IEEE P2800 Kick-Off Meeting

Joint Technical Committee Meeting, Jan 13-17, 2019, Hyatt Regency Orange County (Garden Grove), CA, USA

Jens C. Boemer, WG Chair*

Kevin Collins, Bob Cummings, Ross Guttromson, Manish Patel, Vice-Chairs

Wes Baker, Secretary

January 14, 2019

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

Agenda

Monday 1/14: 8AM – 12PM		
7:45-8:00	Arrival	
8:00-8:05	Welcome, approval of minutes from ConfCall Nov 6, 2018	Chair
8:05-8:10	Facility safety and emergency procedures	Chair
8:10-8:20	IEEE SA Rules, Standards Classification & Language	Chair
8:20-8:40	Introductions (Name, Affiliation)	On-site Participants
8:40-8:45	Stakeholder polling (live poll) • Stakeholder groups	On- and Off-site Participants
08:45-08:55	Overview of the Project Authorization Request • Need, Purpose, Scope, Stakeholders	Chair
08:55-09:10	Review of WG Policies & Procedures, Introduction of WG Leadership Team, Open Positions	Chair, Vice-Chairs, Secretary
09:10-10:00	Technical Presentations (10-min each) 1. Overview on related NERC activities 2. Overview on NERC IRPTF Guideline 3. Transmission planner perspective 4. Developer perspective 5. National lab's related research/projects	 Bob Cummings (NERC) Ryan Quint (NERC) Manish Patel (SouthernCo) Kevin Collins (FirstSolar) Ross Guttromson (SANDIA)
10:00-10:15	Break	

Agenda

Monday 1/14: 8AM – 12PM		
10:15-10:25	Proposed Sub-WG Overview	Chair, Vice-Chairs, Secretary
10:25-11:10	Discussion & Scope Adjustments	All
11:10-11:20	Stakeholder polling (live polls) • Requirements that SHOULD NOT be included • Sub-WG contributors	On- and Off-site Participants
11:20-11:40	Timeline • Proposed timeline • Discussion • Desired timeline (live polls)	Chair, On- and Off-site Participants
11:40-11:50	Coordination • Coordination with P2800.1 • IEC coordination	Chair Chenhui Niu (P2800.1 Chair) Murty Yalla (*invited*)
11:50-12:00	Next Meetings	Chair
12:00	Adjourn	Chair

Welcome 170+ Interested Parties

AEP	DNV GL	ESC Eng. Inc.	MEPPI	PEACE®	SouthernCo	Opal-RT	GridLab
AMSC	DOE	FERC	MISO	PJM	Tesla	LADWP	Entergy
AWEA	Dominion	First Solar	National Grid	Power Grid Eng. LLC	TVA	FuelCell Energy	Shell
Beckwith Electric	Duke Energy	GE	NERC	S&C Electric Co.	University of Auburn	Xanthus Consulting	…
Bernhard Ernst Energy Consulting	Electrotek Concepts	Hydro One	NextEra Energy	SANDIA	University of North Carolina	Seminole Electric Cooperative	
Brush Electric Machines, Ltd.	Enercon	Hydro Quebec	NREL	Sargent Lundy	WES Consulting, LLC	INL	
China State Grid	ESIG	Invenergy LLC	NV Energy	Seattle City Light	Western Energy Board	NYISO	
Cinch, Inc.	EnerNex	IREQ	Open Access Technology Intrntl.	Siemens	Wichita University	SCS Transmission Planning	
ComEd	EPRI	ISO New England Inc.	Outback Power	SMA	XcelEnergy	Avista	
ComRent	ERCOT	Leidos Engineering	Pacific Corp	Southern	XM Columbia	The University of Alabama	

Meeting Goals

1. Introduce Working Group Leadership and Policies & Procedures

2. Define Scope and Form Sub-Working Groups

3. Develop timeline, frequency for meetings & calls

4. Call for volunteers to fill open positions

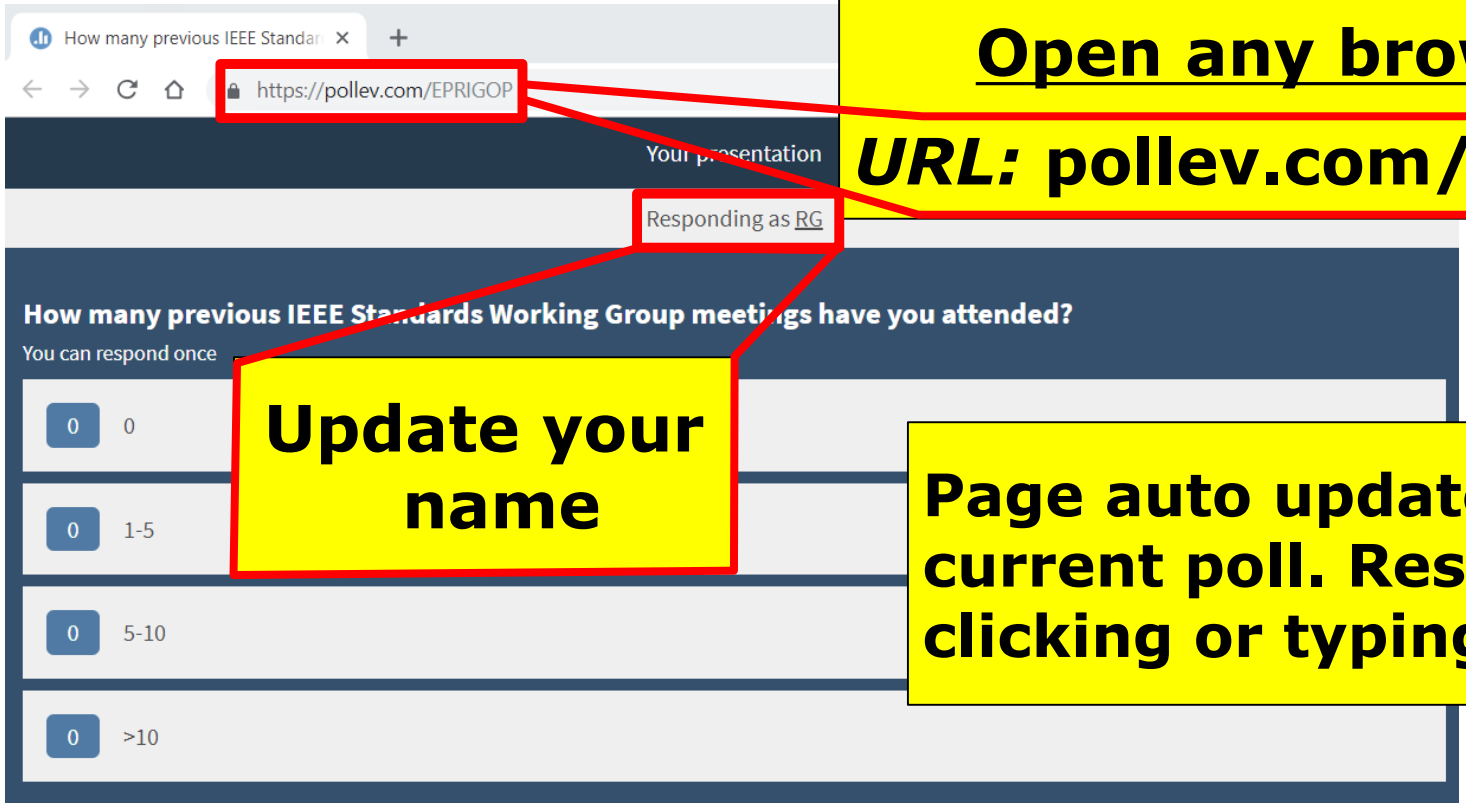
Previous Meeting

- Approval of minutes from ConfCall Nov 6, 2018

Facility safety and emergency procedures

- Emergency exits
- Assembly location
- Defibrillator location
- Dial 911 in emergency

Participate in Interactive Polls – Option A



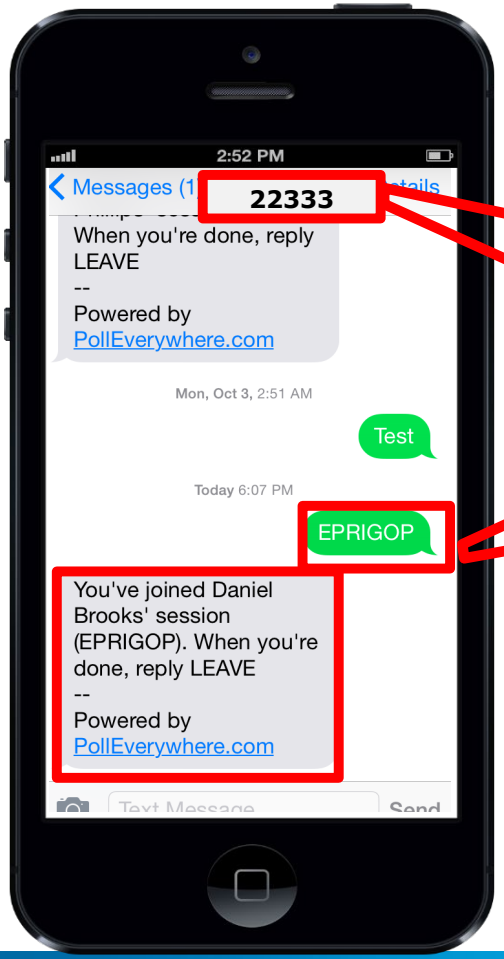
Open any browser:

URL: **pollev.com/eprigop**

Update your name

Page auto updates with current poll. Respond by clicking or typing text.

Participate in Interactive Polls – Option B



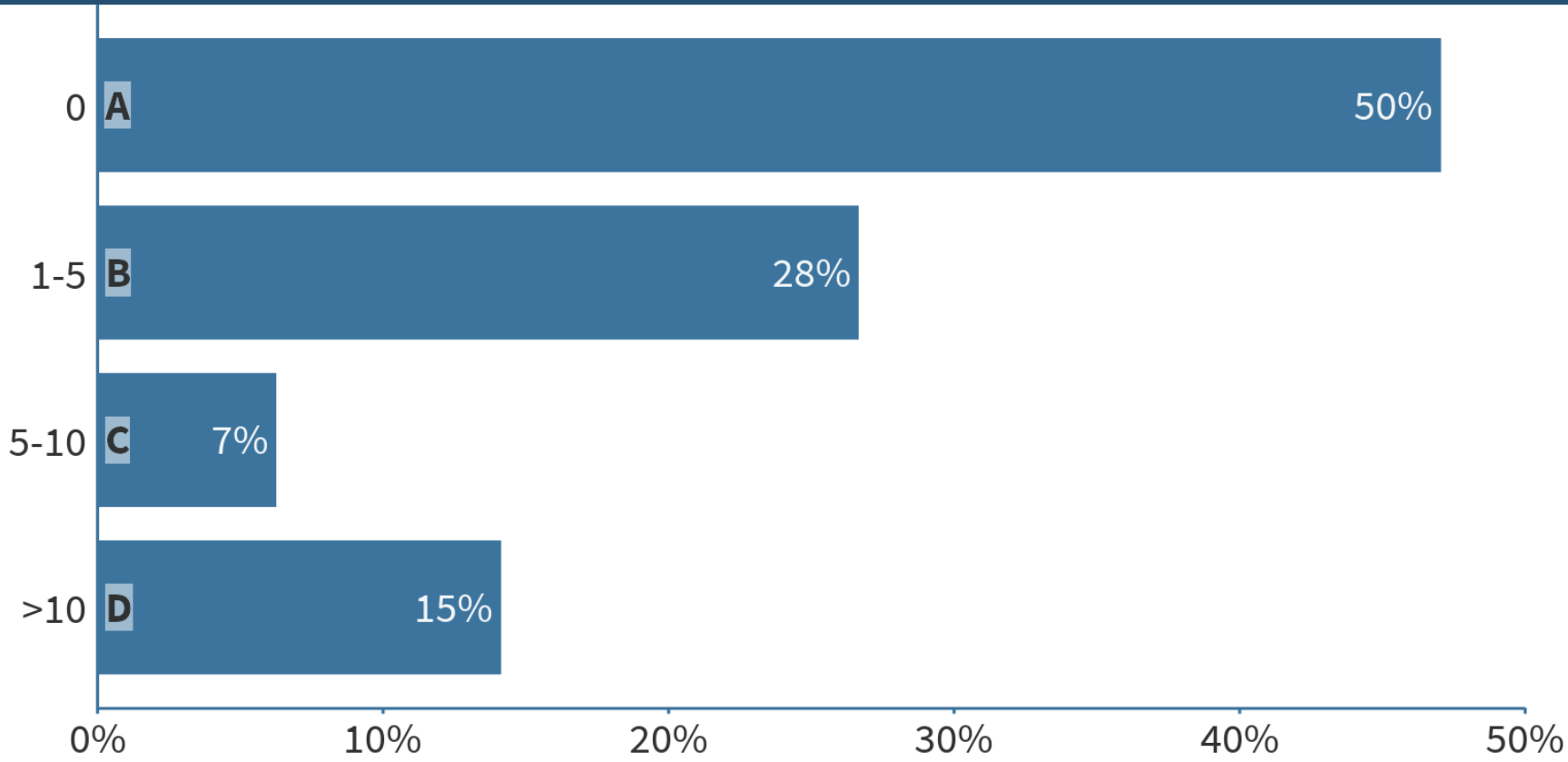
Send following Text:

***Phone #:* 22333**

***Message*: "EPRIGOP"**

You've joined Daniel Brooks' session (EPRIGOP). When you're done, reply LEAVE
--
Powered by PollEverywhere.com

How many previous IEEE Standards Working Group meetings have you attended?



Responses: 60

Electronic Communication & Collaboration

- Sponsor Websites
  - ED&PG Wind and Solar Plant Interconnection Working Group
  - EMC Renewable Energy Systems Subcommittee
  - Power Systems Relaying Committee

- iMeetCentral Workspace … *coming soon!*

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**

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

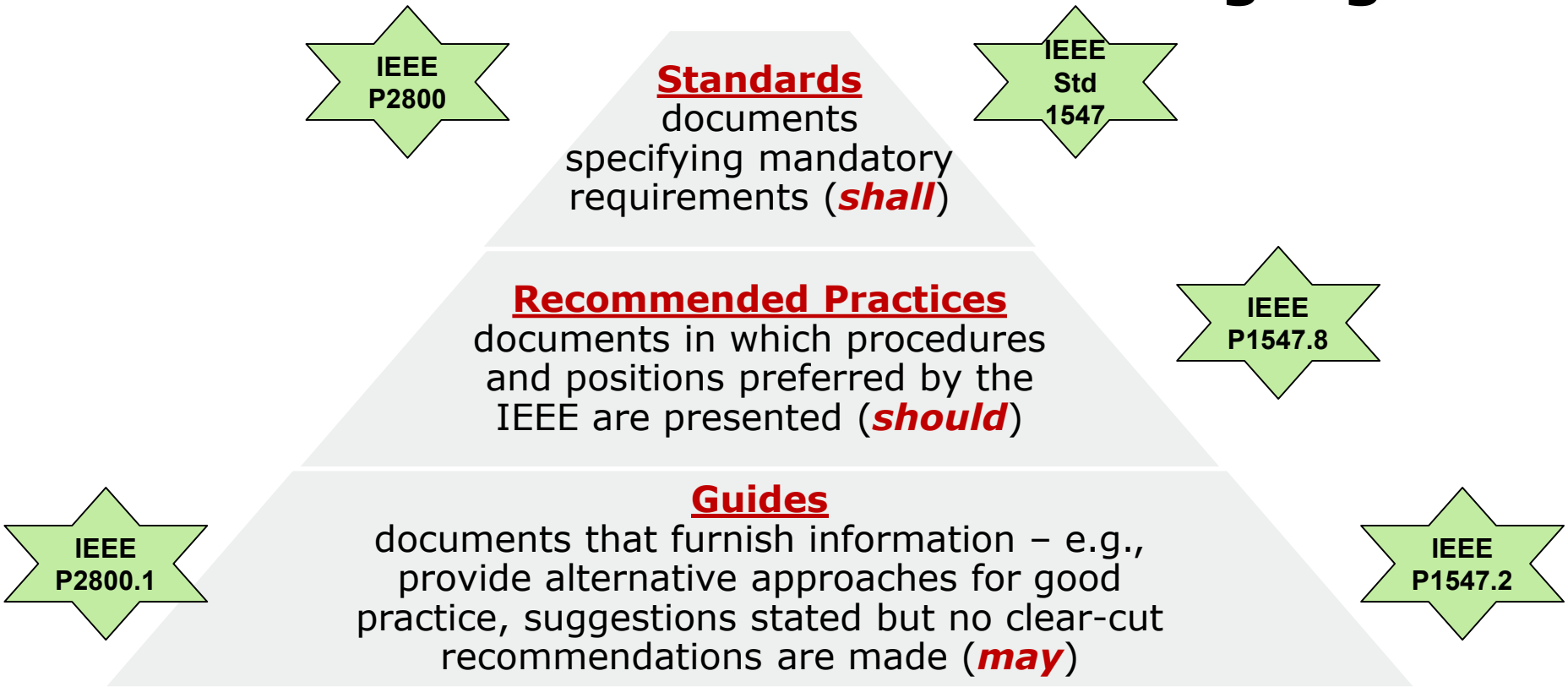
If you have questions, contact the IEEE-SA Standards Board Patent Committee Administrator at patcom@ieee.org

Resources

- **Training Videos**
  - How to Run an Individual Working Group
  - How to Run an Entity Working Group

- **Bylaws and Procedures**
  - IEEE-SA Standards Board Bylaws
    -http://standards.ieee.org/develop/policies/bylaws/
  - IEEE-SA Standards Board Operations Manual
    -http://standards.ieee.org/develop/policies/opman/
  - IEEE Baseline Operational Procedures
    http://standards.ieee.org/about/sasb/audcom/bops.html

IEEE Standards Classification & Language



IEEE SA Balloting Rules

Consensus =

- ≥75% Quorum
- ≥75% Approval
  - *WG Chair's goal is ≥90%!*

Introductions

Name, Employer, Affiliation

Please keep it short!

