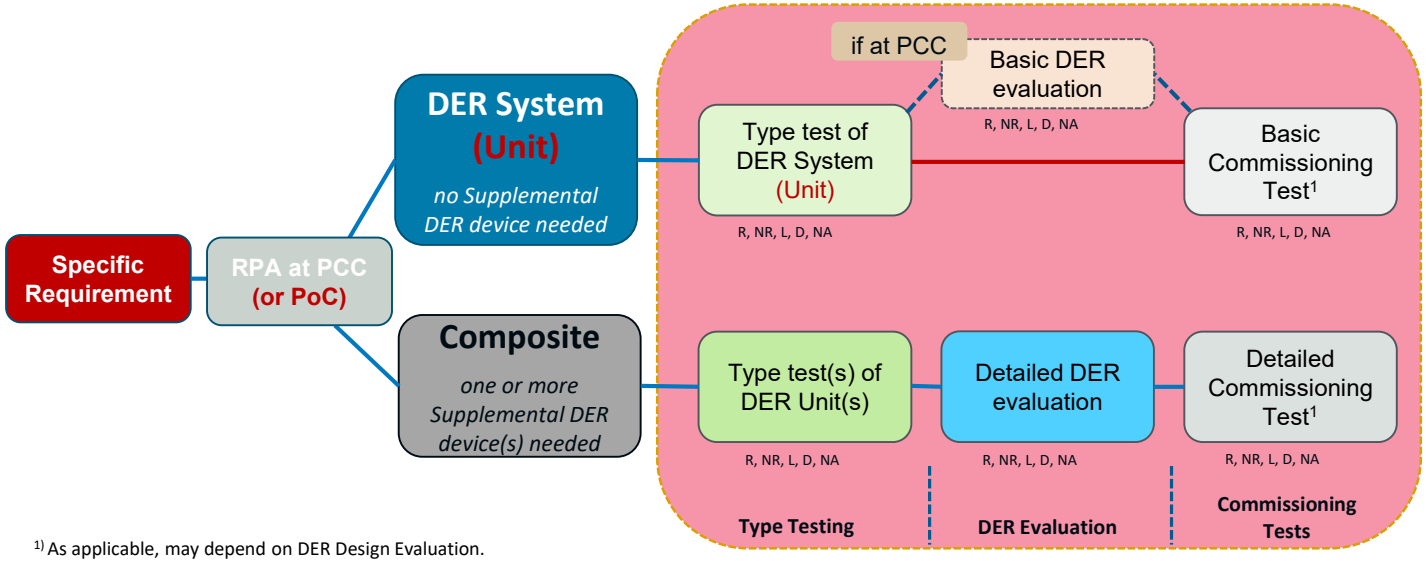
I. Type Tests (NRTL, manufacturer)
II. Production Tests (manufacturer)
III. IBR Evaluations (IBR developer, TEPS operator and/or 3rd party)
- Need to decide whether modeling will be a "shall" or a "may" requirement in P2800.
- Could specific be included as a recommended practice in an P2800 appendix?
- Guidance on how to use modeling for verification purposes could be given in P2800.1.

IV. Commissioning Tests (TEPS operator and/or 3rd party)
V. Post-Commissioning Test/Verification (TEPS operator and/or 3rd party)
- Periodic/scheduled tests (Lifecycle, Major Changes)
- Verification required if any changes occur
- Post-event analysis, as they occur (use of digital fault recordings, need to define what to measure)
- Any post-commissioning measurements if a "Conditional Permission to Operate" had been issued during the commissioning step

Example New IEEE 1547-2018 Test & Verification Requirements for DER

What's the requirement? → Where's the reference point of applicability? → DER Capability & Conformance achieved by → Category of test and verification needed

R: Required
NR: Not required
L: Limited
D: Depends on DER design eval.
NA: Not applicable



[1] As applicable, may depend on DER Design Evaluation.

Examples from Clause 11 of IEEE 1547-2018

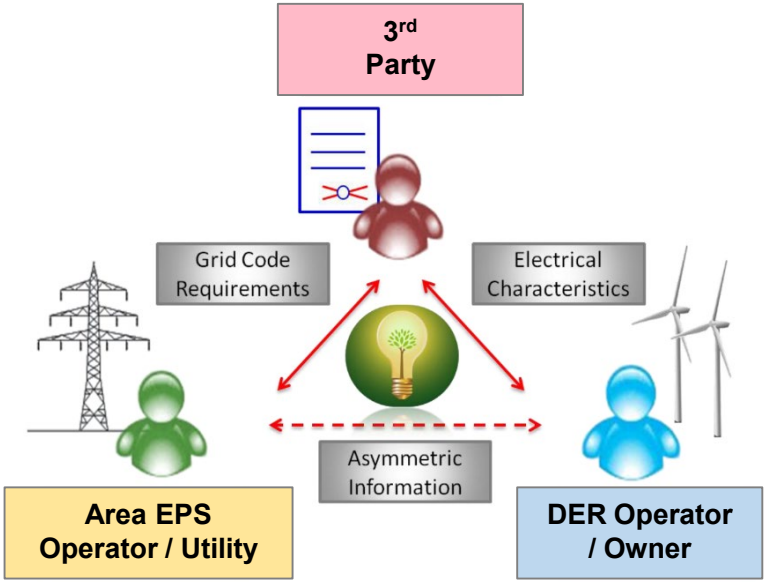
Modeling?

Requirement	Compliance at PCC achieved by:	Type tests	IBR evaluation	Commissioning tests
6.4 Voltage				
6.4.1 Mandatory voltage tripping requirements	DER System	R	Design: R[a] Installation: R[b]	D
	Composite	L	Design: R[a] Installation: R[b]	D
6.4.2.1 General requirements and exceptions	DER System	R	R	D
	Composite	L	R	D[a]
6.4.2.2 Voltage disturbances within continuous operation region	DER System	R	Design: R[a] Installation: R[b]	D
	Composite	L	R	D[a]

- Review Tables 43 and 44 of IEEE Std 1547™-2018 as needed: **R**equired; **L**imited; **D**epends

