Leveraging Voluntary Conformity Assessment Standards to Improve Interconnection, Performance, and Modeling of Inverter-Based Resources

EPRI View from the TOP Webinar Series 2026

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Wednesday, July 8, 2026

Classification: **public**

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Welcome and Agenda

EPRI is recording this webcast and will post the recording, transcription and materials (where possible) for those who could not make it.

Introduction

(Anna Lafoyiannis - EPRI)

Overview of **North American IBR Standards**

(Jens Boemer - EPRI)

In-depth review of
IEEE Std 2800.2™-2026

(Jose Cordova - EPRI)

How **ISO-NE intends to leverage voluntary standards** like
IEEE 2800.2 for NERC compliance

(Brad Marszalkowski - ISO-NE)

Examples of interpretations, implementation guidance, reviews, and tools.

(Jens Boemer - EPRI)

Summary and related
EPRI offerings

(Jens Boemer - EPRI)

Slido Questions and Discussion

(10 mins, moderated by EPRI)

Click on a box to navigate through the slide deck!

Transmission Operations & Planning

- EPRI's Transmission Operations & Planning (TOP) program conducts collaborative research to support reliable, resilient, and economic planning and operation of the bulk electric power system for transmission owners and system operators

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  - Transmission Operations
  - Transmission Planning
  - Bulk System Integration of Renewables and Distributed Energy Resources
  - Electricity Market Design and Operation

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  - Leverage global collaboration across utilities, ISOs, and subject-matter experts
  - Help the industry manage rapid system change, including renewables, large loads, and climate-driven risks

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View from The TOP

Transmission Operations & Planning R&D
Public Webinar Series

Transmission Operations and Planning
Innovating Grid Operations, Shaping Strategic Planning

2026: A public webinar series

- R&D highlights from EPRI and our global collaborators
- 8-12 webinars delivered throughout 2026
- Topics spanning operations, planning and markets issues
- Coordinated with existing EPRI forums
- Open to all participants

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Save the Date
August 5th, 11am ET
Advances in Transmission Planning and Regulation

Recordings & materials posted at: top.epri.com/view-from-the-top

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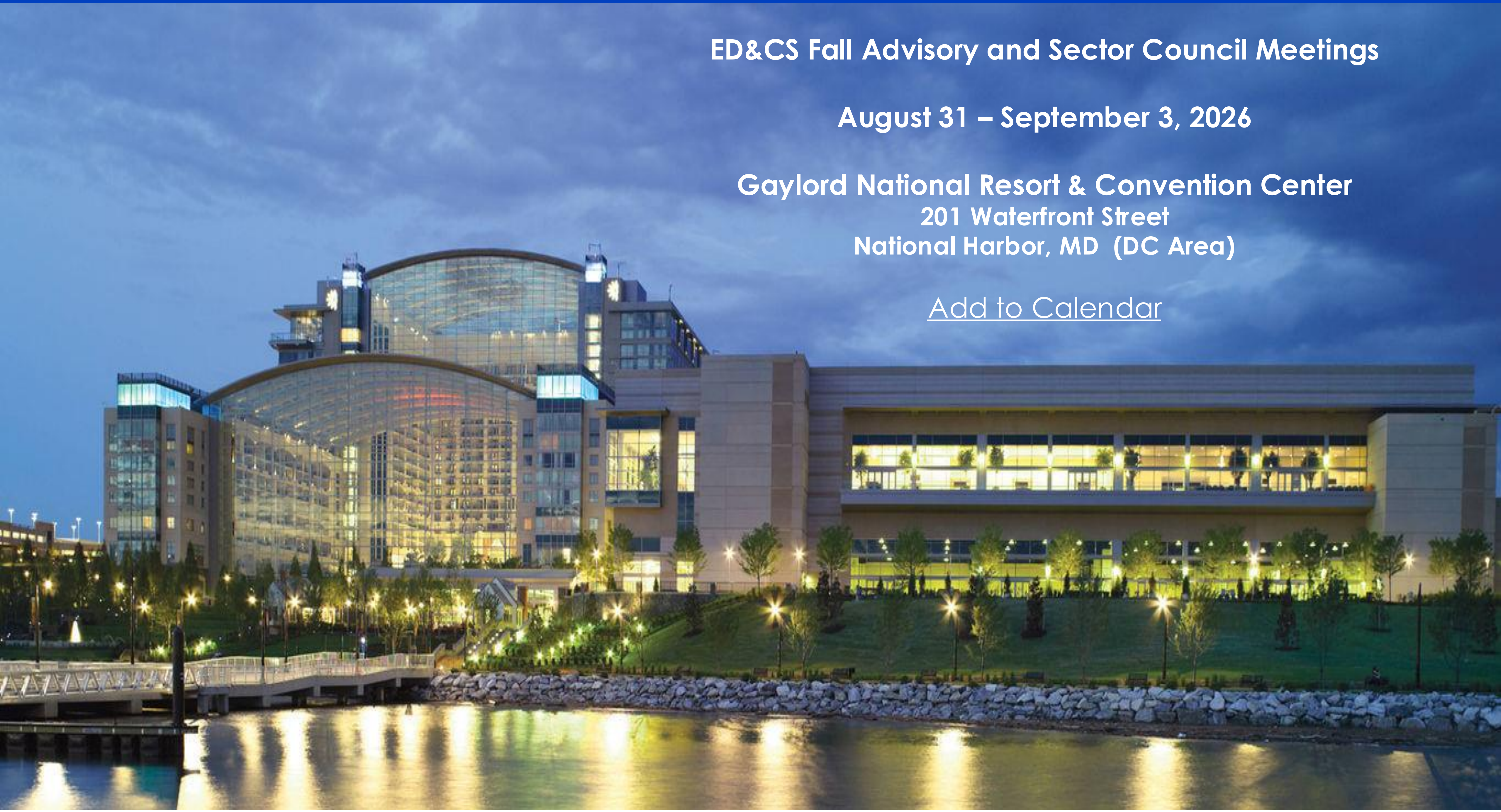


ED&CS Fall Advisory and Sector Council Meetings

August 31 – September 3, 2026

Gaylord National Resort & Convention Center

201 Waterfront Street
National Harbor, MD (DC Area)

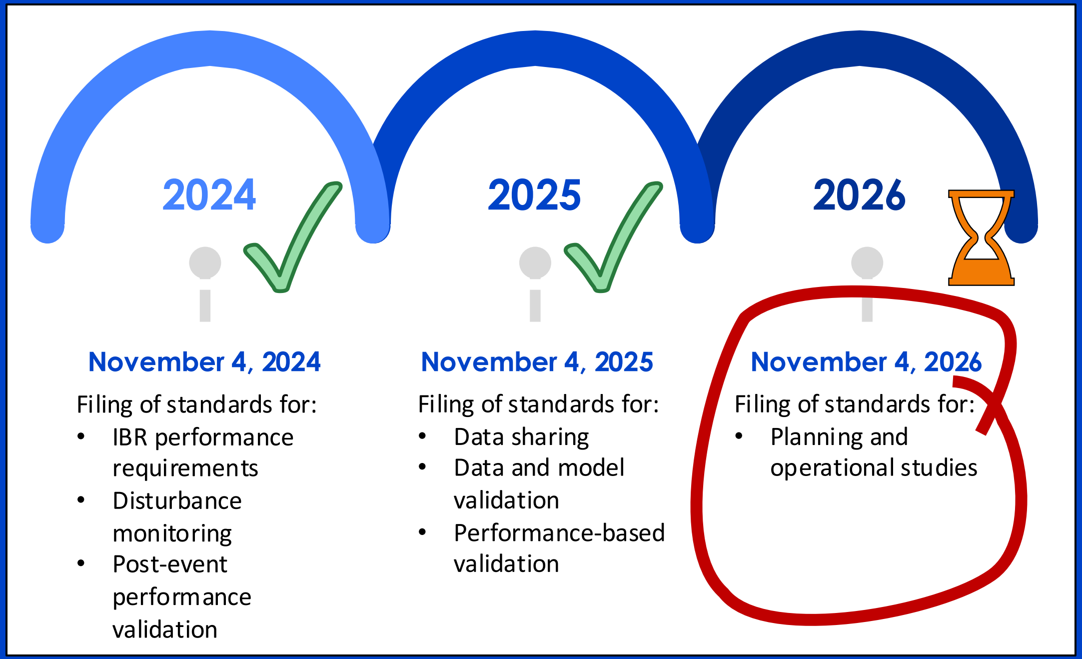
Add to Calendar

Overview of North American IBR Standards

Click here to return to
Welcome and Agenda

FERC Order 901 Reliability Standards to Address Inverter-Based Resources (RM22-12)

