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NERC IRPWG IRPS Interconnection Process Reform Guideline

Inverter-Based Resources Performance Subcommittee (IRPS) Work Plan Item #8

Jens Boemer, EPRI IEEE P2800 Working Group Chair & NERC IRPS Subgroup Co-Lead

ESIG 2021 Spring Technical Workshop Session 4a: Interconnection Processes: Symptom or Solution?

March 23, 2022





This work is, in part, supported by the U.S. Department of Energy, Solar Energy Technologies Office under Award Number DE-EE0009019 Adaptive <u>P</u>rotection and <u>V</u>alidated <u>MOD</u>els to Enable Deployment of High Penetrations of Solar PV (PV-MOD).

This work is, in part, supported by the North American Electric Reliability Corporation (NERC) under EPRI contract 20011165 Inverter-Based Resources Dynamic Response Characterization for Bulk Power System Protection, Planning, and Power Quality.











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- Part of this work was supported in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office and Wind Energy Technologies Office. Other part of this work is supported by the U.S. Department of Energy, Solar Energy Technologies Office under Award Number DE-EE0009019 Adaptive Protection and Validated MODels to Enable Deployment of High Penetrations of Solar PV (PV-MOD). The views expressed in the presentation do not necessarily represent the views of the DOE or the U.S. Government.



Generation Interconnection Queue Process

Technical Update

Project Manager M. Bello

Product ID: 3002020483

September 2021

y in f
 www.epri.com
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- Backlog and long process
- Lack of technical standards
- Diversity of processes
- Different level of technical detail for models & studies
- Often not automated

Generation Interconnection Queue Process. EPRI. Palo Alto, CA: 2021. 3002020483. [Online] https://www.epri.com/research/products/000000003002020483

www.epri.com

ISOs/RTOs Interconnection Process Scope & Durations

FERC LGIP	CAISO	ISO-NE	NYISO	MIQ	MISO	ERCOT	SPP	Ranges of Duratio	
Interconnection Request	Request Initiated								
Feasibility Study	Phase 1 Study (6 months)	Feasibility Study (3 months)	Optional Feasibility Study (3 months)	Feasibility Study (3 months)	Defining Planning Phase (DPP) Phase I Preliminary System Impact (4 ½ months)	ERCOT Screening Study (6 months)	Definitive Interconnection System Impact Study (DSIS) Phase 1 (3 months)	3 to 6 months	
System Impact Study	Phase 2 Study (7 months)	System impact Study (9 months)	System Reliability Impact Study (3 months)	System Impact Study (4 months)	DPP Phase II Revised System Impact Study (2 ½ months)	Full Interconnection Study (FIS) (10 months)	DSIS Phase 2 (4 months)	2 ½ to 9 months	
Facilities Study	System Impact and Facilities Study (4 months)	Facilities Study (3 to 6 months)	Class Year Interconnection Facilities Study (12 months)	Facilities Study (6 months)	DPP Phase III Final System Impact Study (3 ½ months)	Facility Study (3 months)	Facilities Study (4 ½ months)	3 to 12 months	

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Why We Are (Also) Here: Reliability Issues with IBR

Several IBR-based system disturbances have and continue to occur:

- August 2016 Blue Cut Fire Disturbance
- October 2017 Canyon 2 Fire Disturbance
- April and May 2018 Angeles Forest & Palmdale Roost Disturbances
- July 2020 San Fernando Disturbance
- May and June 2021 Odessa, TX Disturbances

Disturbance Analyses and Guidelines

- > Detailed Analysis of IBR-Based disturbances
- Two Level 2 NERC Alerts Issued with industry recommendations
- Reliability Guideline for BPS-connected IBR resources
- Odessa Disturbance recommendations call for more than guidelines





FERC pro forma Large Generator Interconnection Procedures (LGIP)



> Does competition drive costs savings that could ultimately compromise bulk system reliability?