Stakeholder Groups

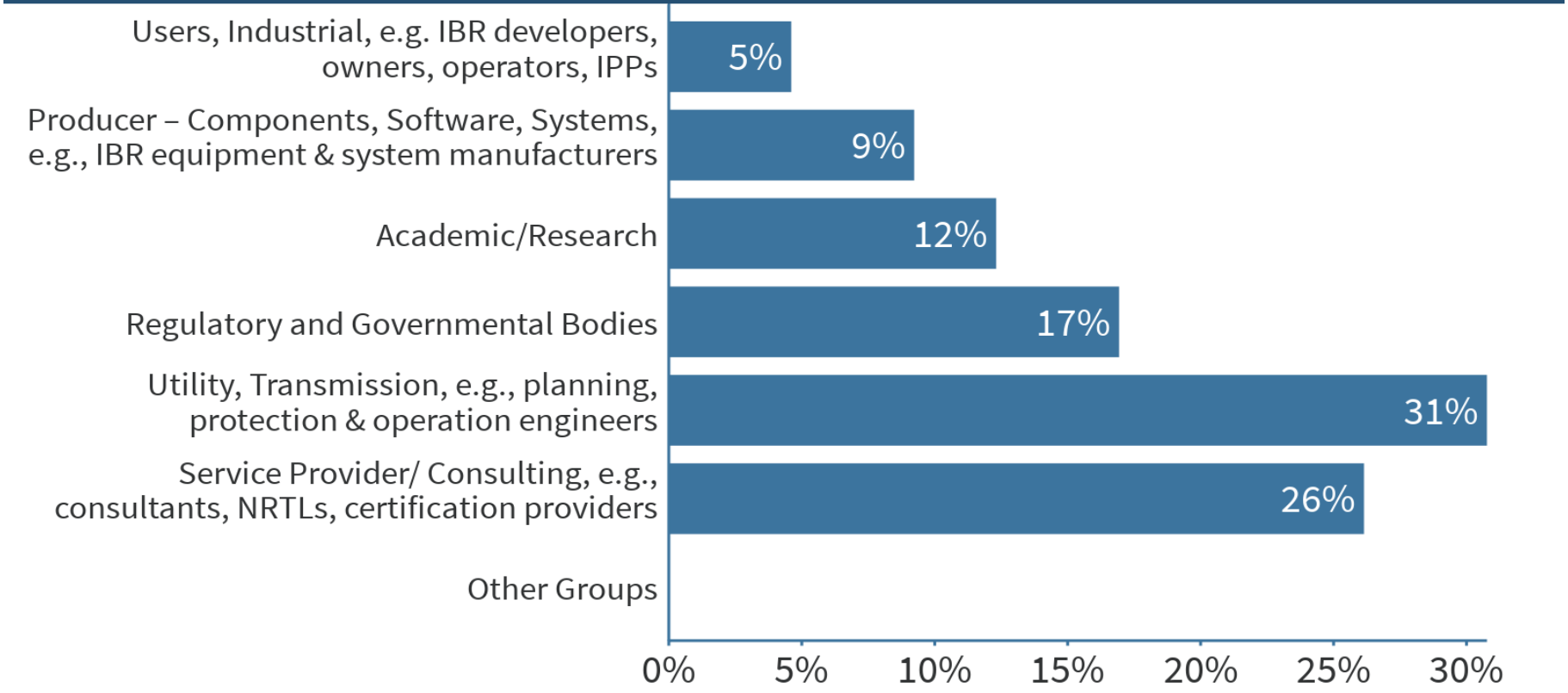
Applicable Groups

- Users, Industrial, e.g. IBR developers, owners, operators, IPPs
- Producer – Components, Software, Systems, e.g., IBR equipment & system manufacturers
- Academic/Research
- Regulatory and Governmental Bodies
- Utility, Transmission, e.g., planning, protection & operation engineers
- Service Provider/ Consulting, e.g., consultants, NRTLs, certification providers

Other Groups?

- Utility, Distribution?
- IBR installers?
- IBR aggregators?
- Non-governmental Organization (NGO) / Advocacy Group?
- Standards Developing Organization?
- General Interest

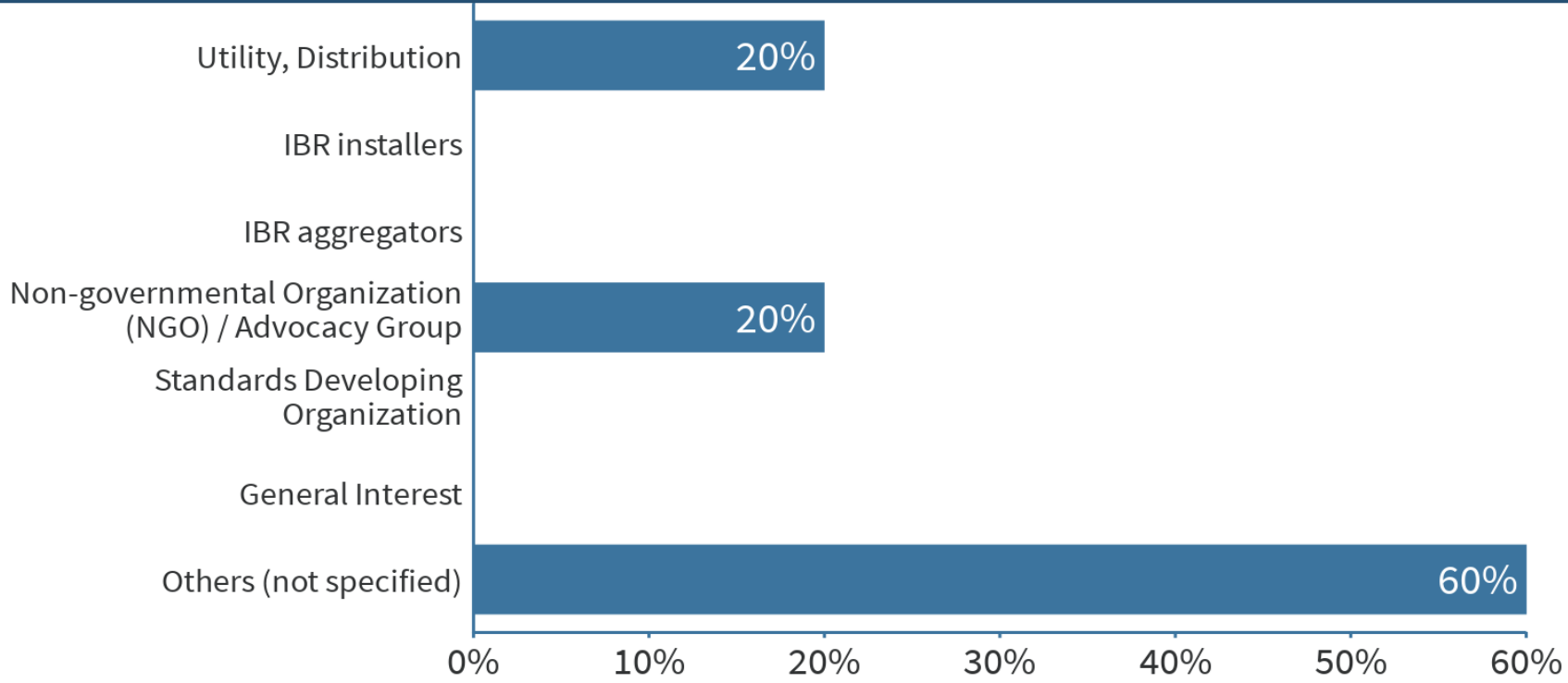
Which of the following balloter classifications do you belong to?



Responses: 65

Total Results: 65

If you chose "Other Groups" in the previous question, which of the following balloter classifications do you belong to?

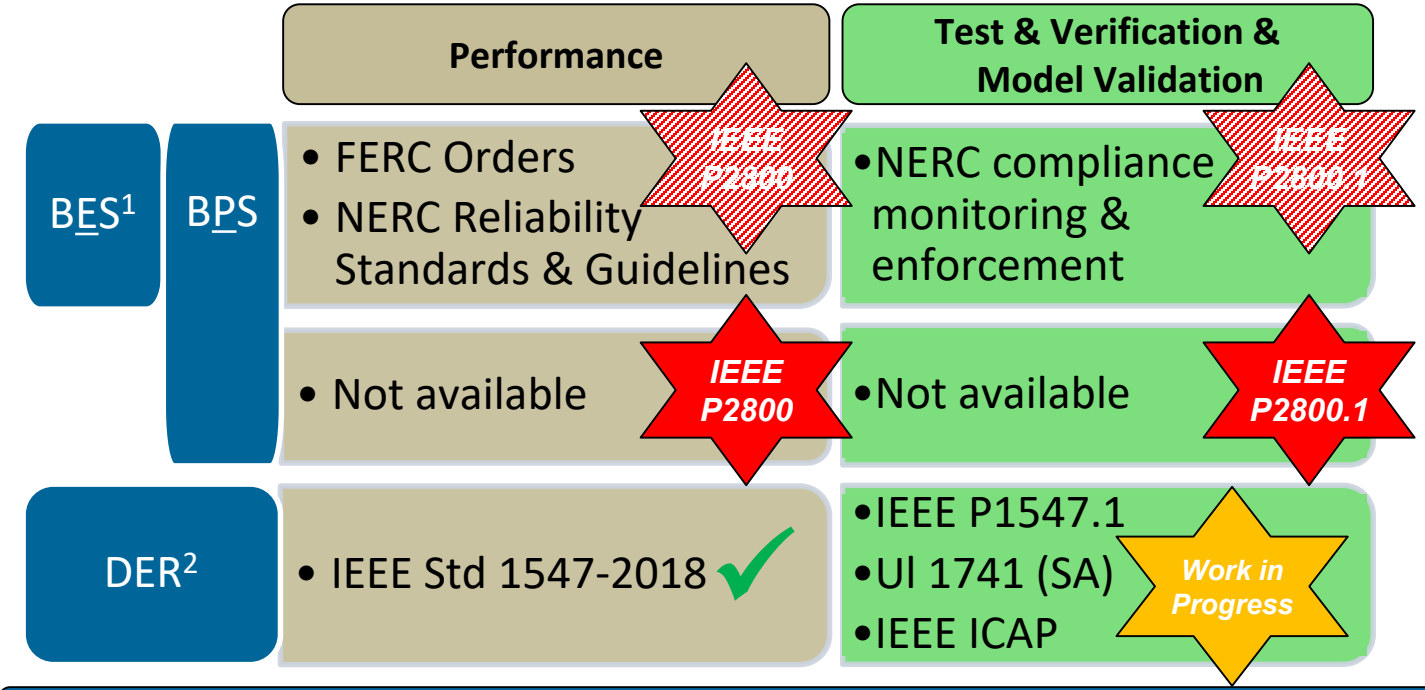


Responses: 5

Total Results: 5

Overview of the Project Authorization Request

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

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

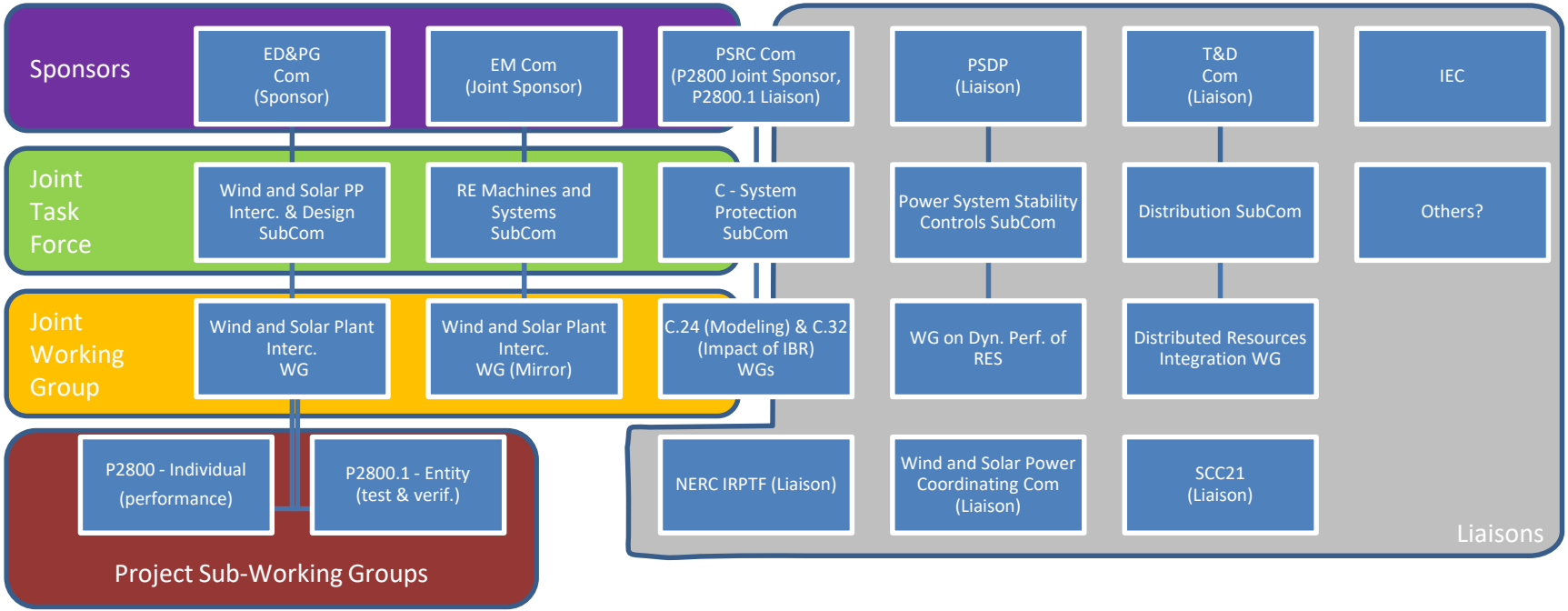
Clarifications from Informal Kick-Off Call

- 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
  - 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

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

Coordination Approach for BPS-Connected Inverter-Based Resources IEEE standards projects P2800 and P2800.1



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.

Review of WG Policies & Procedures, Introduction of WG Leadership Team, Open Positions

Review of WG Policies & Procedures

- Based on IEEE Standards Association (IEEE-SA) Baseline Policies – Individual Method that are available online at https://standards.ieee.org/about/sasb/audcom/bops.html
- **3.0 Officers**
  - 1 Chair, 1 Secretary, 4-5 Vice Chairs, *not needed:* Treasurer?
  - Chair and Vice Chairs shall each be IEEE members of any grade, except Student grade, or IEEE Society affiliates, and also be members of IEEE-SA
- **3.1 Election or Appointment of Officers**
  - Case 1 – Chair appointed and Chair appoints other officers
  - ~~Case 2 – Chair appointed and other officers elected~~ *(deleted)*
  - ~~Case 3 – All officers elected~~ *(deleted)*
  - The appointment of officers shall be for a term of **one year**, but an officer may serve **until a successor is appointed**.