NERC Workplan Milestones 2 through 4



NERC IBR Webinar Series
https://www.nerc.com/comm/RSTC/Pages/IRPS.aspx

- Effective on December 29, 2023
  - Issued October 19, 2023 (link), published in federal register on October 30, 2023.
  - NERC published a work plan (link) on January 17, 2024.
- **Directs NERC to develop new or modified Reliability Standards** that address the following reliability gaps related to inverter-based resources:
  a. Data sharing ✓
  b. Model validation ✓
  c. Planning and operational studies
  d. Performance requirements ✓
- **Apply to IBRs down 60 kV and both new and legacy IBRs!**
- **FERC and NERC** acknowledged potential value of IEEE 2800-2022 performance requirements and plant conformity assessment per IEEE 2800.2 but **declined to incorporate IEEE standards by reference.**

North American mandatory standards are evolving and changing significantly

PRC-029-2 and PRC-028-1 Compliance Dates Approaching Soon

2024 | 2025 | 2026 | TODAY | 2027 | 2028 | 2029 | 2030

NERC

Oct 2024
PRC-029-1
Ballots approved

July 2025
PRC-029-1
FERC Approval

August 28, 2025
PRC-029-1 effective

PRC-028-1 R8
BES IBRs:
Jan 1, 2026

Non-BES IBRs:
Jan 1, 2026
PRC-029-1 R1, R2, and R3 effective

BES IBRs:
Oct 1, 2026
PRC-029-1 R1, R2, and R3 effective

All IBRs:
Oct 1, 2027
PRC-029-2 R4:
In service* *prior to* PRC-029-1 effective date: no later than 12 months after effective date

PRC-028-1 R8
Non-BES IBRs:
Apr 1, 2027

PRC-028-1 R1-R7
BES IBRs: Apr 1, 2028
50% legacy IBRs with COD‡ prior to April 1, 2025

PRC-028-1 R1-R7
BES IBRs: Jan 1, 2030
100% legacy IBRs with COD‡ prior to April 1, 2025
Non-BES IBRs: Jan 1, 2030
100% legacy IBRs with COD‡ prior to May 15, 2026

All IBRs: PRC-029-2 R4 - In service* *after* PRC-029-1 effective date: a) on PRC-029-2 effective date or b) 90 days after IBR compliance is required

PRC-028-1 R1-R7
BES IBRs: a) July 1, 2026, or b) COD
COD‡ after April 1, 2025
Non-BES IBRs: a) July 1, 2026, or b) COD
COD‡ after May 15, 2026

Legend
- PRC-029
- PRC-028

Implementation Plan PRC-029-02 (June 2026)

Performance-Based Elements (all applicable Inverter-Based Resources)

Entities shall not be required to comply with the portion of Requirements R1, R2, and R3 relating to the operation of IBRs *to meet the requirements* ***until the entity has established the required disturbance monitoring equipment capabilities*** *for those IBRs in accordance with the implementation plan for Reliability Standard* ***PRC-028-1***.

* *For the purpose of PRC-029-2, in the United States, the* ***"in-service date"*** *refers to the date upon which the Generator Owner reasonably expects it will be ready to begin use of a transmission provider's interconnection facilities to back feed power.*

PRC-029-02 design requirements apply to *legacy and new IBR plants*

Operation requirements do not apply until GO has established disturbance monitoring equipment compliant to PRC-028-1

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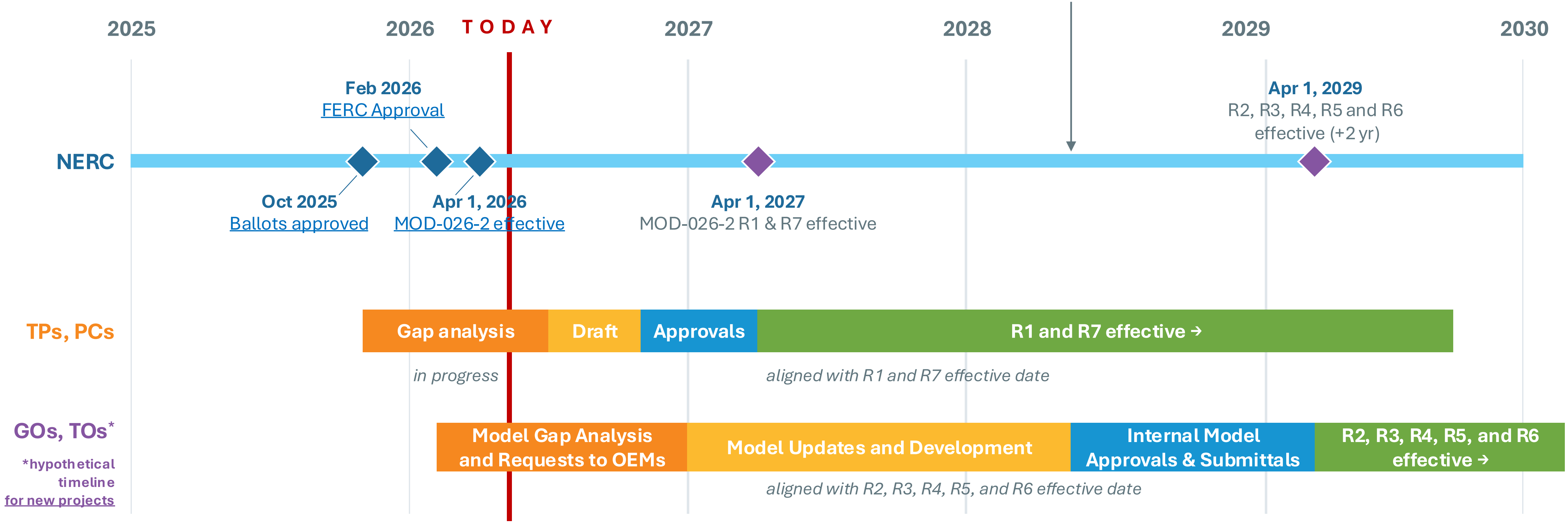
MOD-026-2 – Verification and Validation of Dynamic Models and Data Compliance Dates in Coming Years

Critical Date: *Consolidated TPs and PCs document needs to be in place **by April 1st, 2027***

*For Category 1 and Category 2 IBR plants **commissioned after April 1, 2028,** models must be submitted **365 days after commissioning**. For IBR plants **commissioned before that date** but after the MOD-026-2 effective date of April 1, 2026, models must be submitted **by April 1, 2029**. For **Legacy IBR plants** that were in operation by the effective date of the standard, **transition times** specified in the Implementation Plan **apply.***



Source: Modified based on Brad Marszalkowski, ISO-NE, Presentation to EPRI Application of IBR Standards Collaborative Forum, May 20, 2026

Potential Risks in IBR Unit and IBR Plant Development

IBR plant development steps

Interconnection request and related studies

IBR plant construction

IBR plant commissioning

IBR plant operation

All components procured

All components installed

Risks for OEMs
- Non-standardized or special-purpose capability expectations
- Insufficient or unclear verification procedures
- Non-standardized or superfluous parts of IBR plant documentation (too much to create or document)
- Handling of prototypes

Risks for TS owners
- Insufficient IBR plant design
- Insufficient IBR plant model
- Insufficient IBR plant documentation
- Non-standardized or superfluous parts of IBR plant documentation (too much to process or analyze)

Risks for IBR operators
- Insufficient IBR plant design—utilization
- Insufficient IBR plant model
- Insufficient IBR plant documentation

Risks for IBR developers
- Insufficient or unclear TS owner requirements, mis-interpretations
- Procurement of equipment not compatible with requirements
- Insufficient or invalid OEM documentation or models
- Insufficient or invalid TS owner grid information or models
- Lose position in queue due to material modification
- Non-standardized or superfluous parts of IBR plant documentation (too much to create or document)