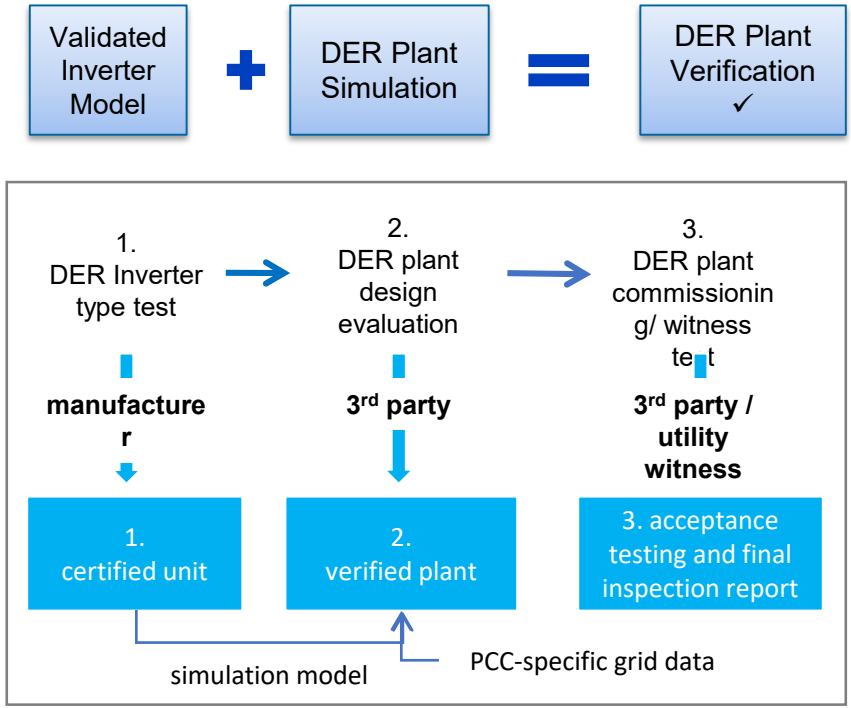
Example Verification Requirements for Utility-Scale DER Facilities in Germany

The Certification Triangle



Source: J. Langstädtler, B. Schowe-Von der Brelie, and F. Kalverkamp, "Certified wind power plants as a dependable solution for effective system integration," in World Wind Energy Conference, 2012.

The Certification Triplet



Requirement of Models – Shall, Should or May?

- Some performance requirements may need to be verified using IBR evaluation (using models).
  - During interconnection process & at the time of COD.
- Need to decide weather modeling will be a “shall”, “should” or “may” requirement in P2800.
  - May be differentiated by IBR size.
- Should specifics/details of various models be written as a recommended practice?

Scoping of protection requirements

Scoping of protection requirements

Include in Scope

- Voltage trip, because coordination with grid protection like distance and overcurrent protection on sub-transmission lines
  - If all transmission lines that differential protection, voltage trip requirements would not be needed in P2800
  - Any distance and overcurrent protection would have to be coordinated with IBR ride-through capability requirements, thus, use intentional delay of at least the ride-through capability duration curves
- All the above needs to be coordinated with ride-through capability requirements, see below table for the proposed ride-through capability

Exclude from Scope

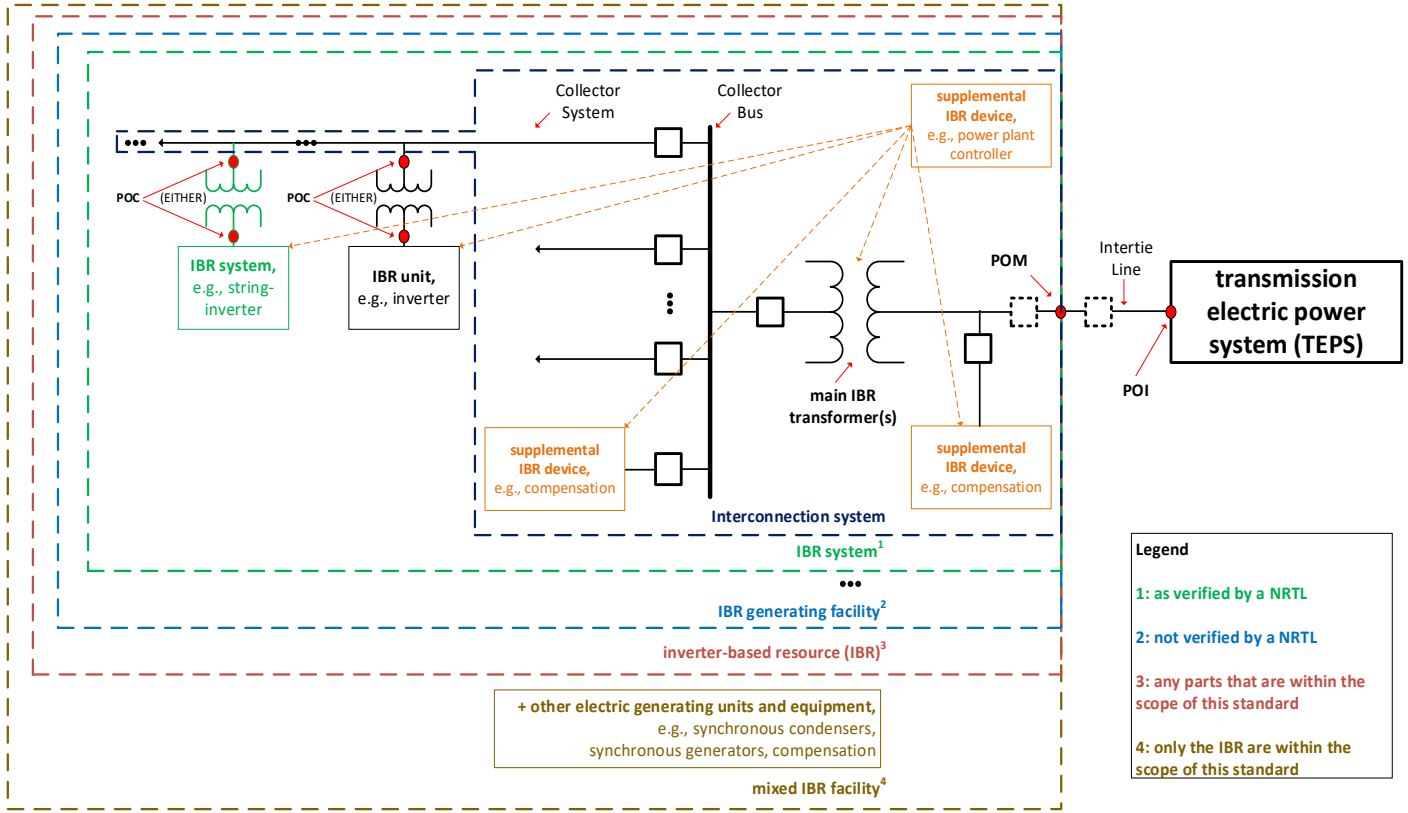
- Frequency trip, because there is no need to include this.
- Impact on transmission grid is outside the scope

Discussion

- Officer recommendation is to write it not as a "shall" but more as a "may" trip requirement, depending on circumstances.
- What about the “intertie line”?

Verification of Requirements – *Where?*

- POC
  - Unit
  - System
- POM
  - Generating Facility
- POI
  - Generating Facility



IEEE P2800: Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Scope:

This standard establishes the recommended **interconnection capability and performance criteria** for inverter-based resources interconnected with transmission and networked sub-transmission systems. Included in this standard are recommendations on performance for reliable integration of inverter-based resources into the bulk power system, including, but not limited to, **voltage and frequency ride-through**, active power control, reactive power control, dynamic active power support under abnormal frequency conditions, **dynamic voltage support under abnormal voltage conditions**, power quality, **negative sequence current injection**, and system protection.