Review of WG Policies & Procedures

- **3.3 Removal of Officers**
  - An officer may be removed by approval of two-thirds of the members of the Working Group
  - Removal of the Chair ~~and Vice Chair~~ requires affirmation by the Sponsor
  - Grounds for removal shall be included in any motion to remove an officer of the Working Group
  - The officer suggested for removal shall be given an opportunity to make a rebuttal prior to the vote on the motion for removal
- **3.4 Responsibilities of Working Group Officers**
  - Act in the best interest of the IEEE, its members and the general public
  - Act not on behalf of any individual, entity or interest group
  - Comply with all applicable policies and procedures
  - See that participants of the Working Group show good conduct
  - Being familiar with training materials available throughIEEE.

Review of WG Policies & Procedures

- **3.4.1 Chair**

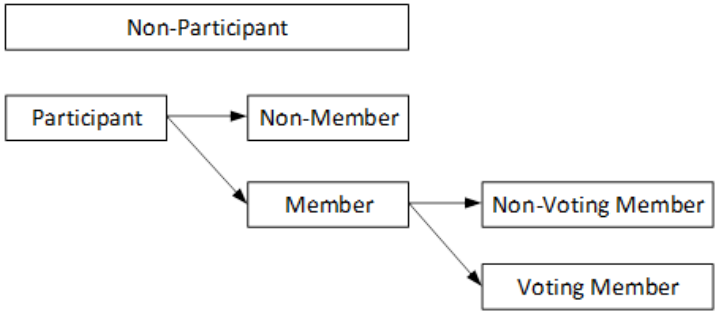
The responsibilities of the Chair or his or her designee shall include (among others)

- Leading the activity according to all of the relevant Policies and Procedures.
- Forming Study Groups, as necessary, and appoint their Leads
- Being objective.
- Entertaining motions, but not making motions.
- Not biasing discussions.
- Delegating necessary functions.
- Ensuring that all parties have the opportunity to express their views.
- Setting goals and deadlines and adhere to them.
- Seeking consensus as a means of resolving issues.
- Complying with the IEEE-SA Intellectual Property Policies

Review of WG Policies & Procedures

- **3.4.2 Vice Chairs**
  - Carrying out the Chair's duties if the Chair is temporarily unable to do so, chooses to recuse himself or herself, or chooses to delegate specific duties
  - **Overseeing the subgroups and preferably leading specific subgroups that he or she or another Vice-Chair oversees.**
  - Being knowledgeable in IEEE standards processes and parliamentary procedures
  - Being familiar with training materials available throughIEEE.
- **3.4.3 Secretary**
  - Scheduling meetings in coordination with the Chair and distributing meeting notices
  - Recording minutes of each meeting and publishing them within 60 calendar days
  - Creating and maintaining the participant roster, submitting to IEEE SA annually
  - Maintaining lists of unresolved issues, action items, and assignments
  - Carrying out minimal treasury responsibilities

Review of WG Policies & Procedures



- **4.0 Working Group Membership**
  - Working Group membership is by individual
  - Membership shall be granted automatically to those attending this kick-off meeting
  - Membership shall be granted after attending two consecutive meetings, at request
    - Attendance credit is granted to those who attend at least 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

Review of WG Policies & Procedures

- **6.0 Meetings**
  - either exclusively in-person or **in-person with one or more participants contributing via electronic means**, or exclusively via electronic means
  - shall be held, as decided by the Working Group, the Chair, or by petition of ***15%*** or more of the voting members
  - meeting notice shall be distributed to all participants ***30*** **calendar days** in advance
  - meetings are open to anyone who has a material interest and wishes to attend
    - some meetings may occur in Executive Session
- **6.1 Quorum**
  - quorum shall be defined as *one-half* of Working Group voting members
  - if a quorum is not present, actions may be taken subject to confirmation by letter or electronic ballot
- **6.2 Conduct:** refer to IEEE Code of Conduct and IEEE Code of Ethics

Review of WG Policies & Procedures

- **7.1.1 Actions Requiring Approval by a Majority Vote**
  - Formation or modification of a subgroup, including its procedures, scope, and duties
  - Disbandment of subgroups
  - Approval of minutes.
- **7.1.2 Actions Requiring Approval by a Two-thirds Vote**
  - Approval of change of the Working Group scope *
  - Establishment of fees, if necessary
  - Approval to move the draft standards project to the Sponsor for IEEE Standards Sponsor ballot

  * This item is subject to confirmation by the responsible subcommittee and the Sponsor.
- **7.2 Voting Between Meetings**
  - discretion of the Chair by the use of a letter or electronic ballot

Call for nomination and self-nominations for P2800 WG leadership positions

- ✓ 1 Chair
- ✓ 4 Vice-Chairs (= Sub-WGs Leads)
  - One additional Vice-Chair position available (as needed)
- ✓ 1 Secretary
- Sub-WG Co-Leads & Facilitators (as needed)
- Sub-WG Members

- Please send your (self-)nominations to
  - Jens C Boemer, j.c.boemer@ieee.org
  - Wes Baker, wbaker@powergridmail.com

Selection Criteria

- Individuals that represent global stakeholders in a balanced way, including bulk system interconnection engineers and planners, vendor and developer representatives.
- Experience with IEEE and NERC standards processes and preferably previous members of NERC IRPTF and IEEE P1547.
- Representatives / Liaisons with involved IEEE PES Committees that either jointly sponsor or send liaisons
- Availability and motivation, availability for travel to 3 -4 in-person meetings (adjacent with IEEE JTCM in winter, NERC IRPTF in spring, PES GM in summer)
- Diversity, nominations of female and non-Caucasian industry leaders should be encouraged.
- Topic area leads.

Anticipated Resource Commitments

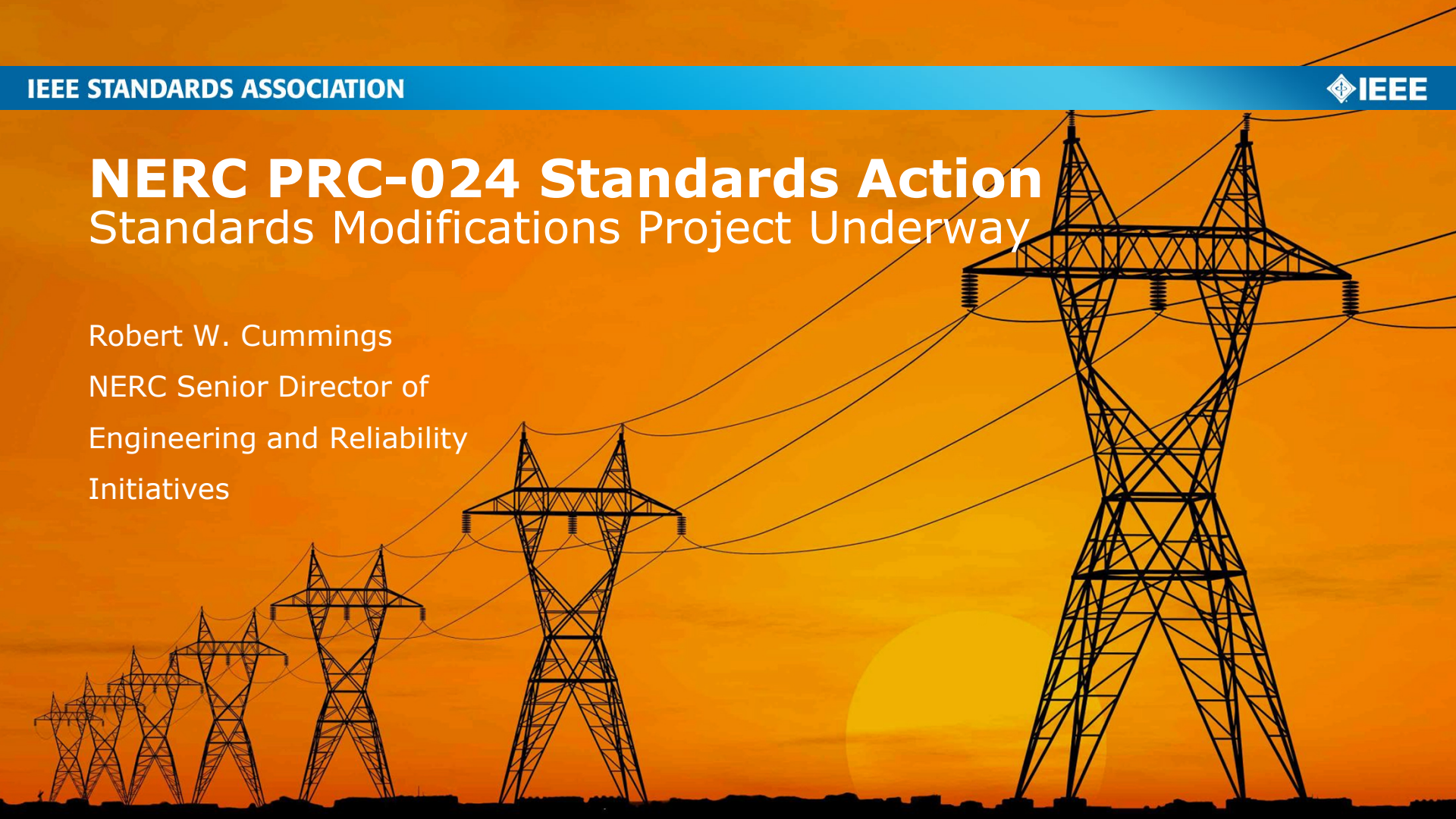
Commitments	Officers (Chair, Vice-Chairs, Secretary)	Sub-WG Leads & Facilitators	Sub-WG Members	Liaisons
Regular attendance of 3-4 in-person meetings per year (2-3 days each) over the duration of the project of 2-3 years	In person	In person	In person or remotely	In person or remotely
Regular attendance of approx. monthly P2800 leadership calls (1hr each)	X			
Review of draft requirements	X	X	X	X
Attendance/contributions to Sub-Working Group draft requirements and calls as needed (may vary, but typically weekly calls of 1 hr)		X	X	as needed

Please send your (self-)nominations to
Jens C Boemer, j.c.boemer@ieee.org and Wes Baker, wbaker@powergridmail.com

Introduction of WG Leadership Team

Position	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	IRPTF
Vice-Chair	Kevin Collins	FirstSolar	Users, Industrial	IRPTF
Vice-Chair	Manish Patel	Southern Company	Utility, Transmission	PSRC, IRPTF
Vice-Chair	Ross Guttromson	SANDIA National Lab	Academic/Research	DOE
Vice-Chair	[open position, as needed]			

Technical Presentations



NERC PRC-024 Standards Action
Standards Modifications Project Underway

Robert W. Cummings

NERC Senior Director of

Engineering and Reliability

Initiatives

NERC Inverter-Based Resources Activities

- NERC/WECC Analyses of 2016 Blue Cut and Canyon 2 Fires showed inverter-based resources dropping off-line during normally-cleared BPS faults
- Two Reliability Alerts issued on IBRs: June 2017 and May 2018

September 2018 Publications

- Reliability Guideline – BPS-Connected Inverter-Based Resource Performance
- Reliability Guideline – Power Plant Model Verification for Inverter-Based Resources

NERC Inverter-Based Resource Performance Task Force (IRPTF) Follow-up:

- PRC-024-2 Gaps Whitepaper – Approved by NERC Planning and Operating Committees in November 2018
- SAR for Modifications to PRC-024-2 – Jointly submitted in November 2018 to the NERC Standards Committee by the Planning and Operating Committees

NERC Inverter-Based Resources Activities

NERC Standards Committee Action on SAR for Modifications to PRC-024-2 (unanimous)

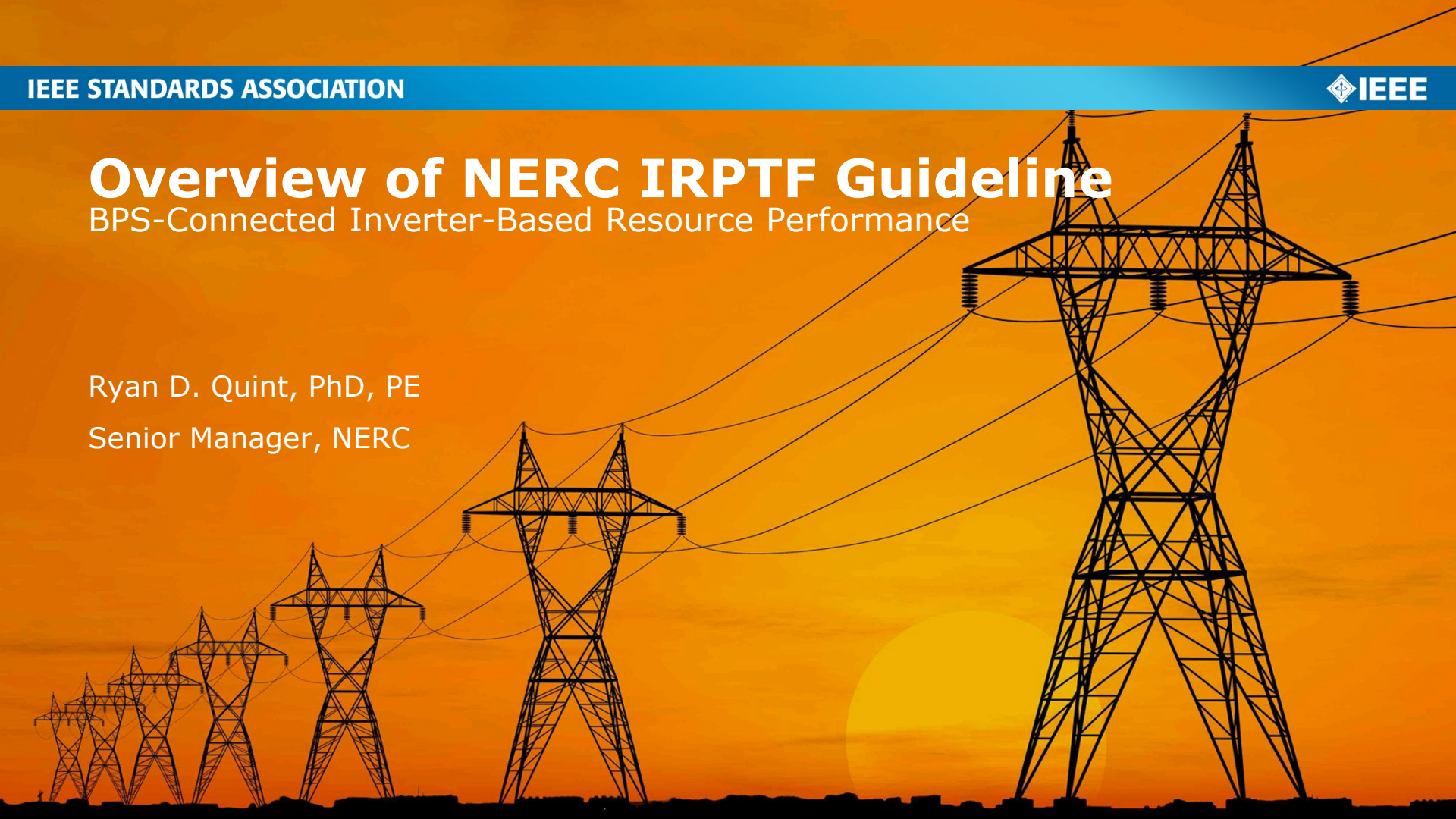
- SAR posted for formal comment period through 18 January 2019
- Nominations being sought for SAR drafting Team Members through 18 January 2019