Risks for IBR owners
- Insufficient IBR plant design
- Insufficient IBR plant model
- Insufficient IBR plant documentation

In-depth review of IEEE Std 2800.2™-2026

Click here to return to Welcome and Agenda

Overview of IEEE 2800/.x Series of Standards

2022

IEEE 2800-2022

- **Interconnection requirements for IBRs on transmission and subtransmission**
- 2800 (mostly) applies at the plant level
- Adopted by >20 utilities and ISOs, and counting…
- Ride-through aspects incorporated into NERC PRC-029-1

Today

IEEE 2800.2-2026

- **Recommended conformity assessment procedures for 2800**
- IEEE-SA balloting completed in late 2025. **96% approval** among 231 balloters
- Approved by IEEE SA Standards Board in February 2026
- **Published on June 30, 2026**

Future

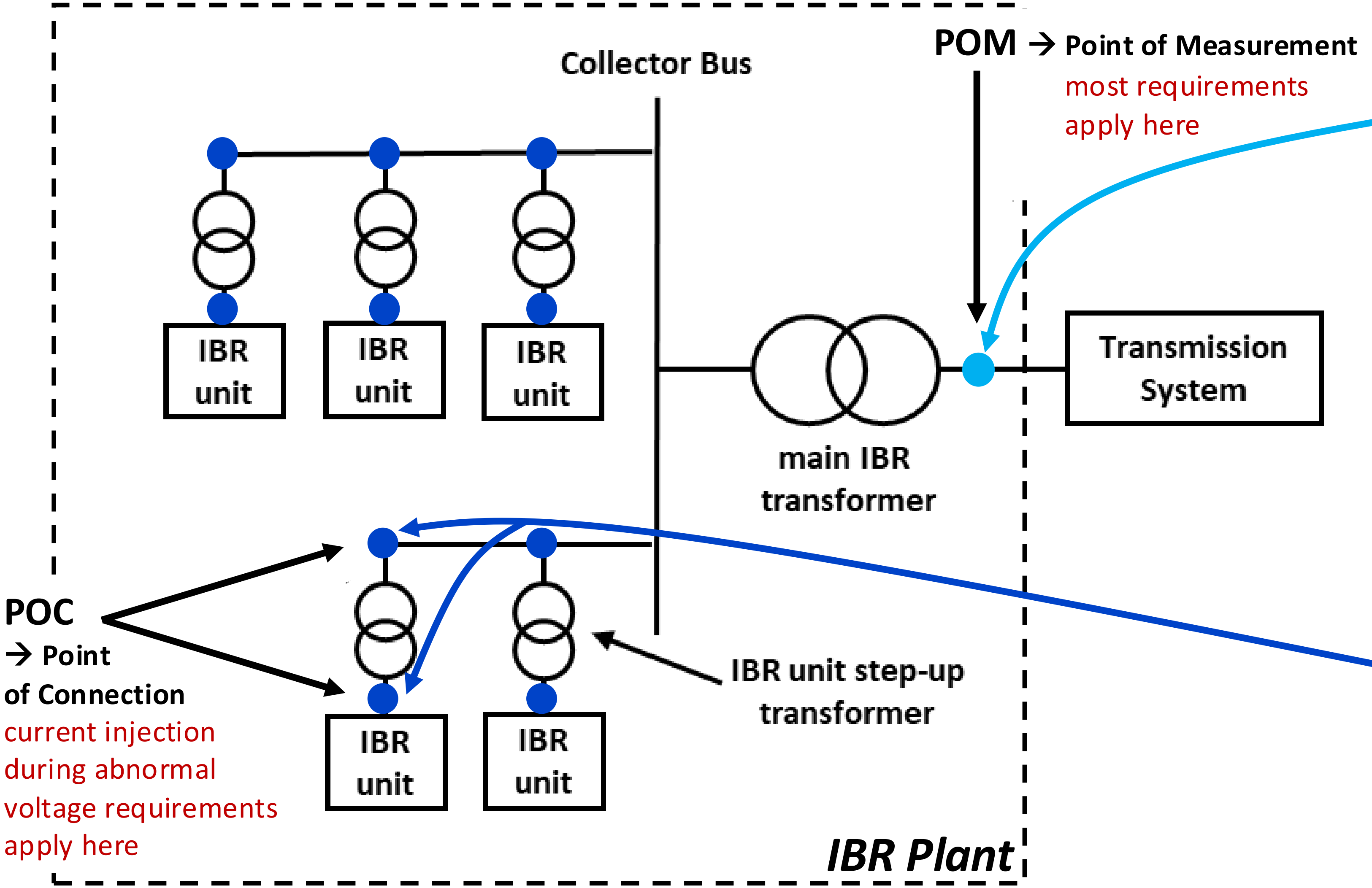
IEEE P2800.1, P2800a, P2800 R1

- **P2800a:** Amendment of IEEE 2800 to reduce barriers to grid-forming (GFM) IBR units
- **P2800.1:** Recommended practice for GFM-IBR units requirements and tests
- **P2800:** Full revision of IEEE 2800
- …

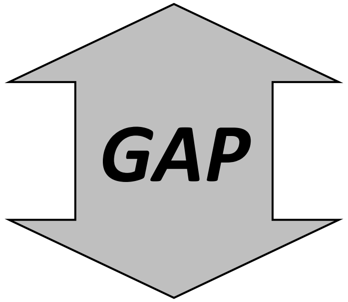
Source: Andy Hoke (NRL)

IEEE 2800.2-2026 is now published and available!

IBR Plant-Level Requirements versus IBR Unit-Level Testing



Location where plant-level performance requirement apply.



Location(s) where unit-level type testing in laboratory can be performed.

IEEE 2800.2-2026 procedures can close the gap.

Conformity assessment framework during IBR plant development

IBR plant development steps (not in scope of 2800.2)

- Interconnection request and related studies
- IBR plant construction
- IBR plant commissioning
- IBR plant operation

All components procured

All components installed

IEEE 2800.2-2026 conformity assessment methods

OEM

1. 2800.2-2026 Type testing
2. 2800.2-2026 IBR unit model validation
2. IBR plant Controller Model Validation

IBR Developer

3. 2800.2-2026 IBR plant model development
4. 2800.2-2026 Plant design evaluation

IBR Dev & TS owner

5. 2800.2-2026 as-built installation evaluation
6. 2800.2-2026 commissioning tests
7. 2800.2-2026 post-commissioning
7. 2800.2-2026 post-commissioning model validation
7. 2800.2-2026 periodic tests and verifications

IBR unit compatibility

Adapted from IEEE 2800-2022

Classification: Public

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① Review of 2800.2 Clause 5 (Type tests)

➢ ***This clause contains recommendations for performing type tests as specified in IEEE Std 2800-2022 subclause 12.2.2. The primary goal of type testing an IBR unit or supplemental IBR device (e.g., PPC) is to collect data for model validation.***

Reactive power capability test

Clause 5.6 Reactive power capability

Table 8-10

Voltage and Reactive power control modes

Clause 5.7 Voltage and reactive power control modes

Active power control

Clause 5.8 Active power control test

Frequency Response

Clause 5.9 Frequency Response

Figure 10 & 12

Table 15 -17

Low Voltage Ride-Through

Clause 5.11

Table 18, Figure 15, 17, 21, 22

High Voltage Ride-Through

Clause 5.11

Figure 16, 18, 23

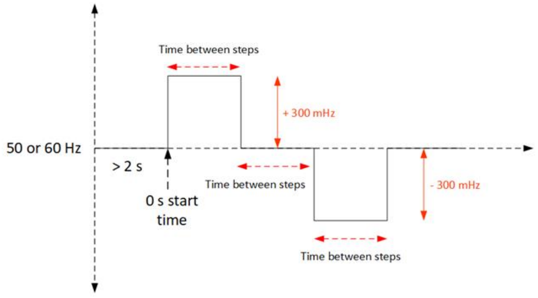


Figure 10—Injecting step signal into the EUT controls to test frequency response capability (5.9.1 (a))