Related activities:

IEC initiative to develop a single framework for connecting and controlling renewables. Contact: Charlie Smith, Charlie@esig.energy , U.S. TA for SC 8A.

Wrap-up and Adjourn

Next Deliverables & Milestones

Deliverable	Due date for SubGroup submissions	Publication date
Draft 1.1 (Annotated)	Oct 31, 2019 (Officer Comments)	Nov 6, 2019 (Posted on iMeet)
WG ConfCall	Nov 21, 2019 – discuss & vote on important decisions, e.g., Definitions	
WG ConfCall	Dec 6, 2019 – discuss & vote on 1-2 important decisions per SubGroup	
WG ConfCall	Dec 17, 2019 – discuss & vote on 1-2 important decisions per SubGroup	
Informal WG Meeting & Voluntary SubGroup Meetings	Jan 13, 2020, 1p-5p ET @2020 IEEE JTCM, Jacksonville, FL (does not count towards WG membership)	
WG ConfCall	Feb 6, 2020* – discuss & vote on 1-2 important decisions per SubGroup	
Milestone: Draft 2 (Complete Draft)	Mar 1, 2020* (SubGroup Input)	Mar 15, 2020* (Posted on iMeet)
WG Meeting	TBD (April 7-9), 2020* (2 ½ days), FirstSolar, Tempe, AZ	
Draft 2.1	April 15, 2020* (SubGroup Posted)	May 1, 2020 (Comments in spreadsheet)
Milestone: Draft 3	June 15, 2020* (Input)	June 30, 2020* (Posted on iMeet)
WG Meeting	TBD (July 14-16), 2020*, Location TBD	
Milestone: WG Vote on Draft 3.x	TBD (July 23), 2020*	
Sponsor Coms Approve WG Draft	August 3-7, 2020 at PES General Meeting, Montreal, Canada	
Initial Ballot	Q3/2020*	
Recirculation	Q4/2020*	
Milestone: Submission to NesCom	Q1/2021*	
Milestone: Publication	Q2/2021*	

* Tentative dates

Thank you for your participation!

Contacts

IEEE P2800

- Jens C Boemer, j.c.boemer@ieee.org
- Wes Baker, wbaker@powergridmail.com

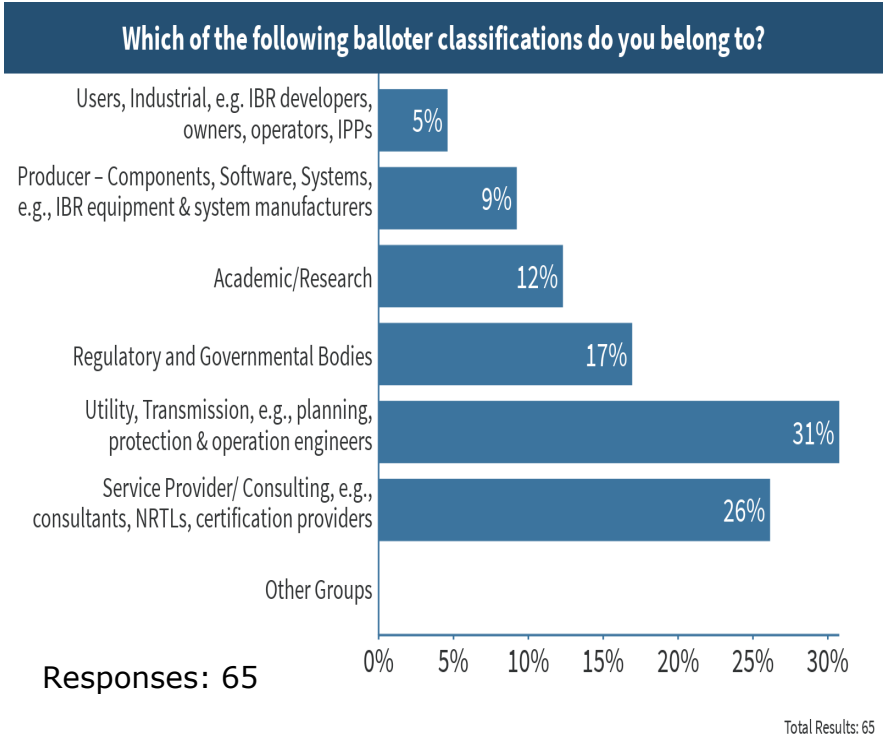
IEEE P2800.1

- Chenhui Niu, niuchenhui@sgepri.sgcc.com.cn
- Jens C Boemer, j.c.boemer@ieee.org

BACKUP SLIDES

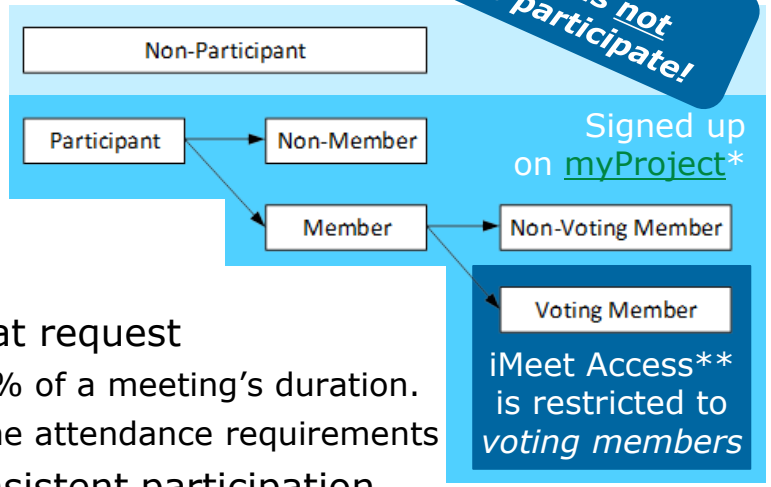
Approximately 300 Interested Parties

- Most of the inverter-based resource vendors
- Many Transmission Planners
- Many Service Providers & Consultants
- Several Regulatory Bodies
- Supported by Academics & Researchers