Overview of NERC IRPTF Guideline

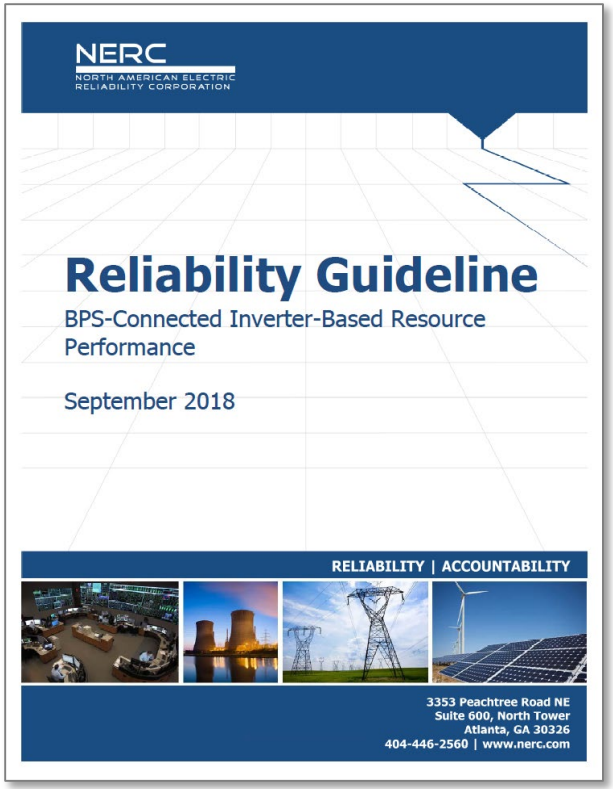
BPS-Connected Inverter-Based Resource Performance

Ryan D. Quint, PhD, PE

Senior Manager, NERC



Reliability Guideline



Topics:

- Momentary cessation (elimination of)
- Ramp rate interactions (mitigation of)
- Active power-frequency control
- Reactive power-voltage control
- Steady-state vs. small/large disturbance
- Protection, tripping, and return to service
- Ride-through capability
- Measurement data and performance monitoring
- Dispatchability
- Modeling and model verification

Momentary Cessation

- Overall goal to eliminate momentary cessation for newly interconnecting resources – use other forms of ride-through
  - Leads to system-wide instability if used (in its current default form)
- May be warranted at very low voltage (e.g., < 0.2-0.3 pu)
- Recovery from any use of momentary cessation should be on the order of cycles (similar to other forms of power electronics – HVDC, STATCOMs)
- Ramp rate interactions (in inverter or plant-level controller) should not impede any dynamic response)

- Overall plant performance characteristic critical

Active Power-Frequency Control

- FERC Order No. 842 – P2800 needs to align with this (possibly clarify)
- Steady-state and dynamic performance specifications critical

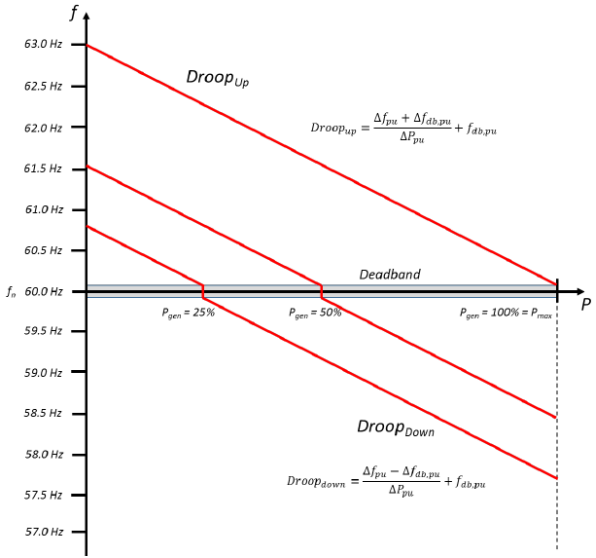


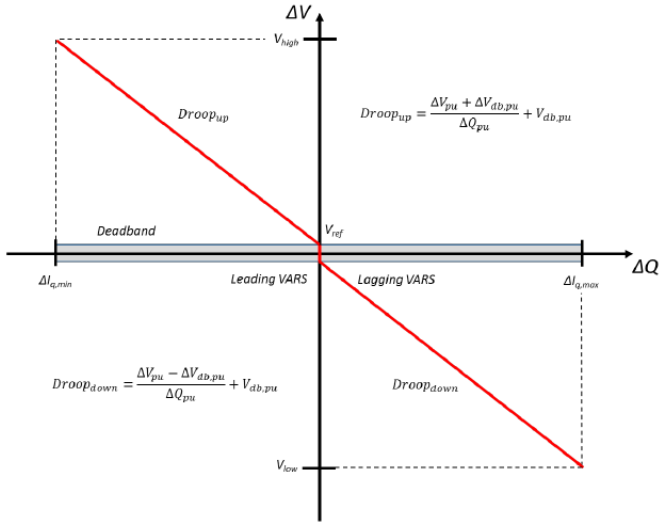
Table 2.1: Dynamic Active Power-Frequency Performance

Parameter	Description	Performance Target
For a step change in frequency at the POM of the inverter-based resource…		
Reaction Time	Time between the step change in frequency and the time when the resource active power output begins responding to the change[31]	< 500 ms
Rise Time	Time in which the resource has reached 90 percent of the new steady-state (target) active power output command	< 4 seconds
Settling Time	Time in which the resource has entered into, and remains within, the settling band of the new steady-state active power output command	< 10 seconds
Overshoot	Percentage of rated active power output that the resource can exceed while reaching the settling band	< 5 percent**
Settling Band	Percentage of rated active power output that the resource should settle to within the settling time	< 2.5 percent**

** Percentage based on final (expected) settling value

Reactive Power-Voltage Control

- Steady-state specification
- Capability and power factor
- Point of measurement
- Dynamic reactive (not static)
- Closed-loop automatic voltage control
  - Droop and deadband option



Reactive Current-Voltage Control

- Dynamic specification
- Small disturbance vs. large disturbance
- Large disturbance:
  - Stable response
  - V outside continuous operating range
  - Local control (fast)
  - Limited to inverter capability
    - Coordination – capability, limits, and protection
  - During and immediately after faults
  - Negative (and zero) sequence specification
- Q at 0 P capability

Table 3.1: Small Disturbance Reactive Power-Voltage Performance

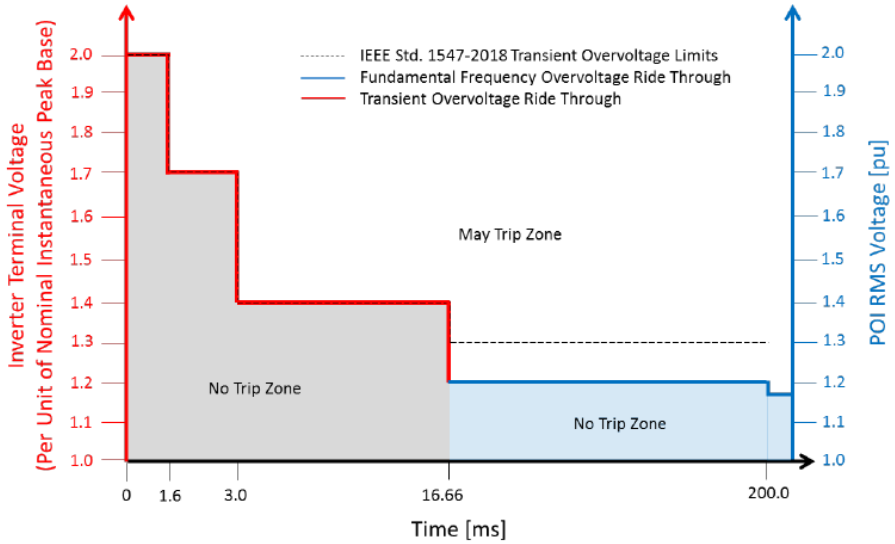
Parameter	Description	Performance Target
For a step change in voltage at the POM of the inverter-based resource…		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change[47]	< 500 ms*
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90 percent of its final value	< 1–30 sec**
Overshoot	Percentage of rated reactive power output that the resource can exceed while reaching the settling band	< 5 percent***

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***

Protection and Limiters

- Many forms of inverter protection/controls that impact response of overall plant
- Capability of automatic reconnection, coordination/control by transmission side
- Coordination with NERC PRC-024-2
- **High** priorities:
  - **Transient overvoltage**
  - Phase lock loop performance
  - Overall inverter ride-through capability
  - Successive voltage dips



Measurements and Performance Monitoring

- Supervisory Control and Data Acquisition (SCADA) data
- Dynamic Disturbance Recorder (DDR) data – (PMU-type data)
- Digital Fault Recorder (point-on-wave) data – plant-level
- Sequence of Event Recorder (SER) data – throughout plant
- Inverter-level point-on-wave data – specified triggers
- Inverter fault codes
- Inverter change of status or operating mode
- Time synchronization

- **Poor data has hindered disturbance analyses! We (all of us) need data!**

Short Circuit Strength Specification

- Low short circuit strength conditions
  - Control interactions
  - Controls instability
  - Controls cycling
- Specification of range of stable operating conditions
  - Expected impedances
  - Expected frequencies
- Mitigation of “weak grid” issues
- Grid forming inverter capability

Goal

- NERC IRPTF Reliability Guideline serves as cornerstone document for recommended inverter-based resource performance in North America
- Manufacturers heavily engaged in the development of this Reliability Guideline
- Will continue to serve as guiding document until P2800 is complete and future IEEE Std. 2800 is enforceable
- Coordination ongoing between NERC and IEEE PES and IEEE SA

- **NERC IRPTF Reliability Guideline should serve as the foundation for P2800**
  - Provides high-level recommendations regarding performance
  - Vetted across wide industry stakeholder group
  - May need more details on exact performance specifications
- **Refer to Appendix A of the IRPTF Reliability Guideline**

Transmission Planner's Perspective
(Utility Engineer's Perspective)

Manish Patel, PhD, PE

Southern Company Transmission

Need & Expectations

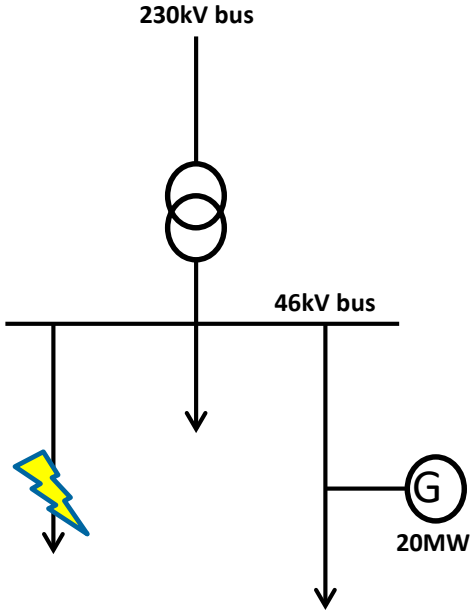
Need for the Project

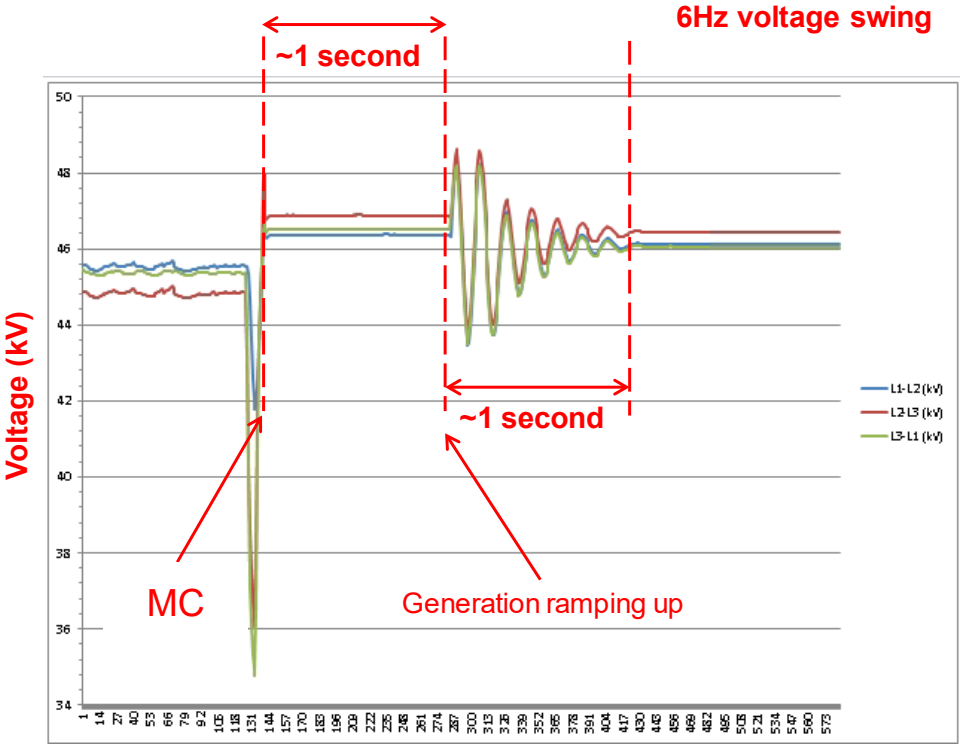
- Lessons learned
- Inappropriate use of 1547 for transmission connected resources
- IBRs replacing synch. machine based generation
- Grid Supportive behavior is necessary
  - System stability
  - System protection
  - Power quality
  - Low relative system strength

Expectations

- Consistent terminology
- Standard that serves as a reference in interconnection requirements.
- Standard (agreed by stakeholders)
  - Equipment capability
  - Technical performance reqs.
  - Modelling & Validation
- Standard that serves as a reference in interconnection requirements.

Example - Ride-through & Low SCR





Fault Currents

8. **Short Circuit Contribution of the Generating Facility at the Point of Interconnection.**

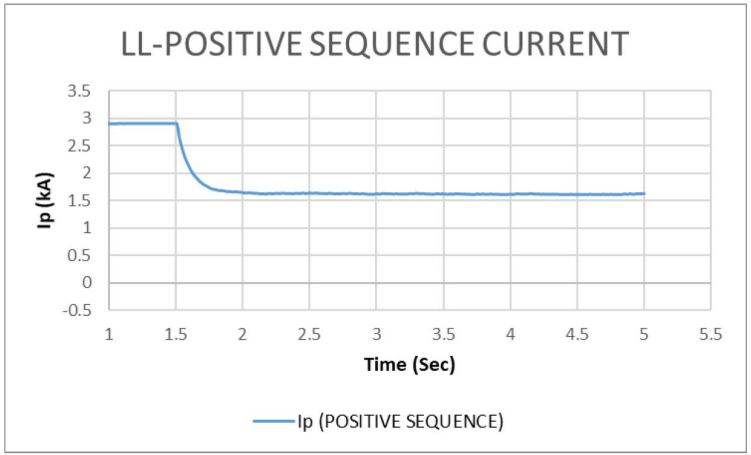
   a) Maximum Three Phase Fault Current: 227 Amps and Duration: 6 Cyles

   b) Maximum Single Line to Ground Fault* Current: 335 Amps and Duration: 4 Cycles

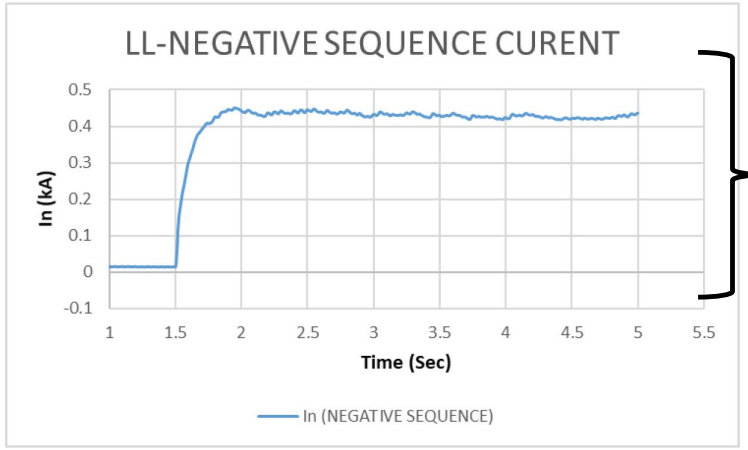
   * Single Line to Ground Fault at the Point of Interconnection with ties to utility at the POI open.