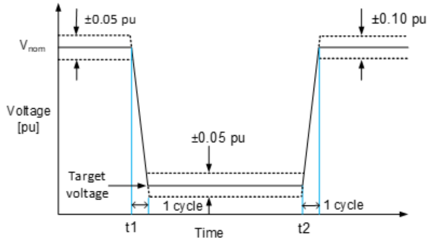


Figure 15 —Tolerances on LVRT voltage

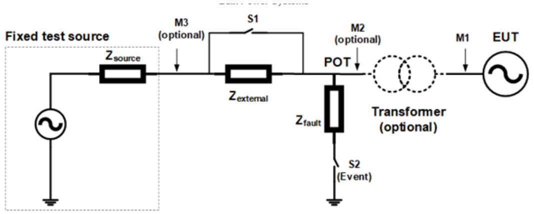


Figure 17—Test circuit for Test Setup Method 1 (LVRT)

Transient overvoltage ride-through capability

Clause 5.12

Frequency disturbance ride-through

Clause 5.13

Power Quality

Clause 5.14

Protection

Clause 5.15

Power plant controller type testing

Clause 5.17

- Active and reactive power setpoint change
- Frequency step
- Voltage measurement
- Voltage setpoint step
- Power factor step response

Clause 5 includes for most type testing:

➢ ***Equipment requirements – test equipment and EUT (equipment under test)***

➢ ***Test procedure***

➢ ***Test results and information***

Source: IEEE ©2025

② Scope of 2800.2 Clause 6 (Model Validation)

Modeling & simulations

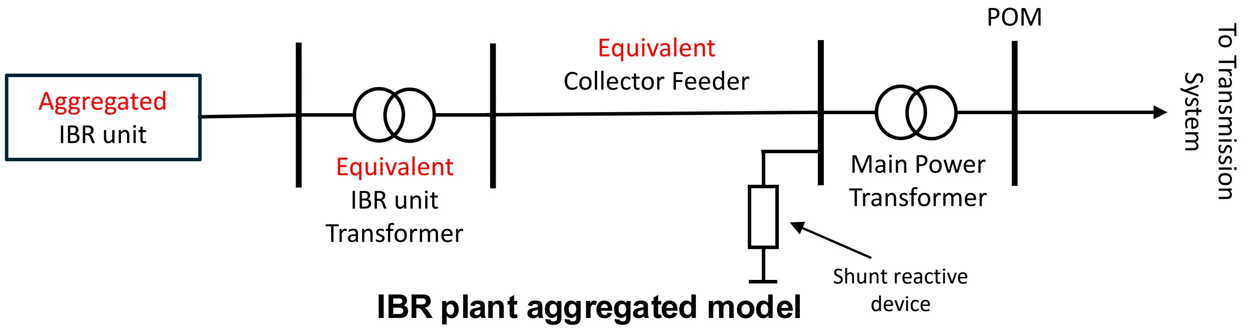
- Validation procedure
  - Simulation Step
  - Simulation tests
  - Test results and information
- Engineer review procedure
- Qualitative criteria

Model Validation

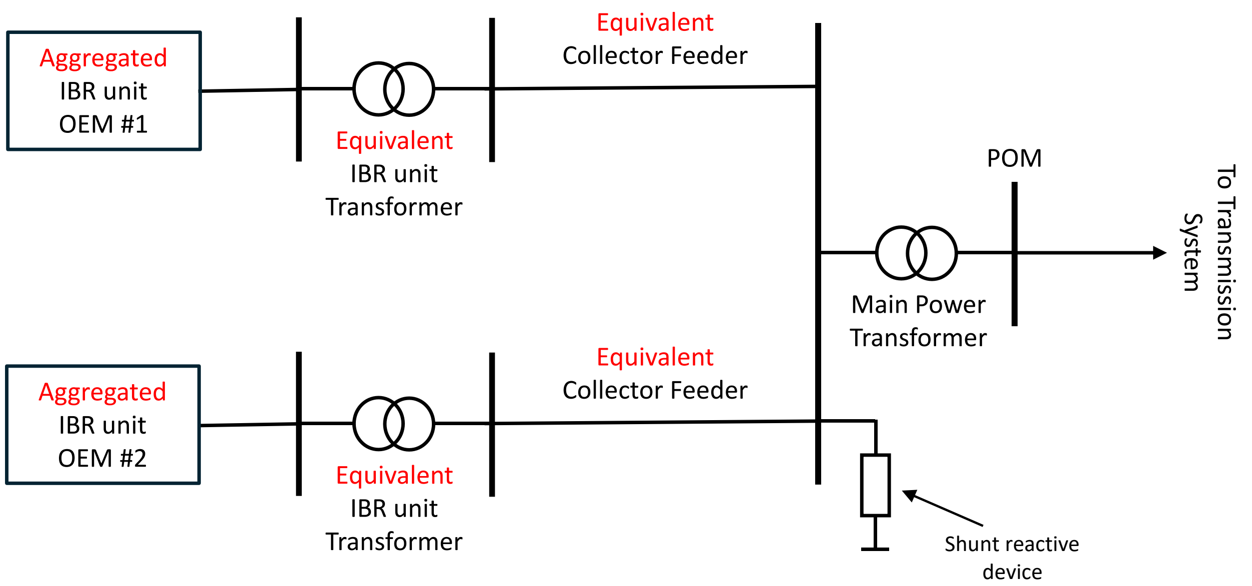
- Validate IBR unit models or supplemental IBR devices models against the test results from type testing:
  - Clause 6. Validation procedures for IBR unit models and supplemental IBR device models
  - Model validation procedures should use the *same tests as used for the type testing*, but implemented in a simulation environment
  - Model validation procedures focus on IBR units and PPCs; they do not focus on other devices that might be found in an IBR plant in a simulation environment.

Model Validation of IBR units and supplemental devices in conjunction with Clause 5

③ 2800.2 IBR plant model development



IBR plant aggregated model



IBR plant aggregated model with multiple type of IBR units

- **Aggregated IBR Unit Model:**
  - Scale up MVA base if all IBR units are identical.
  - Use separate aggregated models for different OEM unit types.
- **Aggregated Transformer Model**
- **Equivalent Collector System Model**
- **Substation-Level Equipment**
  - Explicitly represent main power transformer and reactive devices (capacitors, reactors, SVC, STATCOM, etc.).

How detailed an IBR plant should be modeled depends on the purpose of the study.

④ Scope of IEEE 2800.2-2026 Clause 7 (Design Evaluation)

Documentation check (verification)

- Review of capabilities specified in IEEE 2800:
  - Clause 4.0 (General requirements), Clause 7.2.2.4 (Consecutive voltage deviation ride-through capability), Clause 7.2.3 (Transient overvoltage ride-through), Clause 9 (Protection)
- Review of settings
  - IBR units, supplemental IBR devices like IBR power plant controller, etc.
- Review of equipment model validation report

Modeling & simulations

- Model quality checks
- Plant model development & verification
- Limited amount of capability tests
- Significant amount of performance tests

IBR Conformity Assessment is <u>NOT</u> a System Impact / Reliability Study

④ Scope of IEEE 2800.2-2026 Clause 7 (Design Evaluation)

7.3.3 Verifications based on review of OEM or IBR plant design documentation

- Review of capabilities specified in IEEE 2800:
  - Clause 4.0 (General requirements), Clause 7.2.2.4 (Consecutive voltage deviation ride-through capability), Clause 7.2.3 (Transient overvoltage ride-through), Clause 9 (Protection)
- Review of settings
  - IBR units, supplemental IBR devices like IBR power plant controller, etc.
- Review of equipment model validation report

Scope of today's presentation

Modeling & simulations

- Model quality checks
- Plant model development & verification
- Limited amount of capability tests
- Significant amount of performance tests

IBR Conformity Assessment is NOT only based on IBR Plant Modeling

④ Tests in IEEE 2800.2-2026 Clause 7 (Design Evaluation)

- ***Test for grid conditions specified by TS owner/TS operator*** **for applicability per IEEE 2800-2022, Clause 4.1.1. If no conditions have been specified, use SCR = 2.5 and SCR = 20 with X/R = 10.**
- ***For IBR plants with energy storage systems, run certain tests at P = ICR; 0; and ICAR.***

Reactive power capability test

Table 33

P_init = ICR; ICAR; Pmin (0)