Feasibility Study

- Input: Designated/alternative POIs
- Purpose: identify thermal/voltage limit violations & estimate grid upgrade costs
- Scope: power flow analysis

System Impact Study

- Input: as above
- Purpose: evaluate <u>reliability impact</u> on transmission grid
- Scope: <u>short-circuit</u>, <u>stability</u>, power flow analysis

Facilities Study

 Purpose: <u>estimate cost</u> of the equipment, engineering, and construction work; <u>identify</u> <u>electrical configurations</u> of the transformer(s), switchgear, meters, and other station equipment; identify the nature and estimated cost of any transmission network upgrades



Objective of The NERC IRPS Subgroup

FERC pro forma Large Generator Interconnection Procedures (LGIP)



IRPS Work Plan Item #8

- Addressing challenges with **IBR interconnection process**:
 - a) Lay out a recommended **framework** for how **transmission entities** should be executing the interconnection process and studies and what needs to be done on the **GO/developer** side to ensure that the process runs smoothly.
 - b) To identify/comment on potential gaps and timeline challenges, and to signal potential improvements to the FERC LGIP process when considering sufficiently detailed plant-level modeling and performance conformity assessment.

• Observation: LGIP has (intentionally) little specificity on technical details

> Deliverable: NERC **Reliability Guideline**

How to Improve Process Efficiency <u>and</u> Maintain Reliability?



Recommendation 1

Paradigm shift towards IBRs as the "Good Citizen" – Integrating a minimum set of IBR capability prior to its potential future utilization

— Focus of this presentation

Recommendation 2

Interconnection Process Improvements – *Pre-commissioning and postcommissioning plant-level performance conformity assessment and verification*

Recommendation 3

Education and Collaboration – Continuous and Iterative Improvement of IBR Performance Requirements, Plant-Level Modeling, and Model Validation

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Interconnection Process Today: Challenges





IEEE 2800-2022 Test and Verification Methods



IEEE 2800-2022 requires IBR <u>plant-level</u> conformity *provided and the plant of the*

Modified based on DER Plant-Level Performance Verification and Commissioning Guideline: First Edition. Technical Update. EPRI. Palo Alto, CA: December 2020. 3002019420 9 RELIABILITY | RESILIENCE | SECURITY



Recommendation 2: Interconnection Process Improvements



Legend	
Blue	existing process
Purple	proposed modifications and additions
TIRs	technical interconnection requirements

Recommendation 2: Interconnection Process Improvements



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Continuous and Iterative Improvement of IBR Performance Requirements, Plant-Level Modeling, and Model Validation





Get yourself and/or your colleagues involved in these industry forums...!

ESIG Reliability Working Group	 Scope: modeling, grid codes and interconnection requirements, weak grids, grid forming converters, etc. Contact: Jason MacDowell, GE Power Web: <u>https://www.esig.energy/reliability-working-group/</u> Deliverables: technical reports, webinars meets 3-4x times per year
NERC IRPS Subgroup Work Item #8	 Scope: interconnection process and studies Contact: Ryan Quint, NERC Web: https://www.nerc.com/comm/RSTC/Pages/IRPWG.aspx Deliverables: NERC reliability guideline meets every other week
IEEE P2800.2 Working Group	 Scope: recommended practices for test and verification procedures for plant-level conformance Contact: Andy Hoke, NREL Web: <u>https://sagroups.ieee.org/2800-2/</u> Deliverables: IEEE recommended practice WG meets 3-6x times per year; subgroups meet every other week
NERC Reliability Standards Drafting Teams	 MOD 026/027 Revision: <u>Brad Marszalkowski</u> Web: <u>https://www.nerc.com/pa/Stand/Pages/Project-2020_06-Verifications-of-Models-and-Data-for-Generators.aspx</u> TPL-001-5.1 and MOD-032-1 Modifications: <u>TBD</u> Web: <u>https://www.nerc.com/pa/Stand/Pages/Project2022-02ModificationstoTPL-001-5-1andMOD-032-1.aspx</u> Modifications to FAC-001 and FAC-002: <u>TBD</u> Web: <u>https://www.nerc.com/pa/Stand/Pages/Project-2020-05-Modifications-to-FAC-001-and-FAC-002.aspx</u>
Open or Future FERC Dockets	 Scope based on Federal Power Act Section 205 and 206: Office of Energy Markets and Regulations (OEMR) – transmission generation interconnection process Section 215: Office of Electric Reliability – reliability standards Anyone can submit comments to FERC Web: <u>https://www.ferc.gov/</u>