From Interconnection Request Facility Data

Positive Sequence:



Negative Sequence:



Three Phase Time Domain Model

P2800 Scope
Developer Perspective

Kevin Collins, PE

First Solar

P2800 – Developer Priorities

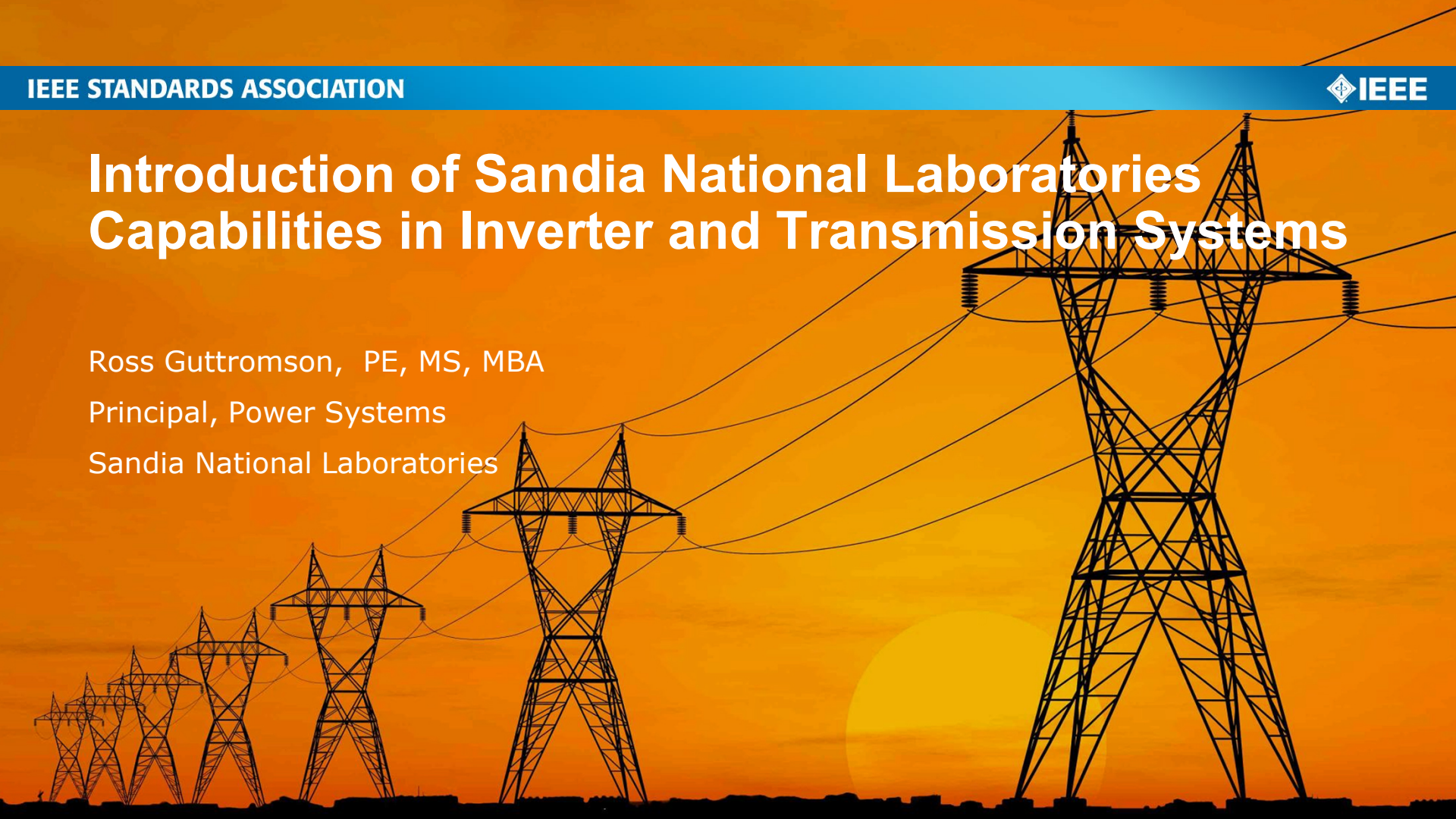
- **There is a clear need for a standard**
  - Current inverter requirements are driven by UL1741 which applies to IBR connected to Distribution
    - Only existing safety standard for inverters
    - Listing is required to comply with project Code requirements
    - Conflicts with the intended requirements of PRC-024 (eg. May trip vs Must trip)
  - Requirements specifically applicable to IBR connected to BPS:
    - Must define requirements at plant level but also sufficiently account for inverter requirements
    - Must coordinate with UL1741 so inverters can be Listed in BPS connected projects
    - Must be uniform and drive performance and capability standardization
  - Operating Data requirements must be standardized– plant and equipment level
    - Acquisition, retention, and access requirements
- **There is an urgent need for a standard**
  - Recommend Expediting the P2800 Schedule by at least 12 months
- **Leverage the NERC IRPTF Reliability Guideline as the starting point for P2800**

Introduction of Sandia National Laboratories Capabilities in Inverter and Transmission Systems

Ross Guttromson, PE, MS, MBA

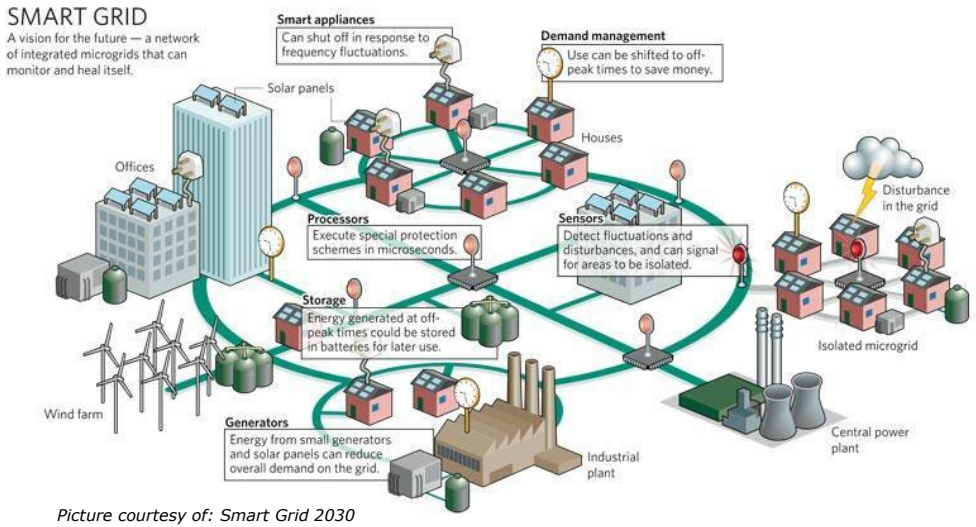
Principal, Power Systems

Sandia National Laboratories



Sandia's Grid Modernization Vision

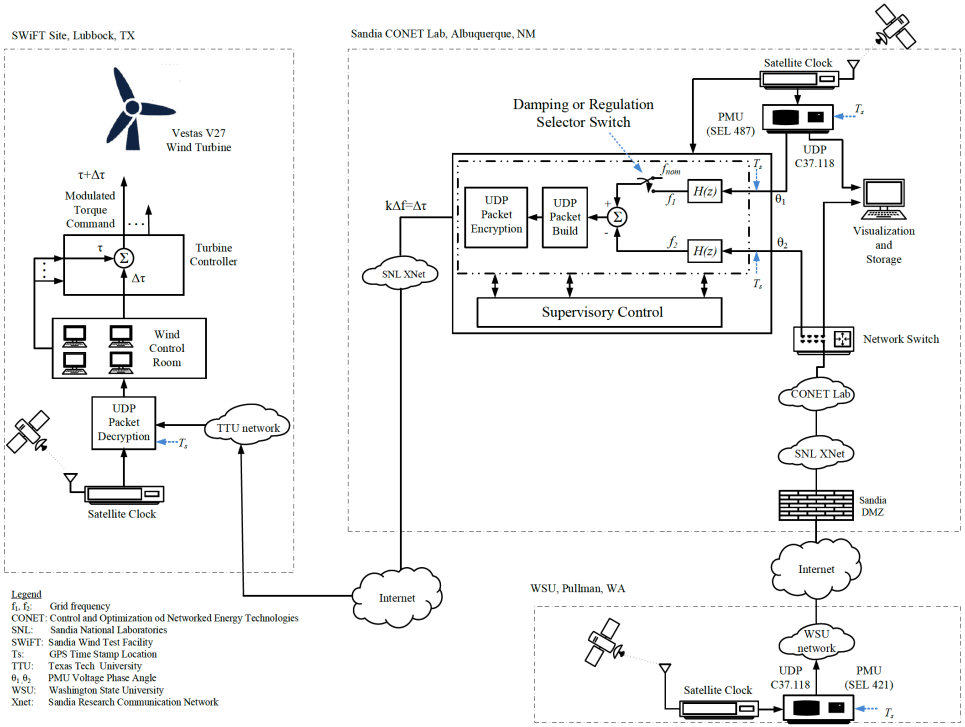
A world of interdependent and variable distributed systems that are optimized at multiple scales – including transmission – to maximize local resources in providing secure, resilient, and clean energy to all users at all times.



Picture courtesy of: Smart Grid 2030

- DER and renewable energy integration
- Power electronics and controls
- Secure and scalable microgrids
- Advanced grid analytics/complex systems
- Infrastructure interdependencies
- Cyber and physical security
- Embedded sensors, information processing, and secure manufacturing
- Energy storage systems

Using Wind to Provide Grid Stability



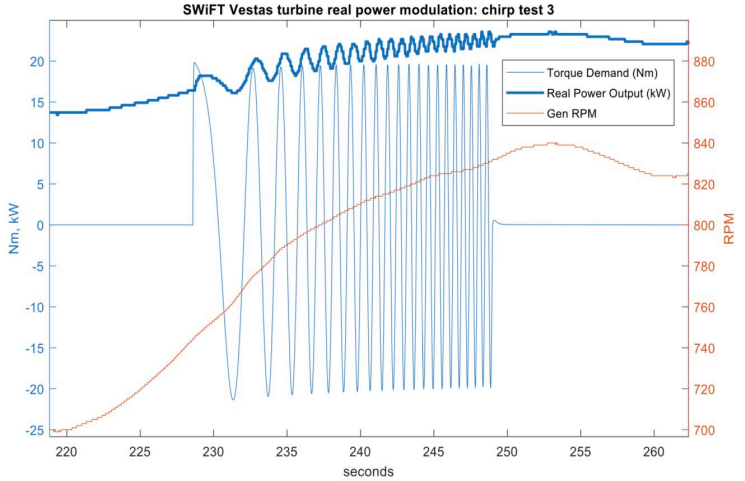
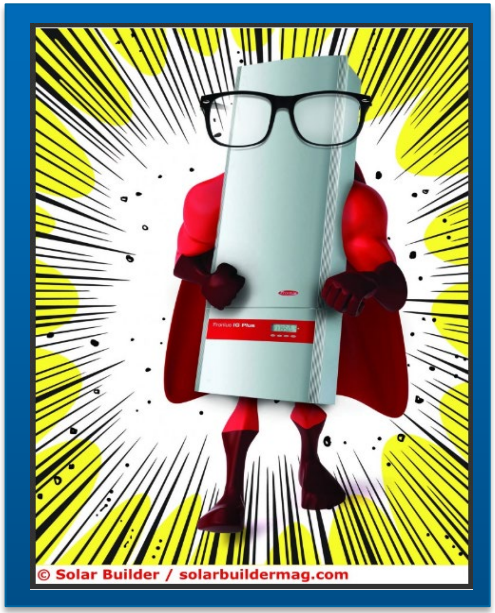


Figure 12 Chirp Test (0.1 To 2Hz) With T = 0.125 And 20Nm Peak Modulation.

Advanced PV inverters can help…

- Deployment of Smart Inverters are an effective way to solve the challenges
  - Can help solve the challenges caused by PV installations
  - Can increase the amount of PV that can be installed without causing problems
  - Could generate financial benefits for the PV system owners

- We are updating standards and policies so that smart inverters can be required in the future

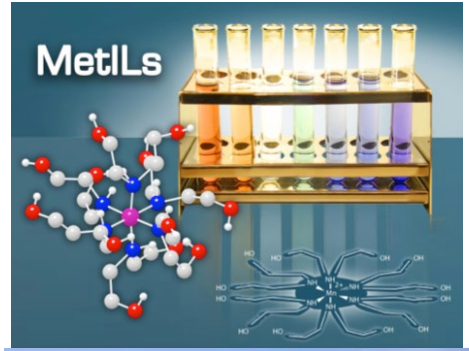


What is a Smart Inverter?

- Actively support the grid operation
  - Tolerate grid disturbances
  - Interact using communications

Energy Storage for the Future Grid

- Materials R&D for battery chemistry, alternate and component technologies
- Analytics
  - Valuation, Control Strategies, Models
- Standards Development
  - Protocols
- Safety and Reliability
  - Focus on developing a fundamental understanding of safety and reliability through R&D in four areas:
    - Materials origin of safety and reliability
    - Device level failures
    - Cascading failures
    - Software's role as a critical safety system
  - Laboratory infrastructure at Energy Storage Test Pad (ESTP) for MW class storage systems evaluation
  - Advanced mod/sim of energy storage systems



Ross Guttromson
Sandia Labs
rguttro@sandia.gov
505-284-6096

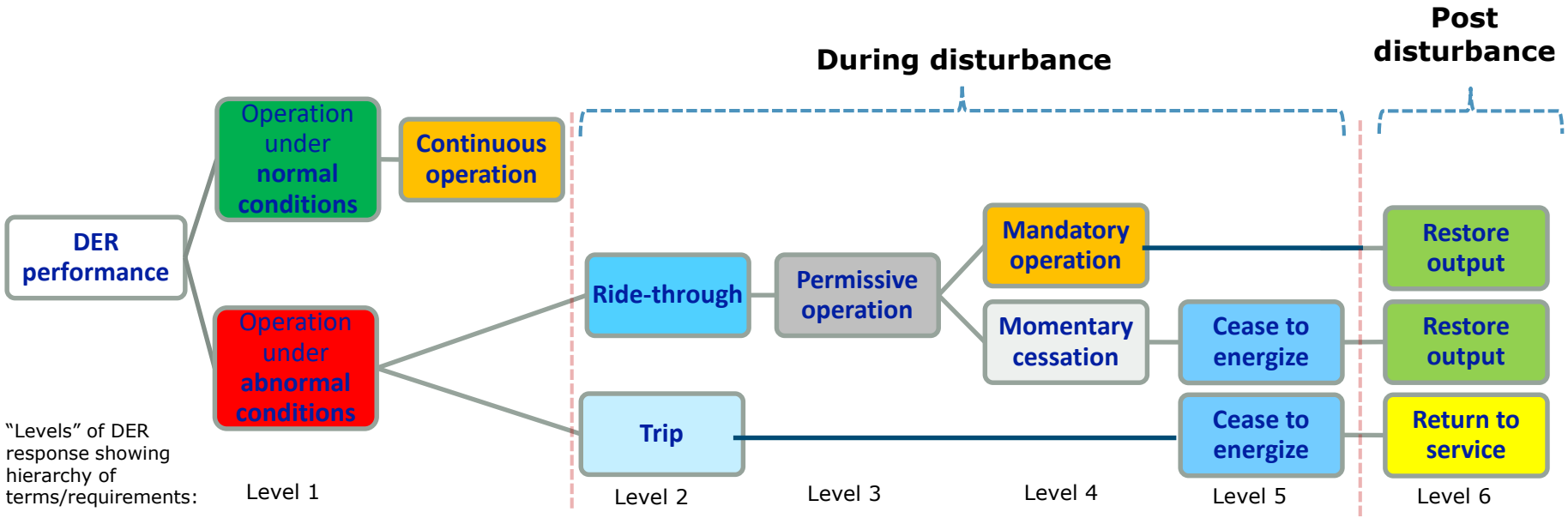
Break

Reconvene at 10:15am

Scope Considerations

- Review of project scope as approved by IEEE SA Standard Board.
- List of specific items that NERC IRPTF identified in their recently published guideline that may provide the basis for performance requirements specified in P2800.
- Analysis of requirements in IEEE Std 1547-2018 that may or may not apply to T-connected resources