Q_init = 0; 0.3287 x ICR and ICAR injecting and absorbing

Test number	*IBR plant* power output			Criteria
	Active power	Reactive Power	RPA voltage (per unit)	
RPC#1[a]	ICR ICAR[d]	0.3287 x 0.7 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	0.90	*IBR plant* conforms to reactive power capability requirements specified in clause 5.1 of the IEEE Std 2800-2022 at the RPA.
RPC#2	ICR ICAR[d]	0.3287 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	0.95	
RPC#3	ICR ICAR[d]	0.3287 x ICR absorbing 0.3287 x 0.7 x ICAR absorbing[d]	V2[b]	
RPC#4	ICR ICAR[d]	0.3287 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	V3[b]	
RPC#5	ICR ICAR[d]	0.3287 x ICR absorbing 0.3287 x 0.7 x ICAR absorbing[d]	V5[b]	
RPC#6[a]	P_{min}[c]	0.3287 x 0.7 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	0.90	
RPC#7	P_{min}[c]	0.3287 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	0.95	
RPC#8	P_{min}[c]	0.3287 x ICR absorbing 0.3287 x 0.7 x ICAR injecting[d]	V2[b]	
RPC#9	P_{min}[c]	0.3287 x ICR injecting 0.3287 x 0.7 x ICAR injecting[d]	V3[b]	
RPC#10	P_{min}[c]	0.3287 x ICR absorbing 0.3287 x 0.7 x ICAR absorbing[d]	V5[b]	

[a] This test may not be applicable for *IBR plants* consisting of type III WTGs.
[b] Refer to IEEE Std 2800-2022, Figure 8 and Table 4.
[c] Refer to IEEE Std 2800-2022, Figure 6 and Figure 7.
[d] Applicable when *IBR plant* consists of battery-energy storage system

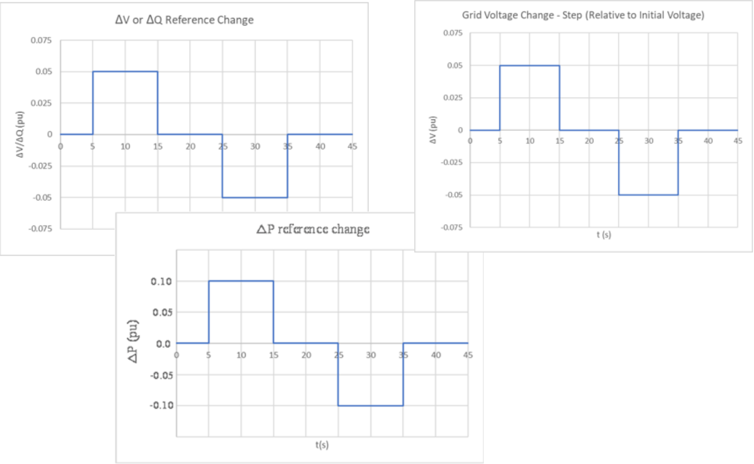
Reactive power control tests signals

Table 34

Figure 42

Figure 43

Figure 44

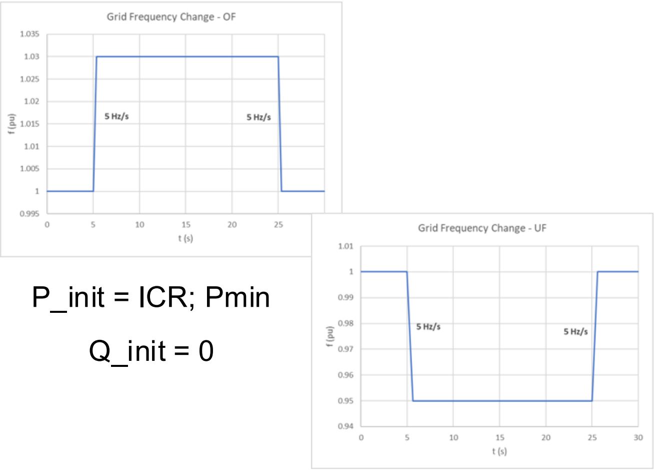


Frequency Response

Table 38

Figure 45

Figure 46



P_init = ICR; Pmin

Q_init = 0

Low Voltage Ride-Through

Table 35 (balanced)

Table 37 (unbalanced)

High Voltage Ride-Through

Table 36 (balanced)

P_init = ICR; ICAR

Q_init = 0; 0.3287 x ICR and ICAR injecting and absorbing

+ Seq. V-phase angle change RT

Table 39

P_init = ICR; ICAR; Pmin (0)

Q_init = 0

Source: IEEE ©2025

⑤ Scope of IEEE 2800.2026 Clause 8: As-Built Installation

- The IBR plant as-built installation evaluation (on-site) is an ***evaluation at the time of commissioning to verify that the IBR units, collector system, supplemental IBR device(s), and protective functions*** forming an IBR plant ***as delivered and installed conform to the design*** as defined in the IBR plant design evaluation (Clause 7).

8. As-built installation evaluations

8.1 Isolation device

8.2 Enter Service

8.3 Protection

Any changes made on-site (including control tuning) that affect the IBR plant performance should be reflected in updated IBR plant models, as necessary.

⑥ Scope of IEEE 2800.2-2026 Clause 9 (Commissioning Tests)

Similar structure of sub-clauses for each test

This clause specifies *commissioning test* procedures for the verification of *IBR plant* capability and performance. **The main goal of these *commissioning tests* is to verify conformity of the *IBR plant* with IEEE Std 2800** capability and performance requirements.

Data obtained from the tests performed during commissioning will be used for post commissioning model validation.

⑦ Scope of 2800.2 Clause 10 (IBR plant Model Validation) and Clause 11 (Post-Commissioning Monitoring)

Clause 10. Post commissioning Model Validation

- Recommended practices for model validation of the IBR plant as-commissioned configuration. Assuming the following steps have been taken:
  - IBR unit-level type testing
  - Design evaluation of IBR plant
  - As-built evaluation of IBR plant
  - Commissioning tests for IBR plant

Post-commissioning model verification and validation

- Model verification:
  - Confirm that the controls and protection settings and parameterization of the models of the IBR plant have not been materially changed
  - A new design evaluation may be needed if IBR plant changes
- Model validation:
  - Data measured from commissioning tests
  - Update models, if necessary and validate EMT and PDT models with measured response during commissioning tests

Field tests:
- Limited range of reactive power
- Voltage and reactive power
- Frequency response (FPR and FFR)

Industry Collaboration on Voluntary Adoption

IEEE 2800-2022
2800.2-2026
(1st edition)

- For the time being, adopting IEEE 2800-2022 and 2800.2-2026 with a "**hybrid integration**" approach may be preferred because it can account for known deficiencies and gaps in the 1st edition of the standard.
  - *Future revisions should be informed by the adjustments entities made in their "hybrid integrations"—**call to action for all stakeholders to get engaged in the ongoing revisions and amendments***

IEEE 2800-202x
2800.2-202x
(2nd edition)

- After the forthcoming revision, a "**detailed reference & customization**" approach may be preferred because it allows for partial adoption via clause-by-clause references to the 2nd edition
  - *Not all gaps identified during the adoption of the 1st edition may be sufficiently addressed in this revision.*
  - *A detailed reference to a new **IEEE 2800.1 Recommended Practice for GFM equipment** may be included.*

+ IEEE P2800.1 for GFM

IEEE 2800-203x
2800.2-203x
(3rd edition)

- For subsequent editions, a "**general reference**" approach **with the necessary specification of** technical minimum **capability** (where **options** are provided) **and** functional **settings** (where no default settings are provided) may be preferred, because it provides the broadest possible harmonization.
  - *Standards may be incrementally revised or amended as technology further matures.*

*Consider updating existing **IBR modeling requirements** to align with IEEE 2800.2-2026.*

How ISO-NE intends to leverage voluntary standards like IEEE 2800.2 for NERC compliance