Questions and Answers





Latest drafts are available at https://epri.box.com/v/PVMOD-IntercStudies-Modeling

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https://www.epri.com/pvmod

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Example Reliability Solutions

- Grid Related Solutions
 - Transmission upgrades
 - Innovative transmission assets
- IBR Related Solutions
 - IBR capability requirements for new plants
 - Utilization of IBR capability / configuration of controls
 - Weak grid tuning
 - o Stability constrained transfer limit tuning
 - Limitation of IBR output
 - Retrofits of existing IBR plants
 - Software patches
 - Hardware retrofits

Cost allocation

Last resource tends to bear costs





Integrating a minimum set of IBR capability from the day of plant commissioning allows for many IBR plants to share the burden and opportunities of a potential future utilization of that capability.

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Difference between IBR Capability and Utilization

Capability: "Ability to Perform"

- Functions & controls
- Ranges of available settings
- Minimum performance specifications



<u>Examples</u>

- Frequency Response
 - Primary Frequency Response
 - Fast Frequency Response
 - Ramp rate limitations
- Ride-Through
 - Voltage ride-through
 - Consecutive voltage ride-through
 - Frequency ride-through
 - ROCOF ride-through
 - Phase angle jump ride-through
- Voltage Support
 - Steady state voltage control
 - Dynamic reactive power
 - o (Un-)balanced current injection during ride-through

Utilization of Capability: "Delivery of Performance" | "Deployment"

- Enable/disable functions
- Functional settings / configured parameters
- Operate accordingly (e.g., maintain headroom, if applicable)

<u>Examples</u>

- DeadbandDroop
- Response Time
- Headroom

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Source: EPRI (2022)



- Harmonizes technical minimum capability for Large Solar, Wind, and Storage Plants at the time of interconnection, including those connected via VSC-HVDC like offshore wind
 - Could create a "level playing field" for IBR developers, *if adopted*
- A consensus-based, voluntary IEEE performance standard
 - Developed by over 175 working group participants from transmission owners, OEMs, developers, and consultants
 - Successfully passed the industry peer review by 466
 IEEE SA balloters (>94% approval, >90% response rate)
- Approved in January 2022, publication in April/May 2022

P280 Draff Inter Resc Asso	00 [™] /D6.3 t Standa operabil ources Ir ociated T by the olar Plant Interconn evelopment and e, and the Power	(December 2 rd for Interco ity of Inverter iterconnectin rransmission edon Performance Working Gro Power Generation Commit System Relaying Committee dots	2021) nnection and -Based g with Systems wp (WSPI-P) - wyballe ttee, the Electric Machine
Version	Date	Editors	Comments
Draft 6.3	12/2/2021 and 12/14/2021	Jens C. Boerner (Chair) Manish Patel (Vice-Chair) With contributions from other Vice-Chairs and SG- Leads	Draft 6.3 for IEEE SA 3rd and 4th Recirculation. 3rd Recirculation Results: Approvals: 373 (04%) Disapprovals: vithout MB Comment(s): 3 Abstentions: 24 (5%) Return Ballots: 420 (90%) Total Comments: 20 Total Balloters: 466
Draft 6.2	10/21/2021	Jens C. Boemer (Chair) Manish Patel (Vice-Chair) With contributions from other Vice-Chairs and SG- Leads	Draft 6.2 for IEEE SA 2 nd Recirculation. 2 nd Recirculation Results: • Approvals: 369 (94%) • Disapprovals: 369 (94%) • Disapprovals: 323 (5%) • MBS Commert(s): 3 • Abstentions: 24 (5%) • Return Ballots: 419 (89%) Total Comments: 110

Latest draft is available from IEEE at <u>https://standards.ieee.org/project/</u> <u>2800.html</u>