Responses: 65

WG membership criteria



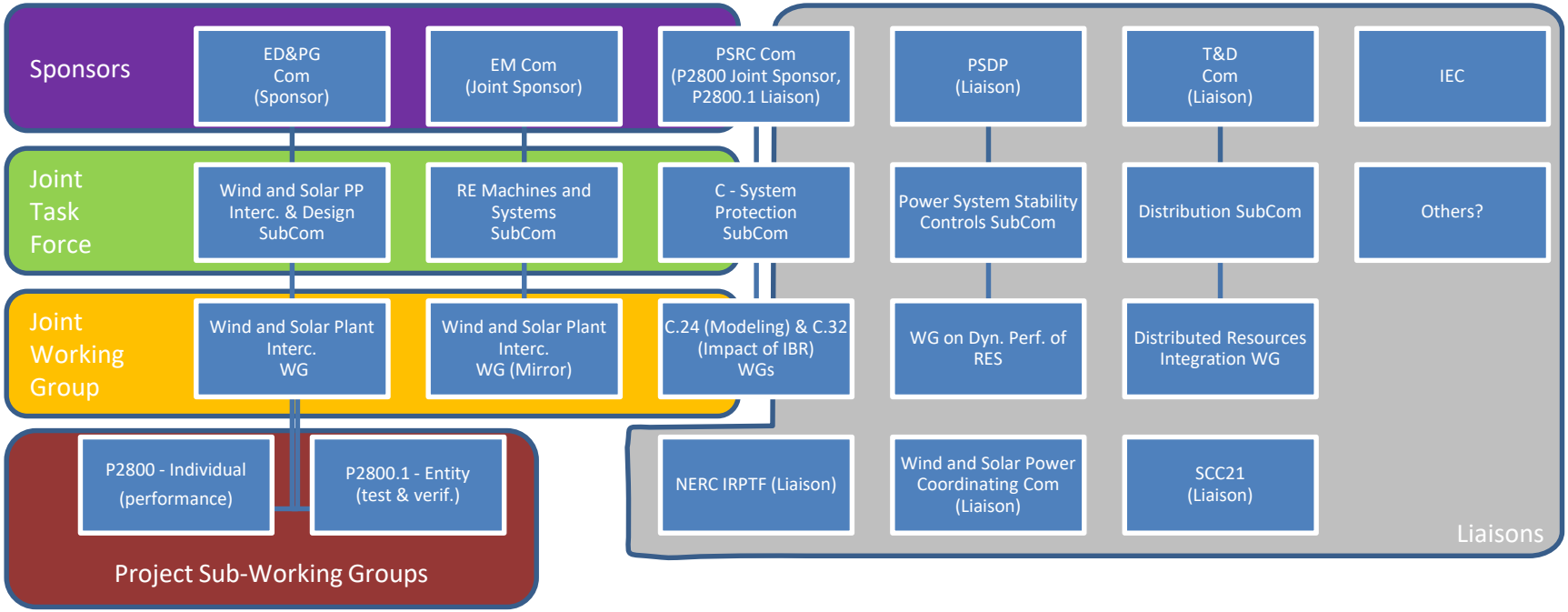
- **PnP's: Clause 4.0 Working Group Membership**
  - Working Group membership is by individual
  - Membership was granted automatically to those attending the kick-off meeting
  - Membership shall be ***granted after attending two consecutive WG meetings or WG calls***, at request
    - Attendance credit is granted to those who attend ≥50% of a meeting's duration.
    - Attendance via teleconferencing shall count towards the attendance requirements
  - Voting member status is maintained through consistent participation at meetings and through Working Group votes
    - may be revoked if a Working Group member misses two consecutive meetings
    - A member who lost voting privileges shall have them reinstated by attendance at two consecutive meetings of the Working Group and upon request for member status
    - Working Group Chair can decide in cases of personal hardship
  - Roster / public list includes name, email address, affiliation, and membership status

* Log WG Mtg attendance via iMAT (imat.ieee.org)
** Available at https://ieee-sa.imeetcentral.com/p2800-wspi-p

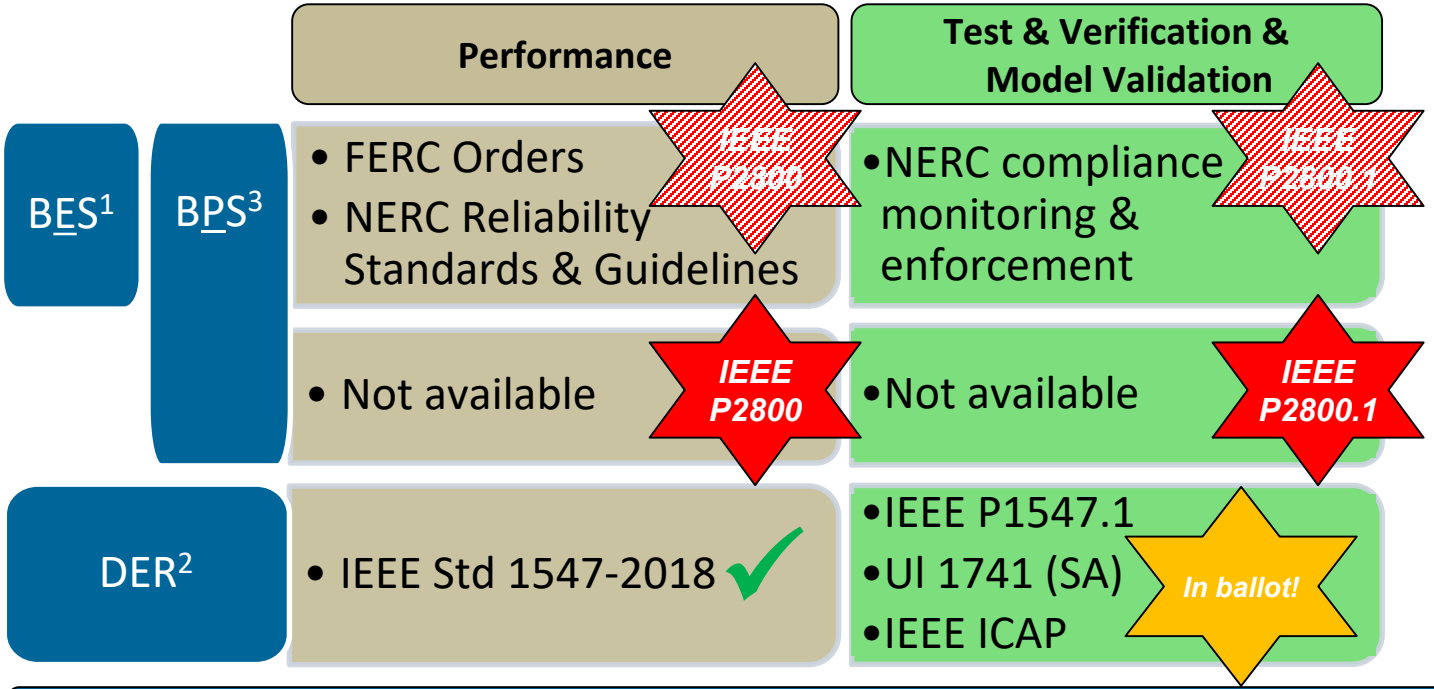
Clarifications of the Scope

- Voluntary standard, requires reference by responsible parties', e.g., interconnection requirements / agreements
  - Candidate parties are transmission owners, state regulators, NERC, and FERC
- Technical minimum requirements, intention is that responsible parties can specify additional requirements
  - Some participants see a risk that it may be regarded as exhaustive requirements
  - Strive for balance between the common denominator and exhaustive requirements
  - May want to consider tiered requirements by use of "performance categories"
- Only "inverter-based" resources, e.g., wind power, solar photovoltaic, energy storage
  - Some participants suggested renaming to "inverter-coupled"
  - "Type 3" wind turbines (doubly-fed induction generators) are in scope
- Applicable to transmission and meshed sub-transmission grids (broad BPS definition)
  - May need different set of requirements for transmission and sub-transmission