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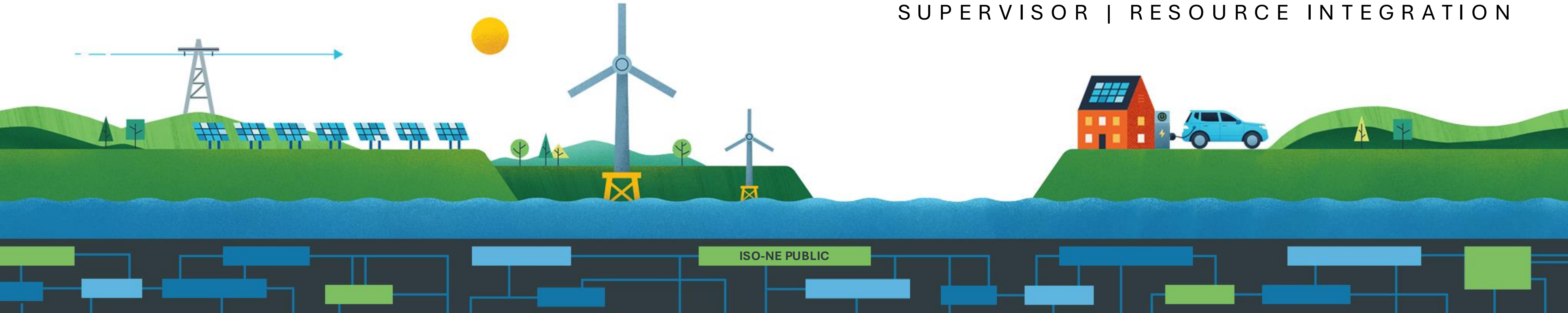
ISO new england

IEEE 2800 Adoption Update

Updates to leverage IEEE 2800.2

Brad Marszalkowski

SUPERVISOR | RESOURCE INTEGRATION



Background

- ISO-New England in conjunction with NE Stakeholders made updates to Planning Procedure 5-6 in 2023 to adopt certain clauses of IEEE 2800-2022
  - Effort was to target those clauses that most effected bulk system reliability:
    - Clauses 4, 5, 6, and 7 were adopted with exceptions
  - Adopted clauses of IEEE 2800 would only be required to be met by non-synchronous resources participating in the first ISO-NE Cluster Study and all subsequent clusters

- Verification of IEEE 2800 compliance was deferred to Phase II of IEEE 2800 adoption
  - PP5-6 updates included EMT model requirements including the addition of Appendices C-1 and C-2 that required model quality attestations and model acceptance testing
  - C-2 performance and testing expectations were based mostly off of IEEE 2800

IEEE 2800 and 2800.2 updates

- IEEE 2800.2 was published June 30th, 2026.
- ISO-NE is moving forward with a proposal to the NE stakeholders to **adapt some of the IEEE 2800.2 tests** into it's Appendix C-2 testing to verify conformance with the adopted IEEE 2800 clauses under Appendix F.
- Some notable updates include:
  - Addition of Power Factor verification testing
  - Consecutive Voltage Deviation Ride Through Testing
  - Updates to voltage ride through testing to both conform with PRC-029* and IEEE 2800 Tables 12 and 15

*ISO-NE is not an applicable entity under PRC-029, however this is tested in-line with good utility practice

Rationale

- ISO-NE Appendix C-2 **applies to newly** interconnecting Inverter Based Resources (IBR).
- Updates to PP5-6 are based mostly on **IEEE 2800.2 section 7.3 "Procedures for IBR plant capability and performance assessment"**
  - This section specifies procedures to evaluate whether IBR plant designs conform with specific sections of IEEE 2800 that apply at this stage.
- Not practical at the moment to run every test under section 7.3 of IEEE 2800.2 to verify conformance
  - Appendix C-2 tests target the specific clauses adopted under Appendix F
- Purpose of the tests is to give ISO a good understanding that the model meets or exceeds the minimum performance specifications adopted under Appendix F that most pertain to bulk system reliability.
  - Tests are run as part of the Interconnection Request Review

Attestations

- IEEE 2800.2 itself in many cases states that certain criteria are unable to be practically tested using models.
- In addition to updates to Appendix C-2, ISO-NE will also be proposing to add Appendix F-1: Appendix F Compliance Attestation Form
  - Developers must attest to their IBR plant design meeting the adopted IEEE 2800 clauses and sub-clauses adopted under Appendix F
  - ISO-NE may inspect evidence that shows compliance

Stakeholder Schedule

Stakeholder Committee and Date	Scheduled Project Milestone
Reliability Committee **July 23, 2026**	Introduction and redlines
Reliability Committee **August 18 and 19, 2026**	Stakeholder feedback and updates to redlines
Reliability Committee **September 16, 2026**	Vote
Participants Committee **October 1, 2026**	Vote

Questions

About the Presenter

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ISO New England

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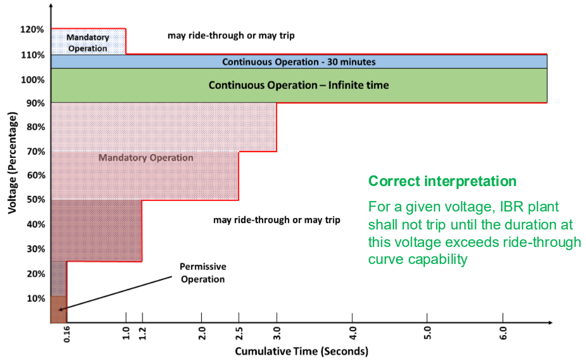
Examples of interpretations, implementation guidance, reviews, and tools

Click here to return to
Welcome and Agenda

Example 1: technical interpretation of mandatory standards

PRC-029 requirements R1 – voltage ride through IEEE 2800 interpretation



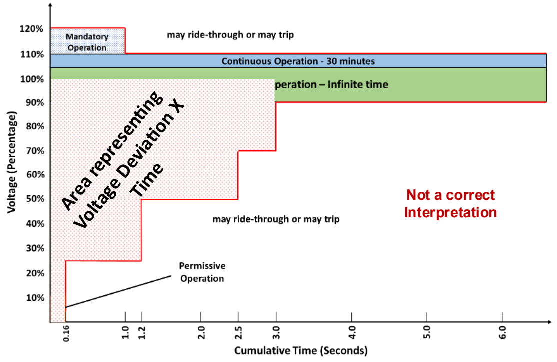
1. **Voltage versus Time curve:** For a given voltage, IBR plant shall not trip until the duration at this voltage exceeds ride-through curve capability.

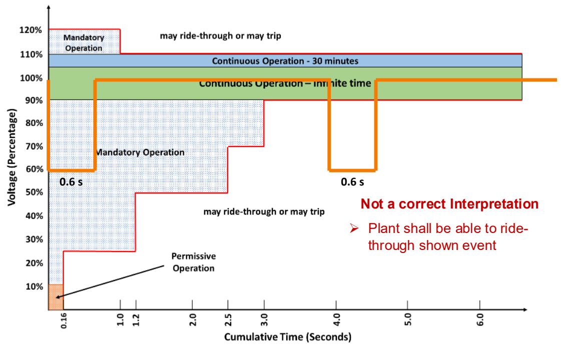
   ✓ **Correct interpretation:** IBR plant shall ride through when the applicable voltage exceeds or is less than the voltage representing the continuous operation region ***except for time durations exceeding those specified***.

2. **Voltage Deviation *times* Time *Area*:** Area between a nominal voltage (100%) and either a low or high voltage ride-through boundary.

   × **Not a correct interpretation**

   × VRT boundary does ***not*** define a voltage deviation times time area





3. **Voltage versus Time Envelope:** Ride-through curves define an envelope to lay as a template over a voltage versus time trajectory.