More Info at https://sagroups.ieee.org/2800/



- Transmission Owners / Planners and RTOs/ISOs may play a key role
 - Gap assessment, improvement of existing requirements, preferably "full adoption" of IEEE 2800
 - Leading example: ERCOT IBRTF has initiated a gap assessment for potential IEEE 2800 adoption on March 18 (link)
- Adoption may <u>not</u> be contingent on publication of IEEE P2800.2 *Draft Recommended Practice for Test* and Verification Procedures
 - Determine reasonable interconnection application enforcement date, grandfathering
- Opportunities for further improvements of interconnection process
 - Potential implications for FERC Large-Scale Generators Interconnection Process (LGIP) and *pro-forma* Agreement (LGIA), e.g., reference for "good utility practice"



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IEEE 2800-2022 Technical Minimum Capability Requirements



Utilization of these capabilities is outside the purview of 2800





Related NERC and IEC activities

NERC IRPWG SubGroup Work Item #8: Improvement of Interconnection Studies and Process

Scope:

- Address challenges associated with the interconnection study process
- Use of models in feasibility study, system impact study, and facilities study
- Recommend adequate test and verification of IBR plantlevel capability & performance

Logistics:

- bi-weekly meetings Thursdays in uneven weeks, 1:00p-2:00p ET / 10:00a-11:00a PT, <u>irps_intstudy@nerc.com</u>
- P2800.2 Liaisons: Alex Shattuck (<u>axsha@vestas.com</u>) and Jens Boemer (<u>jboemer@epri.com</u>)



IEC TS 63102:2021 Grid Code Compliance Assessment Methods For Grid Connection Of Wind And PV Power Plants



TC 8/SC 8A/JWG 4

- IEC TS 63102:2021
- P2800.2 Liaison: Jason MacDowell (jason.macdowell @ge.com)
- Other tech reports in progress



Source: Björn Andresen, Aarhus University, Denmark



P2800.2: Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems

Type: recommended practice, individual project

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- Sponsor(s): IEEE/PES/EDPG+EMC+PSRC+AMPS
- Tentative timeline: June 2023 (initial ballot), Dec 2023 (RevCom approval) – WG kick-off on January 18, 2022
- Scope: recommends leading practices for test and verification procedures that should be used to confirm plant-level conformance of IBRs interconnecting with BPSs under IEEE Std 2800.
 - complements the IEEE 2800 test and verification framework with specifications for the equipment, conditions, tests, modeling methods, and other verification procedures
 - may specify design and as-built evaluations procedures for verification of plant-level capabilities and performance
 - may also specify verification procedures for IBR plant-level generic models applied for different time frames including S/C models, RMS models, and EMT models

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

- Type: guide, individual project
- Sponsor(s): IEEE/PES/AMPS+EMC+EDPG
- Tentative timeline: Dec 2021 (initial ballot), Dec 2022 (RevCom approval) – work is starting in 2022
- Scope: guidelines for the validation of software models for renewable and conventional generators used for power system studies.
 - … 'validation' is a procedure and set of acceptance criteria … to confirm that the models perform well numerically and provide the intended response(s).
 - does not cover ... validation of generator software models against field measurements and other types of site or factory tests
- This activity seems to have different scope compared to P2800.2?



Anticipated Timeline, and What Comes Next?



*Project authorization request (PAR) approved by NesCom on May 21, 2021 (<u>https://development.standards.ieee.org/myproject-web/app#viewpar/12623/9133</u>); contact <u>andy.hoke@nrel.gov</u> and sign up for P2800.2 Working Group and Task/Project on IEEE SA myProject at <u>https://development.standards.ieee.org/myproject-web/app#interests</u>

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A Potential Future? One Streamlined Model Application Example







Application Examples: Interconnection Screens, Transmission Planning Studies Application Examples: Interconnection / System Impact Studies



Grid Codes and Generic Models May Always Lag Behind OEMs' Continuous Product Improvements



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IEEE P2800.2 Motivation

- P2800 contains performance requirements for IBRs, and a <u>table of methods to verify</u> <u>each requirement</u>
 - Details of verification methods not included
- P2800.1 may contain those details, but P2800.1 is developed under the "Entity Method" where participation (voting) requires IEEE-SA Basic (Advanced) Corporate Membership

P2800.2 will
develop details
through "individual
standard" process
(like P2800, 1547,
1547.1, etc)