Coordination Approach



Existing North American Standards for Inverter-Based Generating Resources and Gaps



[1] NERC definition of Bulk Electric System: ≥100 kV with gross individual / aggregate nameplate rating greater than 20 MVA / 75 MVA

[2] DER connected at typical (radial) primary and secondary voltage levels

[3] transmission and meshed sub-transmission

IEEE standards are voluntary industry standards and must be adopted by the appropriate authority to become mandatory.

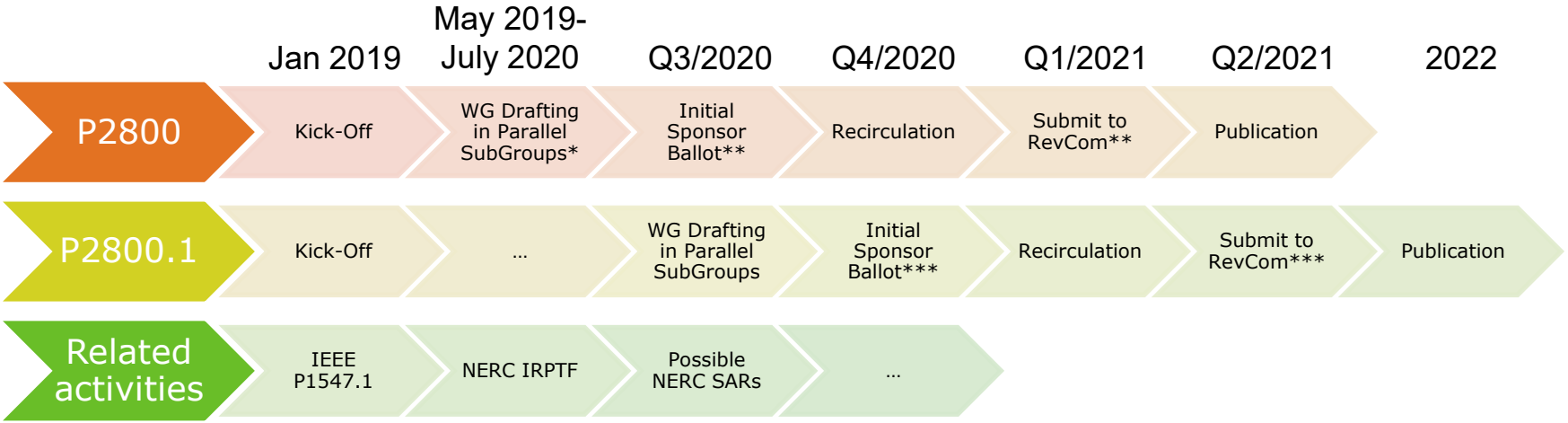
What to expect from IEEE P2800?

- Specify performance and functional *capabilities.*

- Specify functional *default settings.*
- Specify functional *ranges of allowable settings.*

- Specify modeling data, and measurement data for performance monitoring and validation.
- Specify required tests and verifications, but not their detailed procedures (➔ P2800.1)

Updated Timeline With Strech Goals



* Please contact the SubGroup leads and sign up for their Mailing Lists to engage.
** The P2800 PAR states June 2021 for Initial Sponsor Ballot and October 2022 for submission to RevCom.
*** The P2800.1 PAR states Dec 2021 for Initial Sponsor Ballot and October 2022 for submission to RevCom.

The ability to meet this tentative timeline may be subject to strong commitments of Working Group leadership team, i.e., support/funding.

2019/2020 Meetings

- Coordinated with NERC IRPTF Meeting Schedule and IEEE Meetings, as appropriate
- Webex for remote participation is available & counts towards WG meeting attendance
- Striving for no registration fee, as facilities and catering may be provided in-kind

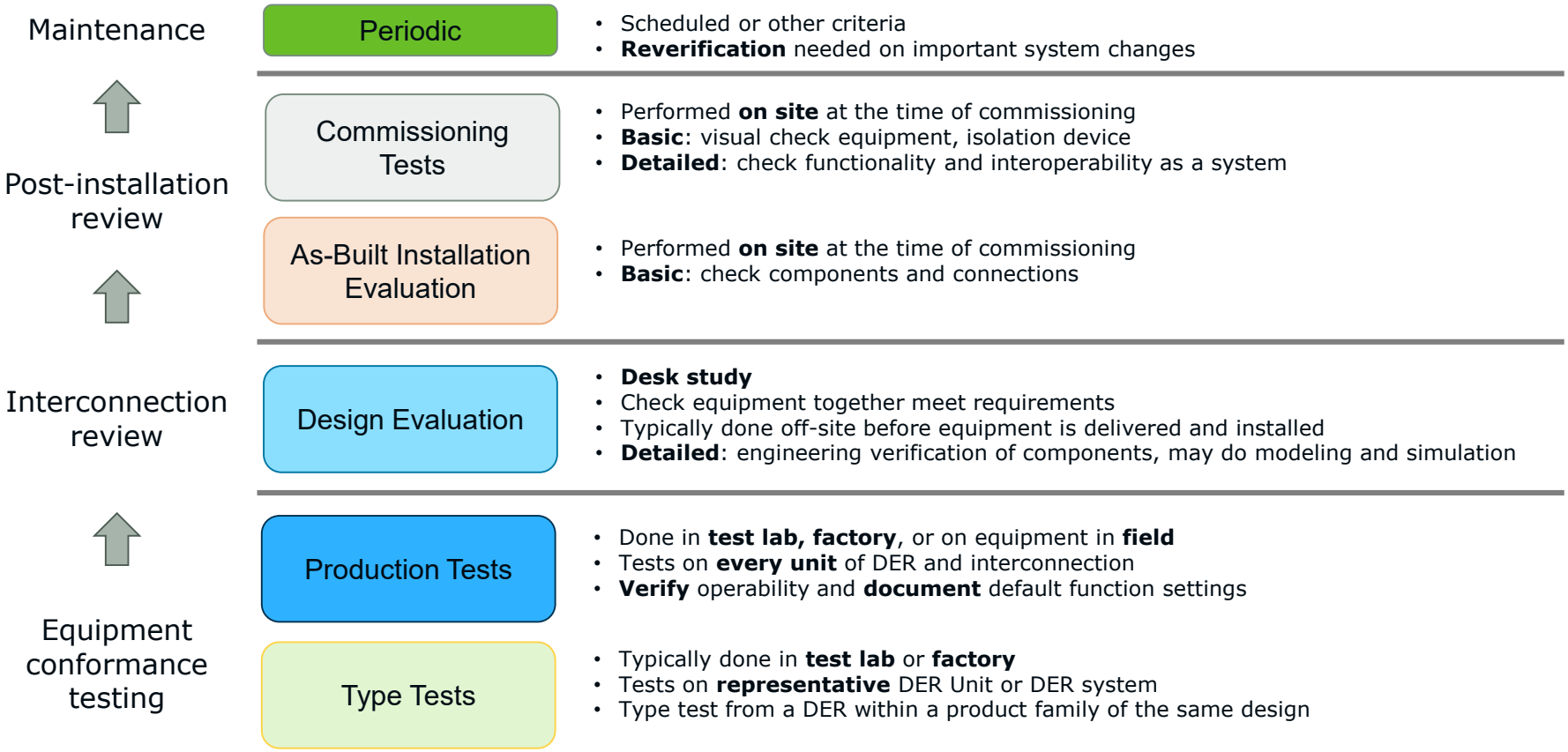
IEEE P2800	Location	Registration	NERC IRPTF
May 22-23, 2019	Atlanta, GA (NERC)	via vtools	Tue/Wed, May 21-22, 2019
September 25-26, 2019	Salt Lake City, UT (WECC)	via 123signup	Wed/Thu, September 4-5, 2019
~~December 4-5, 2019~~	~~Tempe, AZ (FirstSolar)~~	~~Cancelled~~	Tue/Wed, December 3-4, 2019
November 21, 2019	Webex (2:00p–4:00p ET)	Webex	
December 6, 2019	Webex (noon–2:00p ET)	Webex	
December 17, 2019	Webex (noon–2:00p ET)	Webex	
January 13, 2020, 1p-5p*	Jacksonville, FL (IEEE JTCM)	available here	
TBD (April 7-9), 2020	Tempe, AZ (FirstSolar)	N/A yet	
TBD (July 14-16), 2020	TBD	N/A yet	