IEEE Std 1547-2018 Ride-Through Terminology



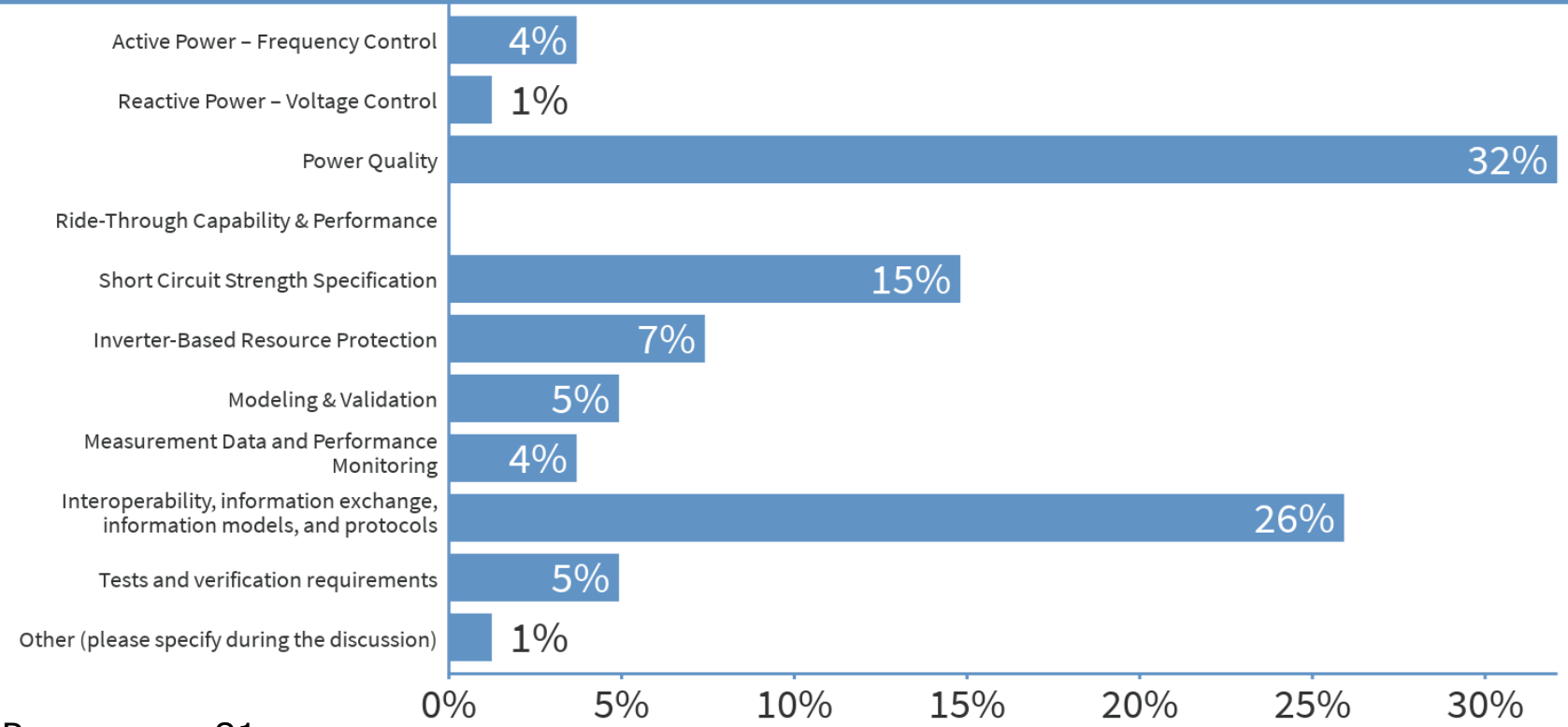
- **Ride-through** – ability to withstand voltage or frequency disturbances
  - **Permissive operation** – DER may either continue operation or may cease to energize, at its discretion
    - **Mandatory operation** – required active and reactive current delivery
    - **Momentary cessation** – cessation 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

Secretary						Wes Baker (Power Grid Eng.) [EMC] - Consultant							
Treasurer (as needed)						*Vacancy (if needed)*							
Officers who supervise SubGroup	**Chair**	**Vice-Chair 1**	**Vice-Chair 2**	**Secretary**		**Vice-Chair 3**	**Vice-Chair 1**	**Vice-Chair 4**	**Vice-Chair 5**	**Vice-Chair 4**	**Vice-Chair 4**	**Vice-Chair 4**	**Vice-Chair 6**
Names	Jens C. Boemer (EPRI)	Bob Cummings (NERC) - Reliability Organization / Regulator ~~Jens C. Boemer~~	Kevin Collins (FirstSolar) - Developer/Operator	Wes Baker (Power Grid Eng.) [EMC] - Consultant ~~Kevin Collins~~	Ross Guttromson (SANDIA) - Researcher	~~Ross Guttromson (SANDIA) - Researcher Kevin Collins~~	Bob Cummings (NERC) - Reliability Organization / Regulator	Manish Patel (SouthernCo) [PSRC] - Transmission Planner ~~Bob Cummings~~	Babak Enayati (NationalGrid) - IEEE PES Leadership ~~Bob Cummings~~	Manish Patel (SouthernCo) [PSRC] - Transmission Planner	Manish Patel (SouthernCo) [PSRC] - Transmission Planner	~~Ross Guttromson (SANDIA) - Researcher~~	Chenhui Niu (China State Grid) - IEEE P2800.1 Chair ~~Ross Guttromson~~
Subgroup	**I. Overall Document**	**II. General Requirements**	**III. Active Power – Frequency Control**	**IV. Reactive Power – Voltage Control**	**V. Low Short-Circuit Power**	**VI. Power Quality**	**VII. Ride-Through Capability Requirements**	**VIII. Ride-Through Performance Requirements**	**IX. IBR Protection**	**X. Modeling & Validation**	**XI. Measurement Data and Performance Monitoring - combine with M&V?**	**XII. Interoperability, information exchange, information models, and protocols**	**XIII. Tests and verification requirements**
Scope / Clause	1. Overview 2. Normative references 3. Definitions and acronyms	1. General interconnection technical specifications and performance requirements	1. capability 2. small disturbance 3. large disturbance	1. capability 2. small disturbance 3. large disturbance	1. Control interactions 2. Grid-forming requirements 3. "Weak Grid" issues	*26 participants suggested to exclude this from the scope*	1. frequency ride-through 2. voltage ride-through	1. Mandatory Operation 2. Permissive Operation 3. Momentary Cessation	1. inverter-level 2. plant-level			*21 participants suggested to exclude this from the scope*	1. Type tests 2. Production tests 3. Design & As-built evaluations 4. Commissioning 5. Periodic tests
Further Details on Scope	4. Scoping for HVDC and FACTS 5. Study requirements and informative annex on applicable study type/models.		4. Fast Frequency Response ("Sythentic Inertia")				3. voltage phase angle RT 4. ROCOF RT 5. PLL stability	4. Current injection, incl. neg. seq.	3. Relay performance and settings 4. Allow for must trip as backup/DTT alternative for unintentional islanding prevention? (maybe only for sub-transmission) 5. Translate system protection impacts into interconnection requirements?				6. Relationship with IEEE P1547.1
SG Lead (=Officer)	Jens C. Boemer (EPRI)	Bob Cummings (NERC)	Kevin Collins (FirstSolar)	Wes Baker (Power Grid Eng.)		*Vacancy*	Bob Cummings (NERC) ~~Jens C. Boemer (EPRI)~~	Manish Patel (SouthernCo)	Babak Enayati (NationalGrid) Manish Patel (SouthernCo) [PSRC] - Transmission Planner	Manish Patel (SouthernCo)	*Vacancy*	Ross Guttromson (SANDIA	Chenhui Niu (China State Grid)
SG Co-Lead / Facilitator (≠Officer)	Farrokh Rahimi (OATI)	Hari Singh (Excel Energy) Farrokh Rahimi (OATI)	Ross Guttromson (SANDIA) Rajat Majumder (Siemens Gamesa)	Mohit Singh (ComEd) Rajat Majumder (Siemens Gamesa) Hari Singh (Excel Energy)	Pouyan Pourbeik (PEACE) - Consultant	Ramesh Hariharan (PSC) Rey Ramos (SouthernCo)	Rajat Majumder (Siemens Gamesa) Hari Singh (Excel Energy) Wes Baker (Power Grid Eng.) Mcpharlen Mgunda (NextEra)	Babak Enayati (NationalGrid)	Manish Patel (SouthernCo) [PSRC] - Transmission Planner	Rajat Majumder (Siemens Gamesa) Hari Singh (Excel Energy) David Piper (SCE)	*Vacancy*	*Vacancy*	Andy Hoke (NREL)
SG Facilitator (as needed)		Anthony Doering (ITC)	Wes Baker (Power Grid Eng.)	Sophie Xu (PGE)	Reigh Walling	Dave Mueller (Enernex	Sophie Xu (PGE)	Sophie Xu (PGE) Jens C. Boemer (EPRI) Hari Singh (Excel Energy) Wes Baker (Power Grid Eng.)	Venkat Reddy (FirstSolar)	Andrew Isaacs (Electranix)			
Members **(to be determined by live polling at kick-off meeting and subsequent nominations to Vice-Chairs by e-mail)**	Ryan Quint (NERC) Pouyan Pourbeik (PEACE) Reigh Walling (WES Consult) Rajat Dat	Hongtao Ma (NERC)	Rajat Majumder (Siemens Gamesa) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Rich Hydzik (Avista) Andy Hoke (NREL) Venkat Reddy (FirstSolar) Steve Wurmlinger (SMA) Hongtao Ma (NERC) Pouyan Pourbeik (PEACE) Chester Li (Hydro One)	Rajat Majumder (Siemens Gamesa) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Andy Hoke (NREL) Venkat Reddy (FirstSolar) Steve Wurmlinger (SMA) Hongtao Ma (NERC) Ryan Quint (NERC) Pouyan Pourbeik (PEACE) Chester Li (Hydro One)		Chester Li (Hydro One)	Andrew Isaacs (Electranix) Rajat Majumder (Siemens Gamesa) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Venkat Reddy (FirstSolar) Steve Wurmlinger (SMA) Hongtao Ma (NERC) Chester Li (Hydro One) Mohamed Elkhatib (S&C)	Andrew Isaacs (Electranix) Rajat Majumder (Siemens Gamesa) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Andy Hoke (NREL) Venkat Reddy (FirstSolar) Hongtao Ma (NERC) Chester Li (Hydro One) Mohamed Elkhatib (S&C)		Songzhe Zhu (CAISO) Sachin Soni (First Solar) Rajat Majumder (Siemens Gamesa) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Venkat Reddy (FirstSolar) Ryan Quint (NERC) Hongtao Ma (NERC) Pouyan Pourbeik (PEACE) Chester Li (Hydro One) Mohamed Elkhatib (S&C)		Sachin Soni (First Solar) Mark Siira (ComRent) Mehriar Tabrizi (DNV-GL) Parimal Saraf (DNV-GL) Shereen Meor Dabial (NREL) Venkat Reddy (FirstSolar) Steve Wurmlinger (SMA) Ryan Quint (NERC)

Legend: green=to be nominated; orange=may be interested; red=not able to commit

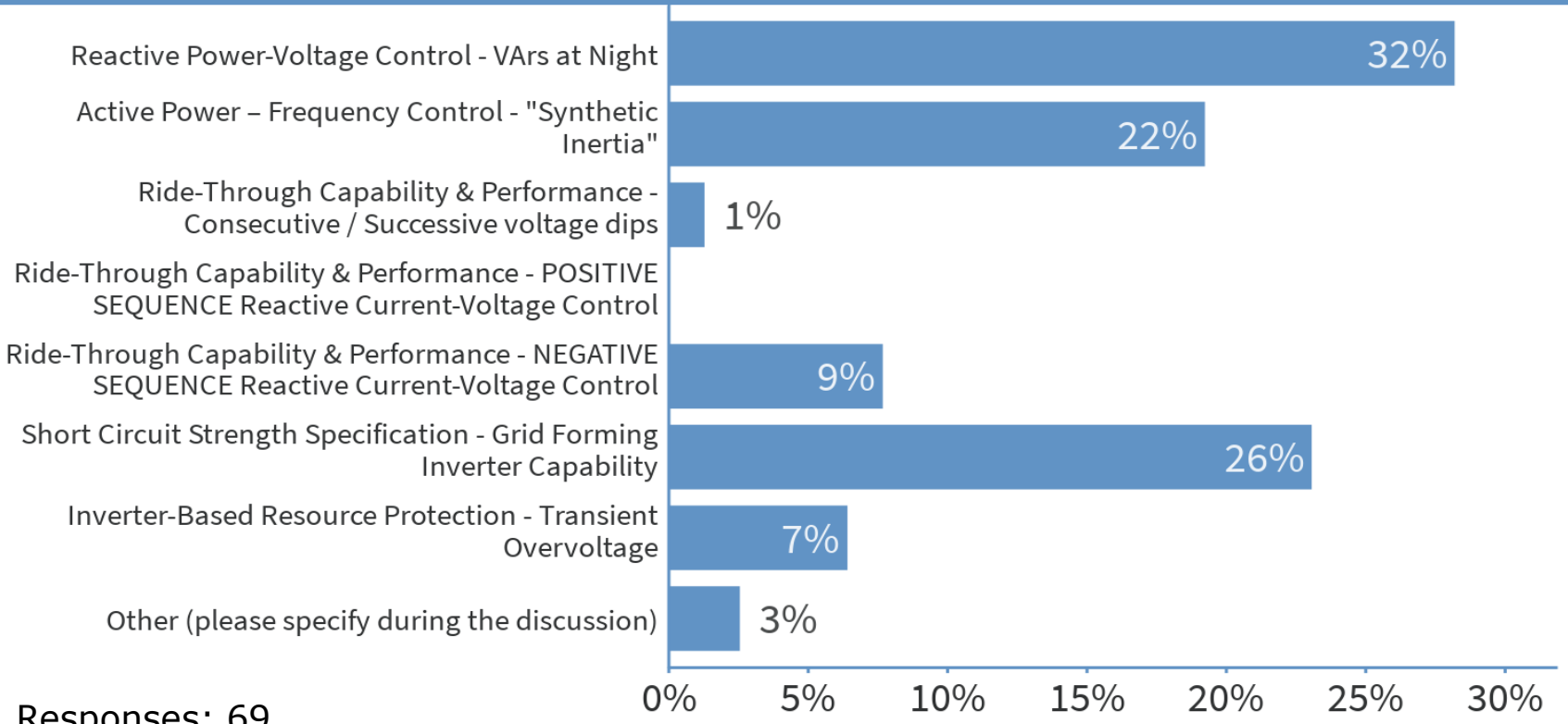
- **Discussion & Scope Adjustments**
- **Sign up at https://www.surveymonkey.com/r/MRW9SLQ**

Which of the following requirements SHOULD NOT be included in the standard? (multiple responses are allowed)



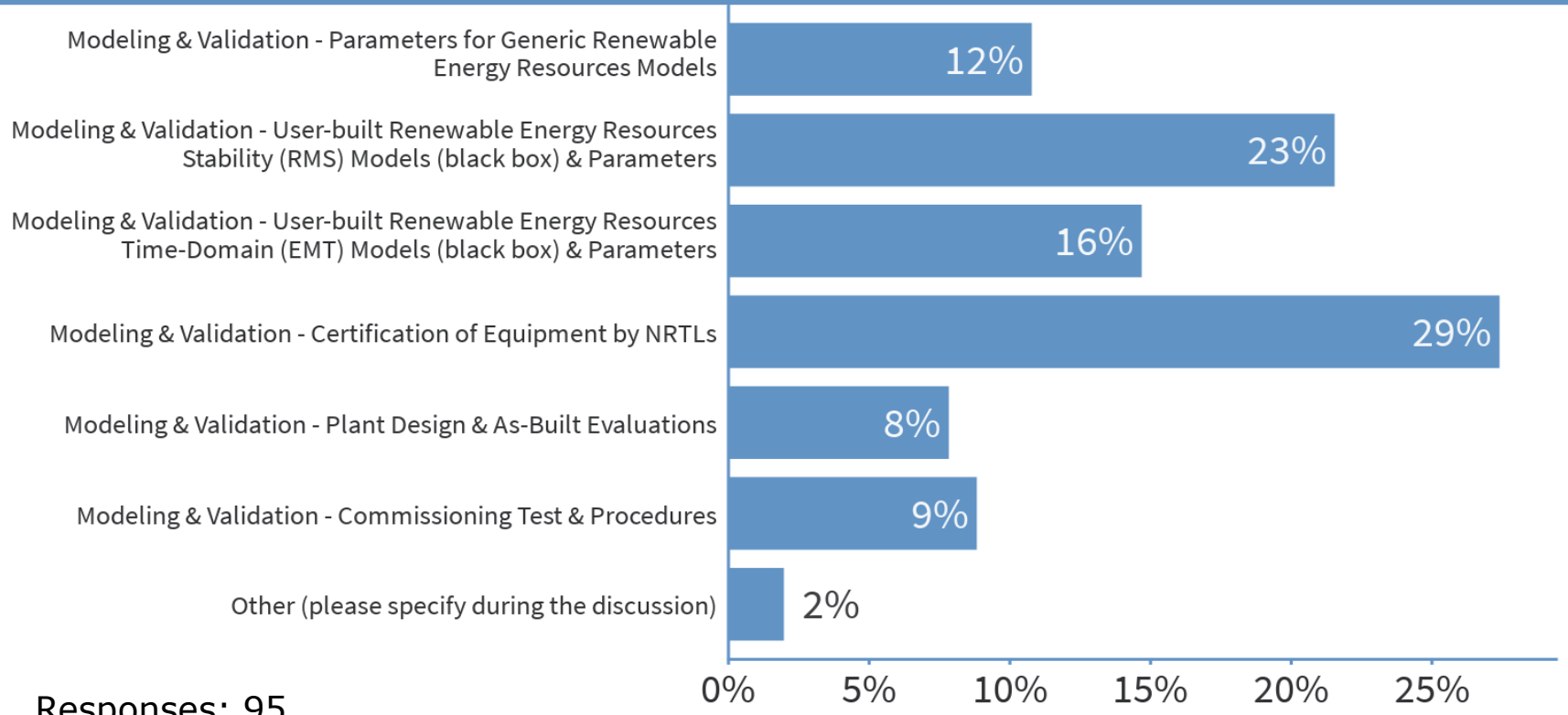
Responses: 81

Which of the MORE SPECIFIC requirements SHOULD NOT be included in the standard? (multiple responses are allowed)