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

IEEE P2800.2 Introduction

- New IEEE <u>PAR for P2800.2 approved by IEEE SASB</u> on May 22, 2021
- Title: Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems
- WG not formed yet
- Recruiting participation from P2800 WG, IRPWG, and industry in general
 - Especially need those with knowledge of best practices in designing, studying, interconnecting, commissioning, and operating large IBRs
 - Utilities, project developers, consultants, manufacturers, labs, etc
- P2800.2 WG will start as P2800 finishes (around Q4 2021)
- Express interest through IEEE MyProject, or contact andy.hoke@nrel.gov

P2800.2

Submitter Email: andy.hoke@nrel.gov Type of Project: New JEEE Standard
Project: New IEEE Standard
PAR Request Date: 18 Mar 2021
PAR Approval Date: 21 May 2021
PAR Expiration Date: 31 Dec 2025
PAR Status: Active
1.1 Project Number: P2800.2 1.2 Type of Document: Recommended Practice
1.3 Life Cycle: Full Use
2.1 Project Title: Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems
3.1 Working Group: P2800.2 - Test and Verification of BPS-connected Inverter-Based Resources(PE/
EDPG/P2800.2 - T&V of BPS-connected IBRs)
3.1.1 Contact Information for Working Group Chair:
Name: Anderson Hoke
a 1 2 Contact Information for Working Group Vice Chair
None
3.2 Society and Committee: IEEE Power and Energy Society/Energy Development & Power
Generation(PE/EDPG)
3.2.1 Contact Information for Standards Committee Chair:
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3.2.2 Contact Information for Standards Committee Vice Chair:
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Email Address: chris.dent@ed.ac.uk
3.3.4 IEEE Power and Energy Society/Power System Relaying and Control (PE/PSRCC)
Contact Information for Standards Representative:
Name: Don Lukach
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4.1 Type of Ballot: Individual

4.2 Expected Date of submission of draft to the IEEE SA for Initial Standards Committee Ballot: Jun 2023

4.3 Projected Completion Date for Submittal to RevCom: Jan 2024

5.1 Approximate number of people expected to be actively involved in the development of this project: 150

5.2 Scope of proposed standard: This document defines recommended practices for test and verification procedures that should be used to confirm plant-level conformance of inverter-based resources (IBRs)



How To Express interest in IEEE myProject?

- 1. On the <u>myProject[™] Home Screen</u>, click on Menu and then on "Manage Profile and Interests"
- 2. Click on the Interests tab, then on "Add Groups"
- 3. Find P2800.2 under PES/EDPG per screenshot excerpts below
- 4. Click bullets under "Groups I Am Interested In" and follow instructions on screen

Group Name	Committee	Group Type	Groups I Am Interested In
IEEE Nuclear and Plasma Sciences Society	NPS	Society	
IEEE Nanotechnology Council	NTC	Society	
IEEE Power and Energy Society	PE	Society	
+ Analytic Methods for Power Systems ()	PE/AMPS	Standards Committee	0
 Energy Development & Power Generation (1) 	PE/EDPG	Standards Committee	0
+ Project Administration ()	PE/EDPG/ADMIN	Working Group	0
 P2800.2 - Test and Verification of BPS- connected Inverter-Based Resources () 	PE/EDPG/P2800.2 - T&V of BPS- connected IBRs	Working Group	•
Recommended Practice for Test and Verification Procedures for Inverter- based Resources (IBRs) Interconnecting with Bulk Power Systems	PE/EDPG/P2800.2 - T&V of BPS- connected IBRs/2800.2	Project/Task Group	•



To get involved in IEEE P2800.2:

- Sign up for listserv to receive future meeting notices by sending an email to <u>listserv@listserv.ieee.org</u>
 - In first line of email body, write: SUBSCRIBE p28002 Your Name
 - For example, "SUBSCRIBE P2800 -2 Andy Hoke"
- In addition, each subgroup will have a Listserv to announce its meetings
 - Details to be announced
- To join Working Group:
 - If you attended 1/18/2022 kickoff meeting, email Manish Patel: <u>Mpatel@southernco.com</u>; CC <u>Andy.Hoke@nrel.gov</u>
 - If not, attend two future meetings and request membership
- Public website (to be populated with more information soon)
 - <u>https://sagroups.ieee.org/2800-2/</u>