   × **Not a correct interpretation**

   × VRT boundary does ***not*** define an envelope to lay as a template over a voltage versus time trajectory

PRC-029 requirements R1 – voltage ride through overly stringent interpretation

NERC PRC-029: overly stringent interpretation

PRC-029-1, Attachment 1, Item #7

At any given voltage value, each IBR shall Ride-through unless the time duration at that voltage has exceeded the specified minimum Ride-through time duration. If the voltage is continuously varying over time, it is necessary to **add the duration within each band** of Tables 1 and 2 **over any 10 second time period**

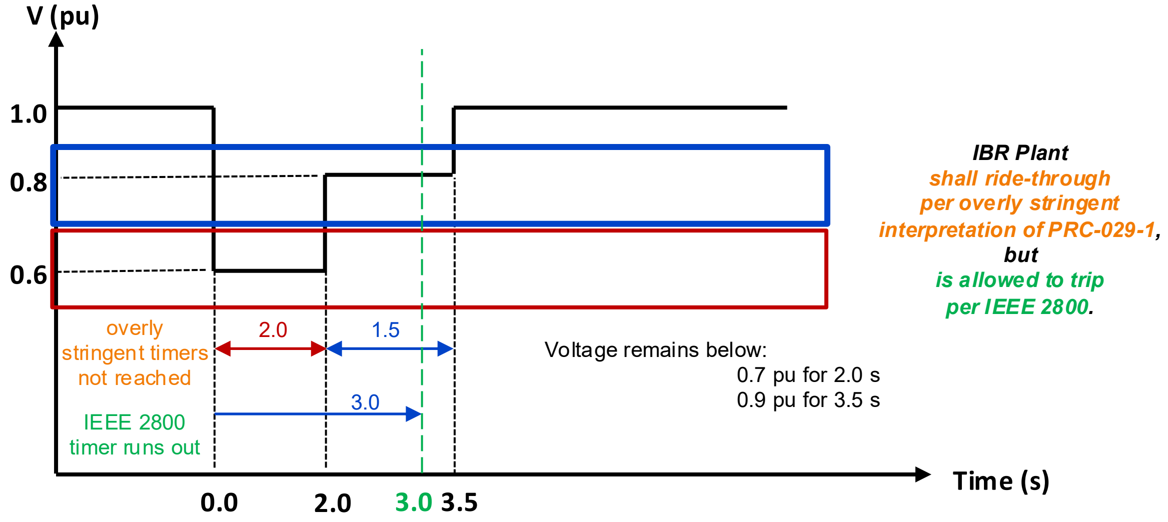
Table 1: Voltage Ride-through Requirements for AC-Connected Wind IBR [13]

Voltage (per unit)[14]	Operation Region	Minimum Ride-Through Time (sec)
> 1.20	N/A[15]	N/A
≥ 1.10	Mandatory Operation Region	1.0
> 1.05	Continuous Operation Region	1800
≤ 1.05 and ≥ 0.90	Continuous Operation Region	Continuous
< 0.90	Mandatory Operation Region	3.00
< 0.70	Mandatory Operation Region	2.50
< 0.50	Mandatory Operation Region	1.20
< 0.25	Mandatory Operation Region	0.16
< 0.10	Permissive Operation Region	0.16

IEEE 2800: reasonable interpretation

IEEE 2800, clause 7.2.2.1

IBR plant shall ride through a voltage disturbance event wherein the *applicable voltage* exceeds or is less than the voltage range representing the *continuous operation region*, **except for voltage magnitude deviations more severe** than the voltage thresholds and **persisting for greater** than the associated durations as specified

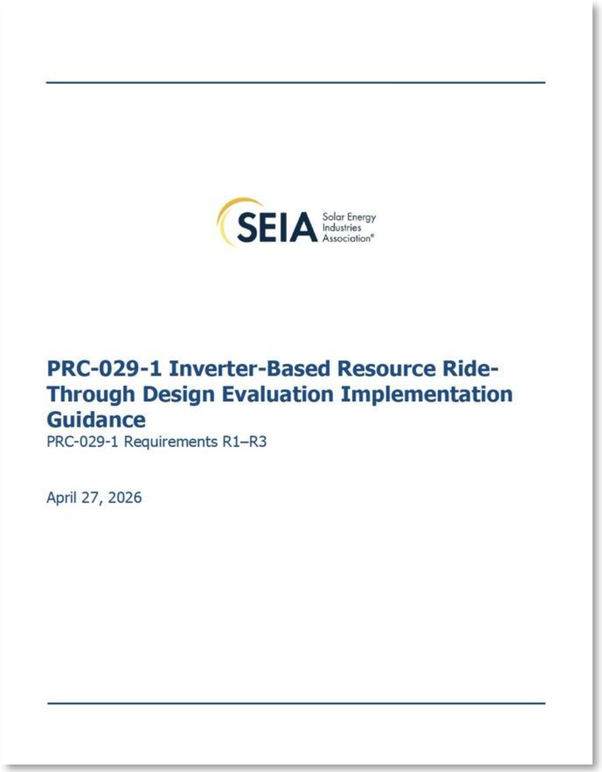


➢ EPRI recommends to interpret PRC-029 curves like IEEE 2800 curves.

Example 2: technical implementation of mandatory standards

PRC-029 requirements R1 – voltage ride through—different testing

SEIA Implementation Guidance NERC PRC-029



SEIA Solar Energy Industries Association®

PRC-029-1 Inverter-Based Resource Ride-Through Design Evaluation Implementation Guidance

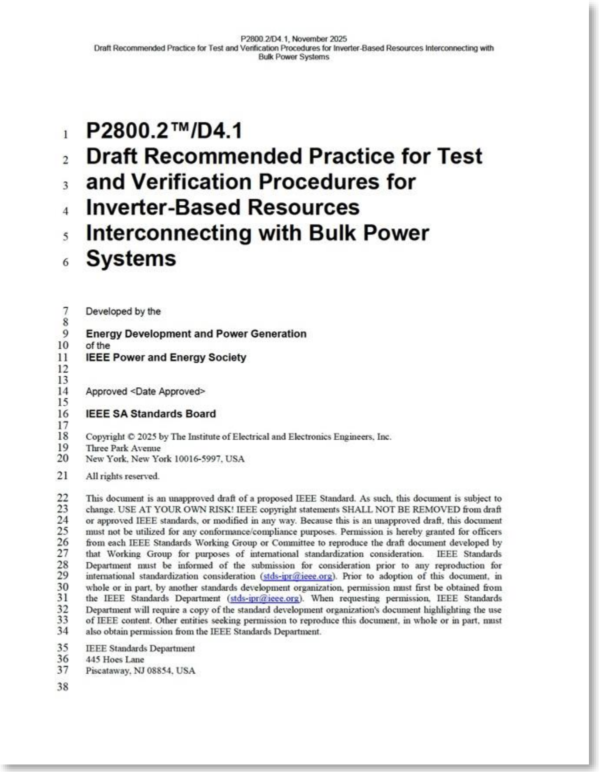
PRC-029-1 Requirements R1–R3

April 27, 2026

- 30 pages
- 6 chapters
- 2 annexes
- **16 tests**

ERO Enterprise Implementation Guidance

IEEE 2800.2 Recommended Practice



P2800.2/D4.1, November 2025
Draft Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

P2800.2™/D4.1
Draft Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

Developed by the

Energy Development and Power Generation
of the
IEEE Power and Energy Society

Approved <Date Approved>

IEEE SA Standards Board

IEEE Standards Department
445 Hoes Lane
Piscataway, NJ 08854, USA

- 253 pages
- 13 clauses
- 10 annexes
- **290 tests**

Available from IEEE at https://standards.ieee.org/ieee/2800.2/10616/

What level of detail is "sufficient"?

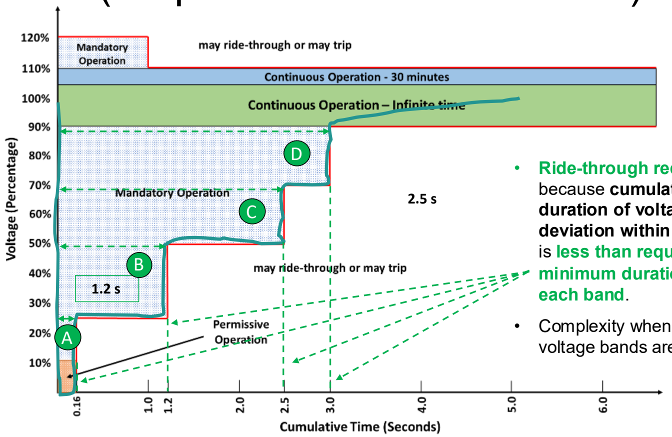
PRC-029 requirements R1 – balanced voltage ride through—different testing

SEIA Implementation Guidance NERC PRC-029

IEEE 2800.2 Recommended Practice

SEIA Proposed Test Curve

(for performance verification)



- Ride-through required because cumulative duration of voltage deviation within each band is less than required minimum duration for each band.
- Complexity when multiple voltage bands are involved.