Responses: 69

Which of the MORE SPECIFIC Modeling & Validation requirements SHOULD NOT be included in the standard? (multiple responses are allowed)



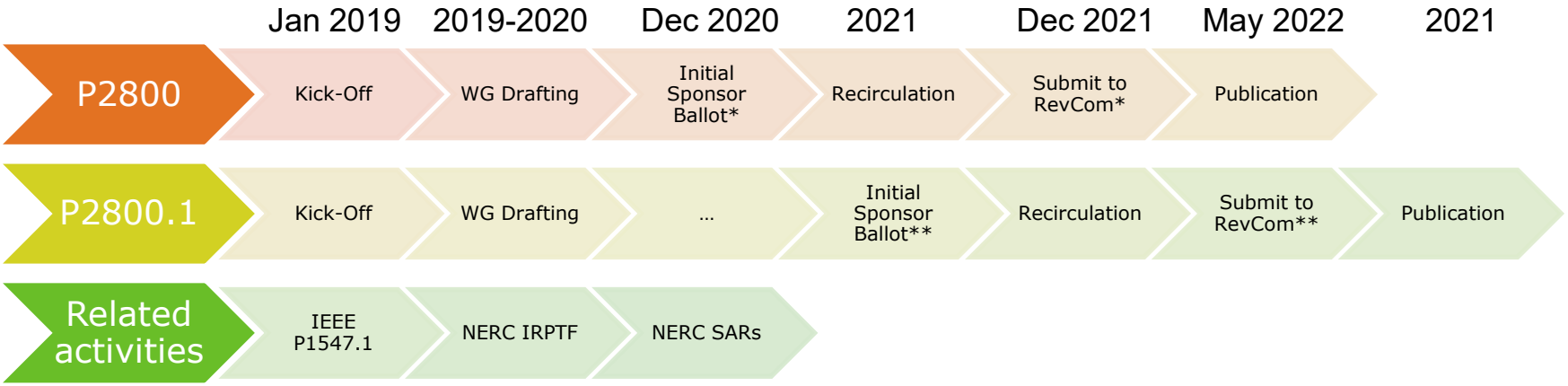
Responses: 95

Anticipated Resource Commitments

Commitments	Officers (Chair, Vice-Chairs, Secretary)	Sub-WG Leads & Facilitators	Sub-WG Members	Liaisons
Regular attendance of 3-4 in-person meetings per year (2-3 days each) over the duration of the project of 2-3 years	In person	In person	In person or remotely	In person or remotely
Regular attendance of approx. monthly P2800 leadership calls (1hr each)	X			
Review of draft requirements	X	X	X	X
Attendance/contributions to Sub-Working Group draft requirements and calls as needed (may vary, but typically weekly calls of 1 hr)		X	X	as needed

Please send your (self-)nominations to
Jens C Boemer, j.c.boemer@ieee.org and Wes Baker, wbaker@powergridmail.com

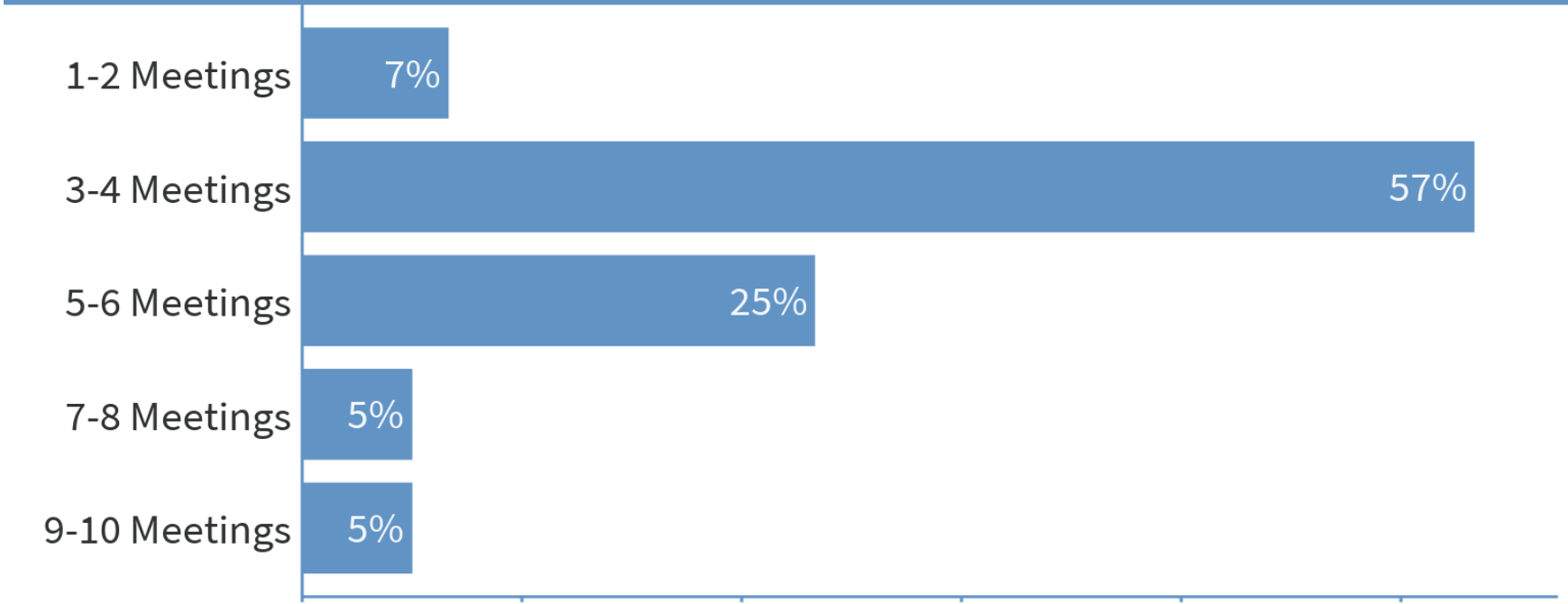
Proposed Timeline



* 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.

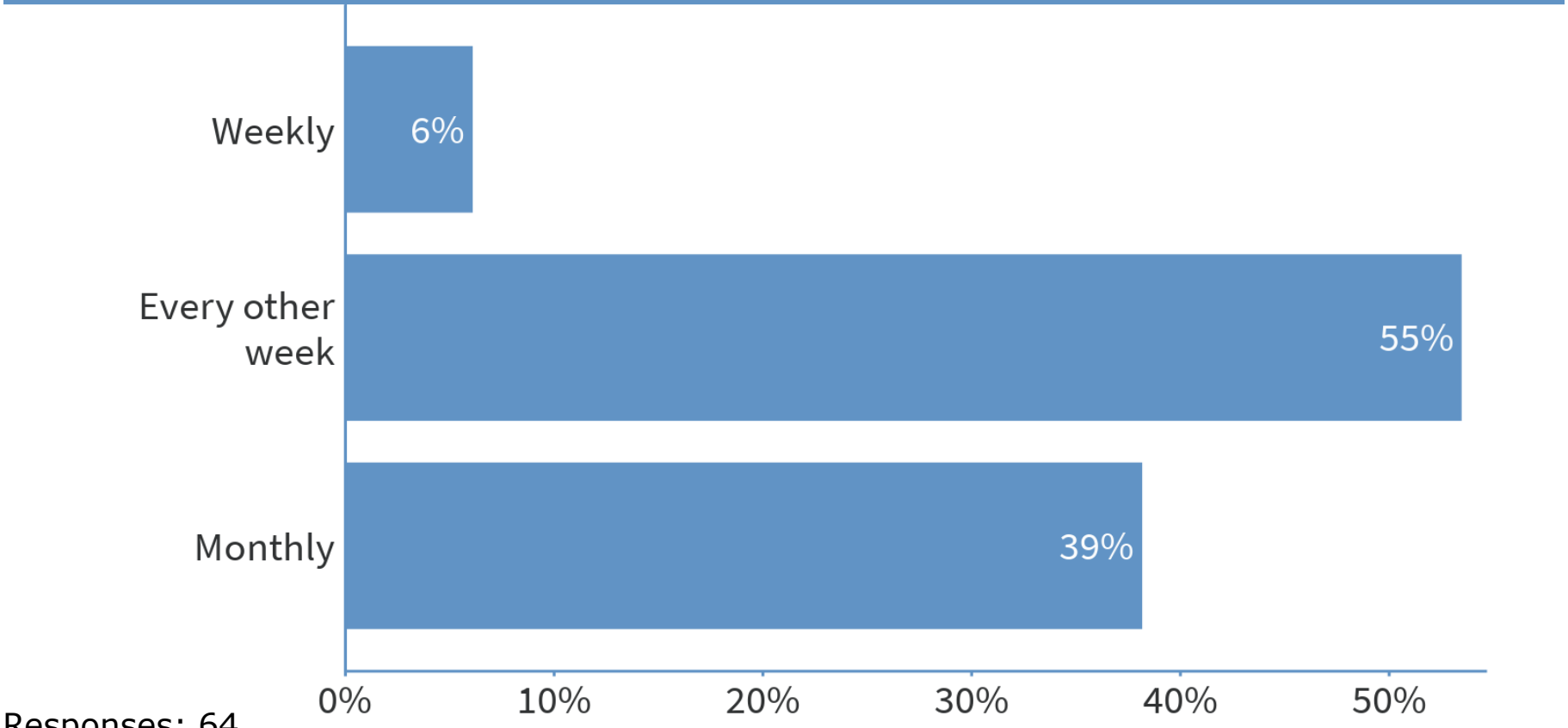
Ability to meet this accelerated timeline or an even more ambitious timeline may be subject to strong commitments (a.k.a. support/funding) of Working Group leadership team.

How many in-person Working Group meetings do you recommend prior to the Initial Sponsor Ballot of P2800? (We will try to schedule these adjacent to NERC IRPTF meetings and plan to allow remote attendance via WebEx)



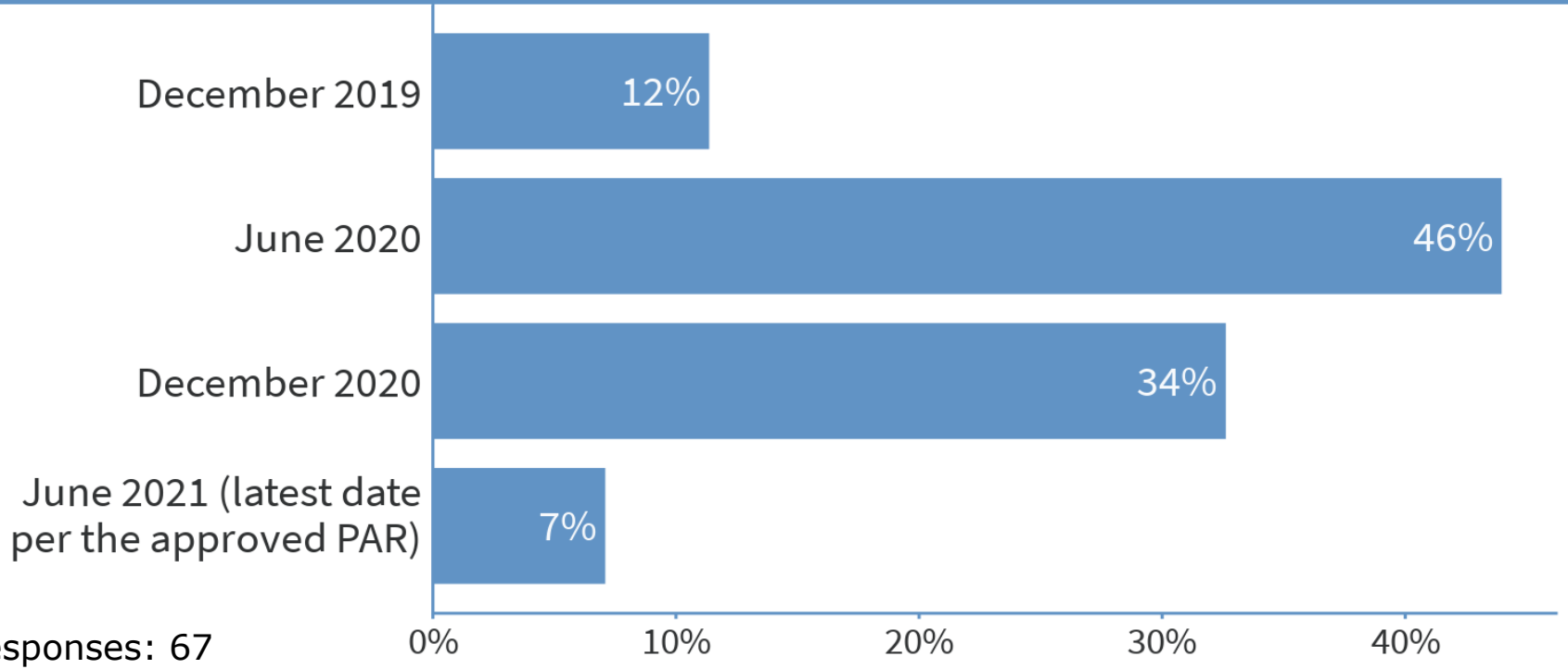
Responses: 56

What frequency for Sub-WG calls are you willing to commit to?



Responses: 64

Based on your previous responses, what is your anticipated time horizon for entering the Initial Sponsor Ballot of P2800? (Publication of the standard may occur approx. 6-12 months later)



Responses: 67

Coordination

- Coordination with P2800.1
- IEC coordination

Next Meetings

- Coordinate with NERC IRPTF Meeting Schedule
- Allow for remote participation via WebEx
- Preferably no registration fee, as long as facilities and catering is provided in-kind

NERC IRPTF	IEEE P2800 (tentative)	Location	Comment
Tue/Wed, May 21-22, 2019	Wed/Thu, May 22-23, 2019	Atlanta, GA (NERC)	Confirmed
Wed/Thu, September 4-5, 2019	Tue/Wed, September 3-4, 2019	Salt Lake City, UT (WECC)	*May be moved to PSRC Meeting Sep 10 – 14, 2018, in Minneapolis, MN*
Tue/Wed, December 3-4, 2019	Wed/Thu, December 4-5, 2019	_____, __ (TBD)	Not confirmed

Any Other Business

- None.

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

Participation Rules & Procedures

Methods for Standards Development

Individual Method (e.g., IEEE P2800)

- Participants are individual technical experts, requires an IEEE SA individual membership
- Individuals represent themselves
- **Each individual participant has 1 vote**
- Ballot groups are made up of a minimum of 10 individuals
- Ballot group participants must be IEEE-SA individual members

Entity (Corporate) Method (e.g., IEEE P2800.1)

- Participants are "entities," i.e., companies, universities, government bodies, etc.
- Designated representative and alternate represent the entity, see IEEE SA corporate membership
- **Each entity has 1 vote** ("Basic members can observe" and "Advanced members can vote")
- Requires 3 entities to commit to participation at project initiation
- Entity sends representatives to meetings
- List of IEEE SA corporate members

How to become an Observing or Voting Working Group Member?