*This is an informal WG Meeting with voluntary Sub-WG meetings (does not count towards WG membership)

PES Committees to Coordinate with

PES Committee or Subcommittee	Reason	Degree
Electric Machinery Committee	EMC seems to be grabbing scope for inverters used to interface generation to the grid. And Type 3 wind is definitely in their scope	M
Energy Development and Power Generation Committee	I believe they are the sponsor of this WG, so not really a liaison, but mentioned for completeness	n/a
Energy Storage and Stationary Battery Committee	Transmission connected energy storage – it already exists, and more is coming	L
Power System Communications and Cybersecurity Committee	Interoperability with transmission system, external SCADA, and cybersecurity	M
Power System Instrumentation and Measurements Committee	Accuracy requirements for measurements	L
Power System Operation, Planning and Economics Committee	Power systems operations inputs needed for reactive requirements, reactive requirements, etc.; anything involved with running the BPS/BES	M
Power Systems Relaying and Control Committee	Relay and protection requirements and limitations	H
Substations Committee	Requirements related to HVDC and FACTS	L
Surge Protective Devices Committee	Grounding requirements, surge protection	M
Switchgear Committee	Operating voltage requirements, load-rejection overvoltage across breakers	M
Transmission and Distribution (HVDC and FACTS SC)	Requirements applicable to VSC-HVDC included in scope.	H
Transmission and Distribution (Power Quality)	Power quality (harmonics, flicker, etc.) requirements	H
Wind and Solar Power Coordinating Committee	Coordination, communication with stakeholders	M

High-Level Test and Verification Process



Brainstorming on Criteria for Verification by Modeling

- Size
  - Small: optional?
  - Large: mandatory?

- Requirement
  - Ride-Through: probably yes?
  - Reactive Power: probably yes?
  - Power Quality: probably not?
  - …

IEEE P2800 Leadership Team

Role	Name	Affiliation	Stakeholder Group	Liaison
Chair	Jens C. Boemer	EPRI	Academic/Research	EDP&G, SCC21
Secretary	Wesley Baker	Power Grid Eng.	Service Provider/ Consulting	EMC, IRPTF
Vice-Chair	Bob Cummings	NERC	Regulatory and Governmental Bodies	NERC IRPTF
Vice-Chair	Kevin Collins	FirstSolar	Users, Industrial	NERC IRPTF
Vice-Chair	Babak Enayati	NationalGrid	Stakeholders represented in IEEE Power & Energy Society	T&D, SCC21, PES GovBrd
Vice-Chair	Ross Guttromson	SANDIA National Lab	Academic/Research	DOE
Vice-Chair	Chenhui Niu	State Grid Corporation of China	Stakeholders represented in IEEE P2800.1 Working Group	IEEE P2800.1, IEC SC8A
Vice-Chair	Manish Patel	Southern Company	Utility, Transmission	PSRC, IRPTF
Treasurer	Diwakar Tewari	Leidos	Service Provider/ Consulting	EDP&G

IEEE P2800 Working Group	Mailing List	stds-p2800@listserv.ieee.org
	Collaborative Workspace for WG Members (only)	https://ieee-sa.imeetcentral.com/p2800-wspi-p/

IEEE P2800 SubGroup	Lead (=Officer)	Mailing List
I. Overall Document	Jens C Boemer	stds-p2800-sg1@listserv.ieee.org
II. General Requirements	Bob Cummings	stds-p2800-sg2@listserv.ieee.org
III. Active Power – Frequency Control	Kevin Collins	stds-p2800-sg3@listserv.ieee.org
IV. Reactive Power – Voltage Control	Wes Baker	stds-p2800-sg4@listserv.ieee.org
V. Low Short-Circuit Power	Ross Guttromson	stds-p2800-sg5@listserv.ieee.org
VI. Power Quality	Ross Guttromson	stds-p2800-sg6@listserv.ieee.org
VII. Ride-Through *Capability* Requirements	Bob Cummings	stds-p2800-sg7@listserv.ieee.org
VIII. Ride-Through *Performance* Requirements	Manish Patel	stds-p2800-sg8@listserv.ieee.org
IX. IBR Protection	Babak Enayati	stds-p2800-sg9@listserv.ieee.org
X. Modeling & Validation, Measurement Data, and Performance Monitoring	Manish Patel	stds-p2800-sg10@listserv.ieee.org
XI. Tests and verification requirements	Chenhui Niu	stds-p2800-sg11@listserv.ieee.org

- Mailing lists are open to all Interested Parties (“Participants”), not only to WG Members.

Logistics of Bi-weekly SubGroup
P2800 Mailing List at stds-p2800@listserv.ieee.org

P2800 SubGroup	Lead	Mailing List	iMeetCentral Folder	Mon	Tues	Wed	Thurs	Fri
I. Overall Document	Jens Boemer	stds-p2800-sg1@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIla				12 PM ET (even weeks)	
II. General Requirements	Bob Cummings	stds-p2800-sg2@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlb					3 PM ET (odd weeks)
III. Active Power – Frequency Control	Kevin Collins	stds-p2800-sg3@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlc				12 PM ET (odd weeks)	
IV. Reactive Power – Voltage Control	Wes Baker	stds-p2800-sg4@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIld		1 PM ET (odd weeks)			
V. Low Short-Circuit Power	Ross Guttromson	stds-p2800-sg5@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIle		11 AM ET (odd weeks)			
VI. Power Quality	Ross Guttromson	stds-p2800-sg6@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlf		11 AM ET (even weeks)			

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P2800 SubGroup	Lead	Mailing List	iMeetCentral Folder	Mon	Tues	Wed	Thurs	Fri
VII. Ride-Through Capability Requirements	Bob Cummings	stds-p2800-sg7@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlg					3 PM ET (even weeks)
VIII. Ride-Through Performance Requirements	Manish Patel	stds-p2800-sg8@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlh			1 PM ET (even weeks)		
IX. IBR Protection	Babak Enayati	stds-p2800-sg9@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIli				4 PM ET (odd weeks)	
X. Modeling & Validation, Measurement Data, and Performance Monitoring	Manish Patel	stds-p2800-sg10@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlj			1 PM ET (odd weeks)		
XI. Tests and verification requirements	Chenhui Niu	stds-p2800-sg11@listserv.ieee.org	https://ieee-sa.imeetcentral.com/p/ZgAAAAAAtIlk	Intentionally Delayed				

Overview of the Project Authorization Request

IEEE Project Authorization Requests

Project	Scope	Status	Lead	Joint Sponsors / Liaisons	Next Steps
P2800 - Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems Link on myProject Adobe Acrobat Document	**Standard** on Performance (**Individual** Project)	Approved by NESCOM/SASB on 9/27/18.	Chair: Dr. Jens Boemer +1.206.471.1180 j.c.boemer@ieee.org	EDP&G – Sponsor EMC – Joint Sponsor PSRC – Joint Sponsor PSDP – Liaison T&D – Liaison Others, see the figure below	Convene WG at 2019 IEEE PES JTCM in January 2019 **Initial Sponsor Ballot: June 2021** Submission to RevCom: October 2022
P2800.1 - Guide for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems Link on myProject Adobe Acrobat Document	**Guide** on Testing (**Entity** Project)	Approved by NESCOM/SASB on 9/27/18.	c/o China State Grid Dr. Chenhui Niu International Department NARI Group Cooperation +86 13451870987 niuchenhui@sgepri.sgcc.com.cn	Same as for P2800, except that PSRC is a Liaison and not a Joint Sponsor	Convene WG at 2019 IEEE PES JTCM in January 2019 Initial Sponsor Ballot: **December 2021** Submission to RevCom: October 2022

IEEE P2800: Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Need for the Project:

The global increase in penetration levels of inverter-based resources is expected to significantly change the dynamic performance of the power grid. As the penetration levels of inverter-based resources increase and the technology of inverter-based resources evolves, specifications and standards are needed to address the performance requirements of inverter-based resources. Currently, there is no one single document of consensus performance requirements covering inverter-based resources interconnected with transmission and sub-transmission systems. Recent events in North America such as the Blue Cut Fire Disturbance as well as institutional challenges in North America that suggest the inappropriate use of IEEE Std 1547 for large-scale solar plants underscore this need. The proposed new standard fulfills this need and can help equipment manufacturers, project developers, transmission planners, and power grid operators improve the quality of the inverter and facility performance to enhance the stability of the power grid. This effort should be aimed to minimize the affected customers and to shorten the time of resynchronizing to the grid if the plant is separated from the grid. Given that IEEE standards are voluntary industry standards, enforcement of any of the requirements specified in this standard will require its adoption by the regional Authority Governing Interconnection Requirements (AGIR); an AGIR is a cognizant and responsible entity that defines, codifies, communicates, administers, and enforces the policies and procedures for allowing electrical interconnection of inverter-based resources interconnecting with associated transmission electric power systems.

IEEE P2800: Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Scope:

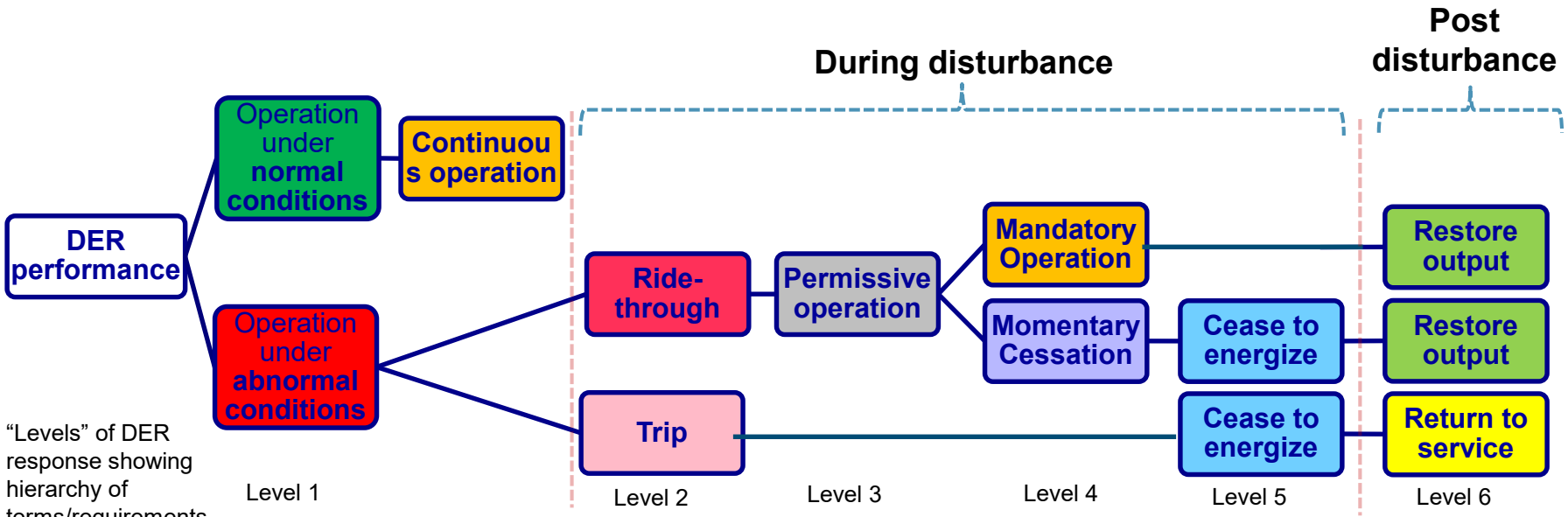
This standard establishes the recommended **interconnection capability and performance criteria** for inverter-based resources interconnected with transmission and networked sub-transmission systems. Included in this standard are recommendations on performance for reliable integration of inverter-based resources into the bulk power system, including, but not limited to, **voltage and frequency ride-through**, active power control, reactive power control, dynamic active power support under abnormal frequency conditions, **dynamic voltage support under abnormal voltage conditions**, power quality, **negative sequence current injection**, and system protection.