Please send an e-mail to the following contacts to be added to the Working Group rosters as an Observer:

IEEE P2800

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

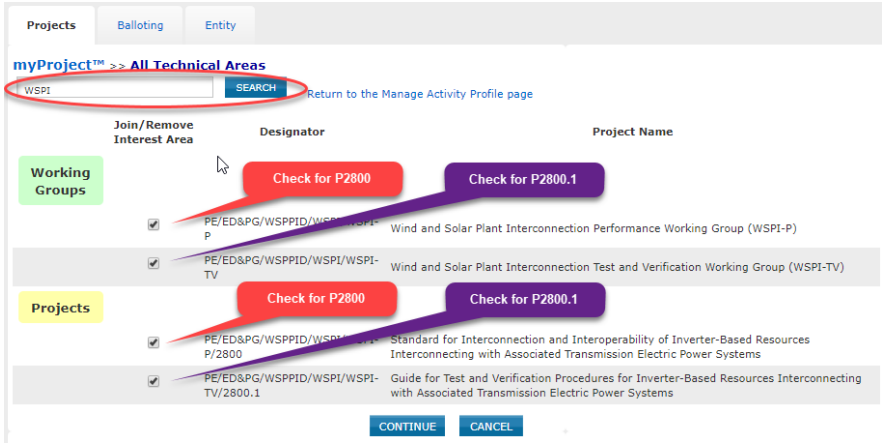
IEEE P2800.1

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

- For P2800, **voting membership** shall be granted automatically to those participants attending the **first meeting upon their request**.
- Attend a minimum of at least four of the last six WG meetings, ConfCalls count.
- Membership in the IEEE Standards Association (IEEE-SA).

How to be notified of the Initial Sponsor Ballot (2020 timeframe) and Vote on Ballot?

- Any IEEE and IEEE SA member can sign up to receive P2800 or P2800.1 Working Group updates in myProject
- Any individual IEEE SA member can sign up for the P2800 project but only entity members can sign up for the P2800.1 project
- Only IEEE SA members can vote on ballots.



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**"

Scope Supporting Materials

NERC Reliability Guideline: "BPS-Connected Inverter-Based Resource Performance"

Chapter 1: Momentary Cessation
- Functionally the same as tripping as it pertains to PRC-024-2

Chapter 2: Active Power – Frequency Control
- Steady state and dynamic

Chapter 3: Reactive Power – Voltage Control
- Reactive capability
- Steady State and dynamic

Chapter 4: Inverter-Based Resource Protection
- Inverter level
- Plant level
- Transient overvoltage protection

Chapter 6: Measurement Data and Performance Monitoring
- Measurement and monitoring data

Chapter 7: Other Topics for Consideration
- Dispatchability
- Grid Forming Inverters
- Negative sequence current injection

Conclusion:
- **All of the guideline topics are appropriate** for P2800—can define the starting point for P2800.

Overview of Clauses in IEEE Std 1547-2018

1. Overview
2. Normative references
3. Definitions and acronyms
4. General interconnection technical specifications and performance requirements
5. Reactive power capability and voltage/power control requirements (*Normal Conditions*)
6. Response to Area EPS abnormal conditions (*Abnormal Conditions*)
7. Power quality
8. Islanding – Unintentional islanding & intentional islanding
9. DER on distribution secondary grid/area/street (grid) networks and spot networks
10. Interoperability, information exchange, information models, and protocols
11. Tests and verification requirements

\+ Seven new informative annexes, including
  – Annex F: Discussion of testing and verification requirements at PCC or PoC

Clauses from IEEE Std 1547-2018 that do not apply to P2800

Clause 4 (General Requirements):

- 4.2 (Reference Point of Applicability): The RPA is always the PCC
- 4.10 & 6.6 (Enter / Return to Service): Inhibition of prompt return to service is not applicable and may have adverse impacts on the BPS.
- 4.11 (Interconnect integrity): may not be applicable.
- 4.12 (Integration with Area EPS grounding): Ground fault protection is different at BPS level than at distribution level.
- 4.13 (Exemptions for emergency systems and standby DER): not applicable.

Clause 5 (Reactive Power / Voltage Ctrl):

- 5: Voltage regulation functions are unnecessarily complex for BPS.
- 5.1 (Introduction) and other mention of ANSI C84.1 are inappropriate for BPS.
- 5.2 (Reactive power capability of the DER): may prescribe inappropriate reactive power capability values for BPS.
- The 5.3.3 (Volt-Var) and 5.4.2 (Volt-Watt) functions (proportional control regulating reactive or active power) are inappropriate for the BPS where resources shall provide voltage control (PI controller regulating voltage).
- Other parts of this clause may prescribe inappropriate functional settings.

Clauses from IEEE Std 1547-2018 that do not apply to P2800

Clause 6 (Response to Abnormal Condts):

- 6.2 (Area EPS fault and open phase conditions) are not applicable to BPS because of vast differences between BPS and distribution protection schemes.
- 6.4.1 (Voltage) and 6.5.1 (frequency) shall-trip philosophy is contrary to BPS needs.
- 6.4.2: Momentary Cessation is not consistent with bulk system needs.
- 6.6 (Return to service after trip): not applicable because communication-based remote startup/shut-down preferred over automatic return to service.

Clause 7 (Power Quality):

- 7: References and power quality assessment values may be inappropriate for BPS interconnections
- 7: Power quality requirements may not be stringent enough.

Clause 8 (Islanding):

- 8.1: (Unintentional islanding): Autonomous UI detection may be inappropriate due to availability of communication-based means.
- On-board active AID function should be disabled to prevent destabilization of the grid under normal conditions.
- 8.2 (Intentional islanding) inappropriate, at least in the short- to mid-term.

Clauses from IEEE Std 1547-2018 that do not apply to P2800

Clause 9 (Secondary Networks):

- 9: Requirements for interconnections to secondary networks are not applicable.

Clause 10 (Interoperability, Comms):

- 10: Communication requirements may not be appropriate for grid operations, SCADA, EMS.
- 10: Framework may already be specified for BPS interconnections in IEC 61850

Clause 11 (Tests and verification):

- 11: Type tests of equipment may never be sufficient to verify compliance at the PCC.
- Plant-level verification framework may be applicable for BPS interconnections.
- Wholesale interconnections incl. FERC LGIP and SGIP use modeling & simulation

Conclusions:

- IEEE Std 1547-2018 Standard for DER does not directly apply to BPS-connected inverter-based resources. **75% of the content is inappropriate** for BPS connected projects.

- **Roughly 25%** of 1547-2018 requirements **may be appropriate** in context of BPS, including:
  - 3.1: Harmonized terminology and general concepts
  - 6: Ride-through capability requirements, including voltage, frequency, ROCOF, voltage phase angle jump, etc.

Other questions:

- What about sub-transmission IBR?

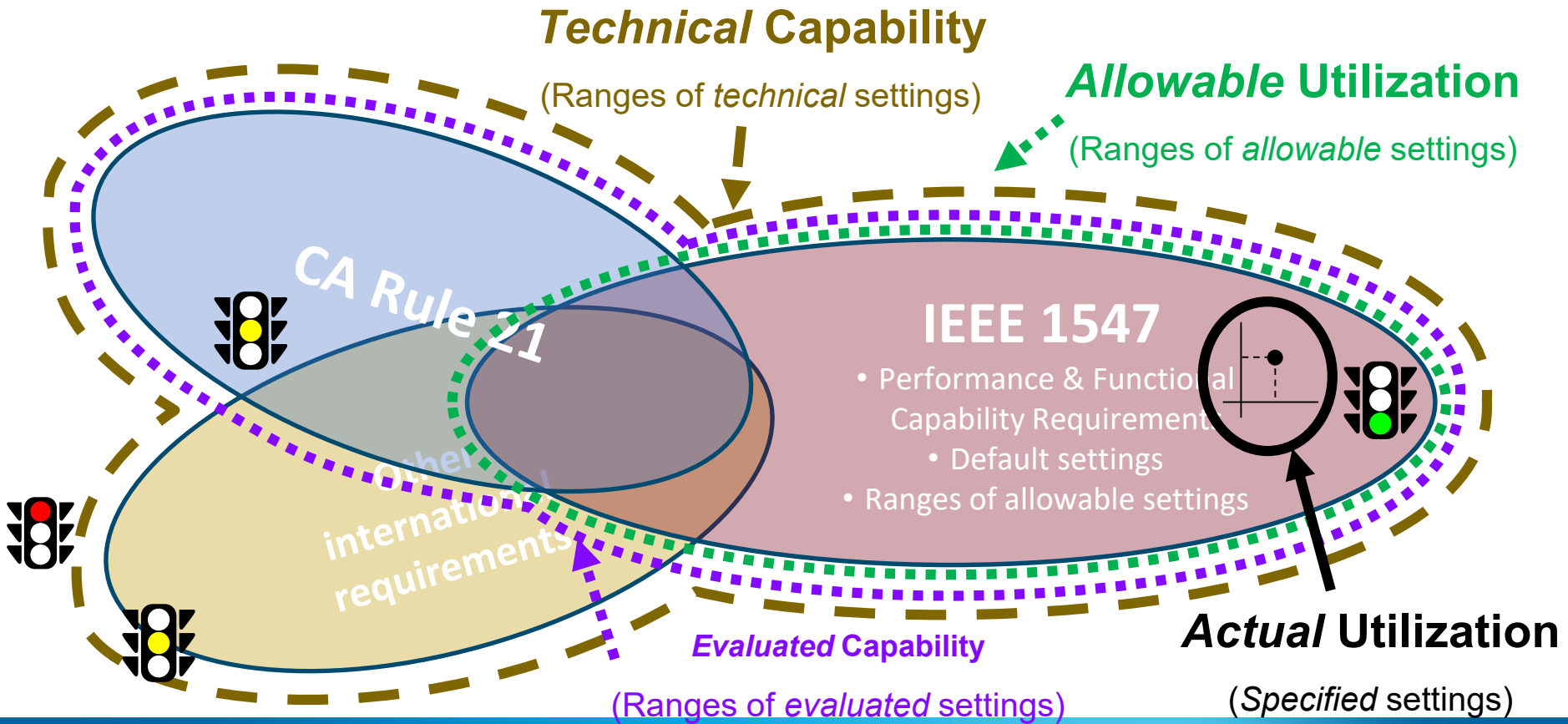
Comparison of DER standards and certification

Standards for DER		Listing/ Certification			Interconnection Standards			State/ PUC/Utility Rules	
								CA	HI/HECO
Function Set	**Advanced Functions Capability**	**UL 1741**	**UL 1741(SA) 2016**	**IEEE 1547.1 -201?***	**IEEE 1547-2003**	**IEEE 1547a-2014**	**IEEE 1547-2018**	**Rule 21** (Phases)	**Rule 14H & UL SRDv1.1**
All	**Adjustability in Ranges of Allowable Settings**			**Δ**		**√**	**‡**		
Monitoring & Control	**Ramp Rate Control**		**Δ**					**‡ (P1)**	**‡**
	Communication Interface			**Δ**			**‡**	**‡ (P2)**	**‡**
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			**Δ**			**‡**	**‡ (P3)**	**‡**
	Limit Active Power			**Δ**			**‡**	**‡ (P3)**	
	Monitor Key DER Data			**Δ**			**‡**	**‡ (P3)**	
Scheduling	**Set Active Power**							**[‡ (P3)]**	
	Scheduling Power Values and Models							**‡ (P3)**	
Reactive Power & Voltage Support	**Constant Power Factor**	**√**	**Δ**	**Δ**	**√**	**√**	**‡**	**‡ (P1)**	X
	Voltage-Reactive Power (Volt-Var)		**Δ**	**Δ**	X	**√**	**‡**	**‡ (P1)**	**‡**
	Autonomously Adjustable Voltage Reference			**Δ**			**‡**	**!!!**	**!!!**
	Active Power-Reactive Power (Watt-Var)			**Δ**	X		**‡**		**‡**
	Constant Reactive Power	**√**		**Δ**	**√**	**√**	**‡**		
	Voltage-Active Power (Volt-Watt)		**Δ**	**Δ**	X	**√**	**‡**	**‡ (P3)**	**‡**
	Dynamic Voltage Support during VRT						**√**	**[‡ (P3)]**	
Bulk System Reliability & Frequency Support	**Frequency Ride-Through (FRT)**		**Δ**	**Δ**			**‡**	**‡ (P1)**	**‡**
	Rate-of-Change-of-Frequency Ride-Through			**Δ**			**‡**	**!!!**	**!!!**
	Voltage Ride-Through (VRT)		**Δ**	**Δ**			**‡**	**‡ (P1)**	**‡**
	VRT of Consecutive Voltage Disturbances			**Δ**			**‡**	**!!!**	**!!!**
	Voltage Phase Angle Jump Ride-Through			**Δ**			**‡**	**!!!**	**!!!**
	Frequency-Watt		**Δ**	**Δ**	X	**√**	**‡**	‡ (P3)	**‡**
Other Advanced DER Functions	**Anti-Islanding Detection and Trip**			**Δ**			**‡**	**‡ (P1)**	**‡**
	Transient Overvoltage						**‡**		**‡**
	Remote Configurability						**‡**	**‡ (P2)**	**‡**
	Return to Service (Enter Service)						**‡**	**‡ (P1)**	**‡**

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

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

Capability (versus Utilization, determined by settings)



Other Topics / Brainstorming

Other Topics:

- Power quality
- Ride-through capability (inverter limitations)
- Performance of phase lock loop
- Desired behavior during faulted conditions and post-fault clearing
- Capability (ride-through robustness) vs. Utilization (trip settings)
- Short Circuit Duty contribution (inverter limitations)
- Monitoring and recording for performance reporting:
  - Data supportive of NERC GADS reporting
  - Data consistent with NERC & IEEE defined Availability Factor calculations
- Appropriate autonomous frequency measurement
- Ramp rates
- Interoperability & Cyber Security, Communications
- Connection to weak grids
  - Applicable short-circuit ratio (SCR) and X/R ratio limits for this standard
- Control interactions
  - Plant level
  - Between multiple plants in an area
- Control stability limits
  - e.g., for droop values of voltage control
- Reference point of applicability
  - Definitions and illustrations
  - Point of Common Coupling (PCC)
  - Point of Interconnection (POI)
- Applicability to FACTS devices, Type 3 wind turbines, etc.

IEEE P2800.1

Need and Scope

IEEE P2800.1: Guide for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Need for the Project:

This guide is needed for testing and verification the performance of inverter-based resources interconnecting with associated transmission electric power systems. The guide can help manufacturers and project developers improve the quality of the inverter and facility design to enhance the stability of the power grid. This guide fills the need for global standardized methods to help testing organizations optimize their test methods. It will refer to appropriate related standards, research results, operation and maintenance experience of inverter-based resources, including photovoltaic and wind power plants, and performance tests of the inverters all around the world. 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 1547.1 for large-scale solar plants underscore the need of this guide. Given that IEEE guides are voluntary industry guides, enforcement of any of the procedures specified in this guide 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 P2800.1: Guide for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

Scope:

This guide provides **test and verification procedures** for inverter-based resources interconnecting with transmission electric power systems. This guide specifies the test equipment, test conditions and test and verification methods for type tests, production tests, **facility design and as-built evaluations** and commissioning tests to be performed to demonstrate the interconnection capabilities and functions for equipment connected with transmission electric power systems. Included in the test and verification procedures are all performance and functional requirements for reliable integration of inverter-based resources into the power grid, including, but not limited to, voltage and frequency ride-through performance, reactive power control, power quality, and dynamic voltage support under abnormal voltage conditions. This guide may also specify **verification procedures for generic steady-state short-circuit models for fault analysis, as well as, generic fundamental frequency, stability-type models** (root-mean-square, rms with positive-sequence and possibly negative-sequence representation) of inverter-based resources interconnecting with transmission electric power systems for bulk system stability studies and/or **proprietary time-domain (electromagnetic transient, emt) models** for verification of interconnection requirements of composite systems (facilities) at the point of interconnection.

Related activities: IEC TS 63102, Contact: Charlie Smith, Charlie@esig.energy , U.S. TA for SC 8A.