Related activities:

IEC initiative to develop a single framework for connecting and controlling renewables. Contact: Charlie Smith, Charlie@esig.energy , U.S. TA for SC 8A.

Disturbance Ride-Through Terminology

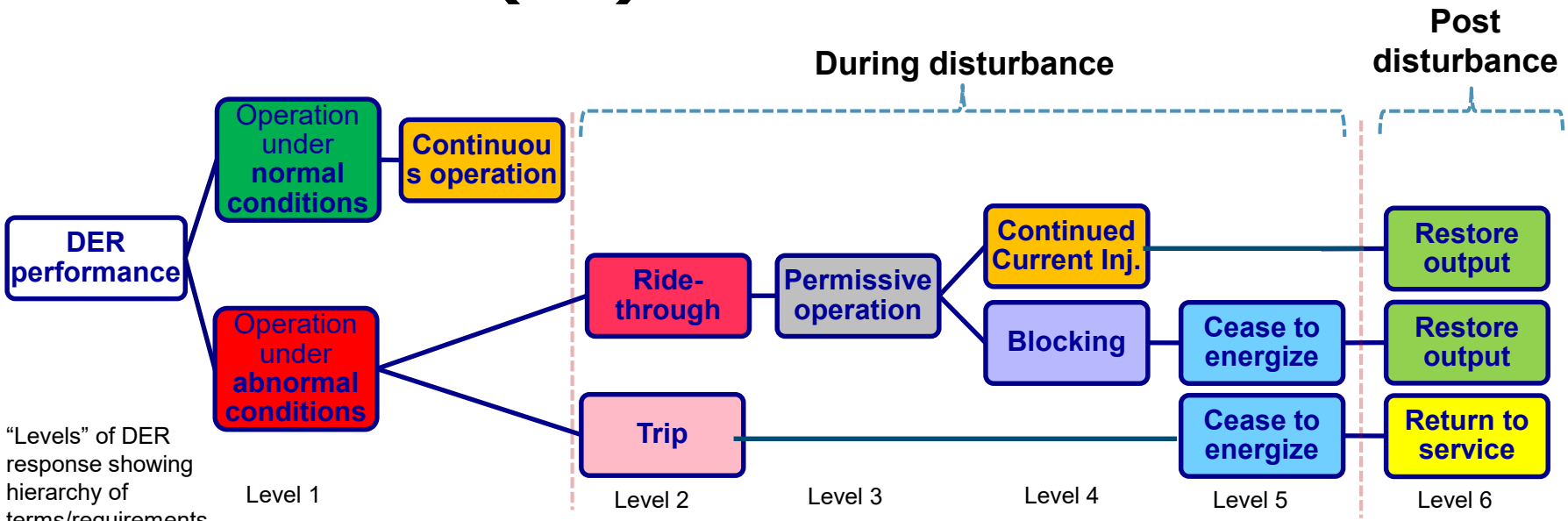
Disturbance performance terminology – IEEE 1547-2018



"Levels" of DER response showing hierarchy of terms/requirements:

- **Ride-through** – ability to withstand voltage or frequency disturbances
  - **Permissive operation** – DER may either continue operation or may cease to energize, at its discretion
    - **Mandatory operation** – required active and reactive current delivery
    - **Momentary cessation** – cessation of energization for the duration of a disturbance with rapid recovery when voltage or frequency return to defined range
  - **Restore output** – DER recovery to normal output following a disturbance that does not cause a ***trip***.
- **Trip** – cessation of output without immediate return to service; not necessarily disconnection
  - **Return to service** – re-entry of DER to service following a trip; equivalent to start-up of DER

Disturbance performance terminology – NERC IRPTF (RL)



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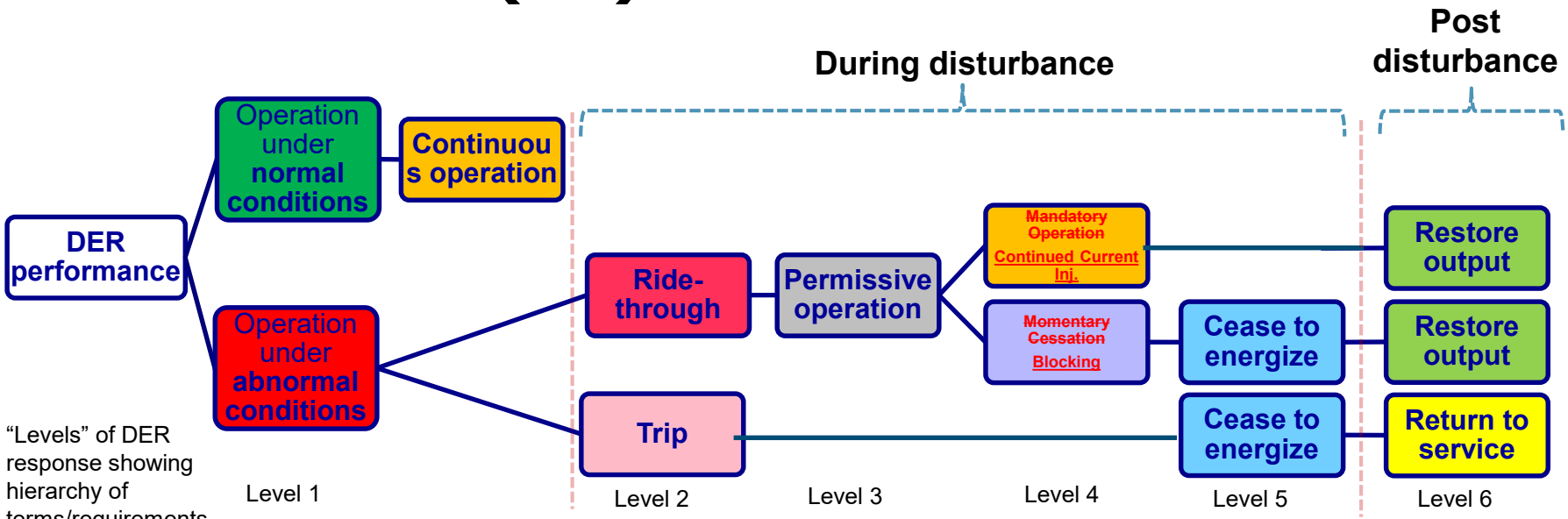

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