Table 3. Example of Simulation Tests Used for IBR Plant Ride-Through Study Evaluations

#	Base Case	Simulation Test	PDT Sim	EMT Sim	Tested Requirements
1	Max Lagging PF	Low Voltage Ride-Through (LVRT)	☑	☑	R1, R2.2, R2.3
2	Max Leading PF	Low Voltage Ride-Through (LVRT)	☑	☑	R1, R2.2, R2.3
3	Max Lagging PF	High Voltage Ride-Through (HVRT)	☑	☑	R1, R2.2
4	Max Leading PF	High Voltage Ride-Through (HVRT)	☑	☑	R1, R2.2
5	Max Lagging PF	Small Voltage Disturbance	☑	☑	R2.1
6	Max Leading PF	Small Voltage Disturbance	☑	☑	R2.1
7	Max Lagging PF	P Recovery and Q Response	☑	☑	R2.2, R2.3, R2.4, R2.5
8	Max Leading PF	P Recovery and Q Response	☑	☑	R2.2, R2.3, R2.4, R2.5

IEEE 2800.2, Clause 7 (Design Evaluation)

(for performance verification)

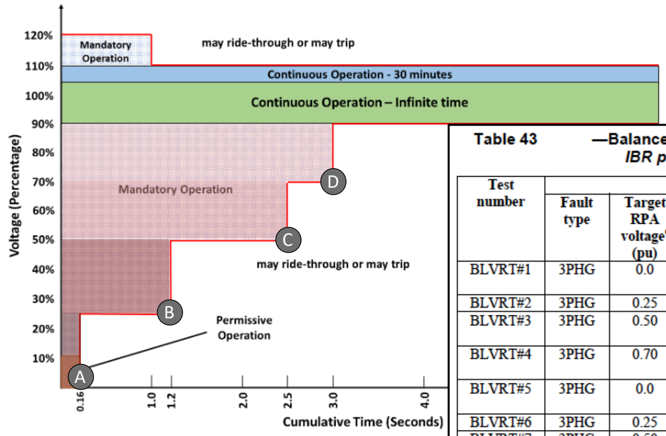


Table 43 —Balanced low-voltage disturbance *ride-through* tests (EMT and PDT) for *IBR plants* without active power absorption capability

Test number	Test description					Criteria
	Fault type	Target RPA voltage[c] (pu)	Duration (s)	*IBR plant* active power	*IBR plant* reactive power	
BLVRT#1	3PHG	0.0	0.16[a] 0.32[b]	ICR	0.0	The *IBR plant* does not trip. If the *IBR plant* enters current blocking mode when the retained voltage at the RPA is less than 10%, the *IBR plant* starts injecting current in 5 cycles or less once the applicable voltage at RPA enters the continuous operation region. The *IBR plant* injects active and reactive current as specified. The *IBR plant* restores active power as specified in clause 7.2.2.6 of IEEE Std 2800-2022.
BLVRT#2	3PHG	0.25	1.20			
BLVRT#3	3PHG	0.50	2.50[a] 3.00[b]			
BLVRT#4	3PHG	0.70	3.00[a] 6.00[b]			
BLVRT#5	3PHG	0.0	0.16[a] 0.32[b]	ICR	0.3287 × ICR injecting	
BLVRT#6	3PHG	0.25	1.20			
BLVRT#7	3PHG	0.50	2.50[a] 3.00[b]			
BLVRT#8	3PHG	0.70	3.00[a] 6.00[b]			
BLVRT#9	3PHG	0.0	0.16[a] 0.32[b]	ICR	0.3287 × ICR absorbing	
BLVRT#10	3PHG	0.25	1.20			
BLVRT#11	3PHG	0.50	2.50[a] 3.00[b]			
BLVRT#12	3PHG	0.70	3.00[a] 6.00[b]			

[a] For *IBR plants* with auxiliary equipment that cause *ride-through* limitations
[b] For *IBR plants* without auxiliary equipment that cause *ride-through* limitations
[c] The specified voltage should be considered a target voltage, and the RPA voltage may vary over the duration of the event. Due to practical considerations in testing, the measured RPA voltage may not exactly match the target voltage. For example, injection of current into a test source may cause the voltage at the RPA to rise above target voltage.

IEEE 2800.2-2026 has more tests which may reduce risks and increase accuracy

Example 3: review of modeling guidelines

How Voluntary IBR Standards Can Support with Implementation of Mandatory IBR Standards? *Some initial thoughts…*

Mandatory IBR Standards (NERC)

- Capability and performance standards:
  - Voltage and frequency ride-through: **PRC-029**
  - …
- Measurement and performance monitoring standard: **PRC-028**
  - Equipment-level
  - Collector system feeder-level
  - Plant-level
- Model validation & verification standard: **MOD-026**
  - Equipment-level
  - Plant-level
- Performance mitigation standard: **PRC-030**
- Facility standards: **FAC-001, FAC-002**

Voluntary IBR Standards (IEEE)

- **IEEE 2800** (IBR Interconnection Standard)
  - Capability and performance requirements: **Clauses 4–9**
  - Measurement data for performance monitoring and model validation: **Clauses 11**
  - Test and verification requirements: **Clause 12**
    - …
    - Post-commissioning monitoring: Subclause **12.2.7**
    - Periodic tests: Subclause **12.2.8**
    - Periodic verification: Subclause **12.2.9**
- **IEEE 2800.2-2026** (Conformity assessment standard)
  - Type test of IBR equipment: **Clause 5**
  - Equipment model validation: **Clause 6**
  - IBR plant design evaluation: **Clause 7**
  - Post commissioning model validation: **Clause 10**
  - Post-commissioning monitoring: **Clause 11**

How to bridge the gap to implement mandatory standards?

How Voluntary IBR Standards Can Support with Implementation of Mandatory IBR Standards? *MOD-026-1 Example*

Mandatory IBR Standards (NERC)

- Capability and performance standards:
  - Voltage and frequency ride-through: **PRC-029**
  - …
- Measurement and performance monitoring standard: **PRC-028**
  - Equipment-level
  - Collector system feeder-level
  - Plant-level
- Model validation & verification standard: **MOD-026**
  - Equipment-level
  - Plant-level
- Performance mitigation standard: **PRC-030**
- Facility standards: **FAC-001, FAC-002**

Model validation and verification requirements (***What***)

Voluntary IBR Standards (IEEE)

- **IEEE 2800** (IBR Interconnection Standard)
  - Capability and performance requirements: **Clauses 4–9**
  - Measurement data for performance monitoring and model validation: **Clauses 11**
  - Test and verification requirements: **Clause 12**
    - …
    - Post-commissioning monitoring: Subclause **12.2.7**
    - Periodic tests: Subclause **12.2.8**
    - Periodic verification: Subclause **12.2.9**
- **IEEE 2800.2-2026** (Conformity assessment standard)
  - Type test of IBR equipment: **Clause 5**
  - Equipment model validation: **Clause 6**
  - IBR plant design evaluation: **Clause 7**
  - Post commissioning model validation: **Clause 10**
  - Post-commissioning monitoring: **Clause 11**

Detailed model validation and verification procedures (***How***)

How Voluntary IBR Standards Can Support with Implementation of Mandatory IBR Standards? *Full picture..*

Mandatory IBR Standards (NERC)

- Capability and performance standards:
  - Voltage and frequency ride-through: **PRC-029**
  - …
- Measurement and performance monitoring standard: **PRC-028**
  - Equipment-level
  - Collector system feeder-level
  - Plant-level
- Model validation & verification standard: **MOD-026**
  - Equipment-level
  - Plant-level
- Performance mitigation standard: **PRC-030**
- Facility standards: **FAC-001, FAC-002**

Voluntary IBR Standards (IEEE)

- **IEEE 2800** (IBR Interconnection Standard)
  - Capability and performance requirements: **Clauses 4–9**
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    - …
    - Post-commissioning monitoring: Subclause **12.2.7**
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    - Periodic verification: Subclause **12.2.9**
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  - Equipment model validation: **Clause 6**
  - IBR plant design evaluation: **Clause 7**
  - Post commissioning model validation: **Clause 10**
  - Post-commissioning monitoring: **Clause 11**

EPRI can provide review and feedback to ISOs/RTOs

- **IBR Facility Interconnection Requirements**
- **IBR Modeling Guidelines / Performance Verification Tests**

Example 4: IBR Conformity Assessment Module

IBR-CA Module (Version 1.1) - Streamlining Conformity Assessment Process

Set of tests to be assessed can include:

- Flat run
- SCR change
- Voltage/reactive power control
- Primary frequency response
- Phase Angle Jump
- LVRT (balanced+unbalanced)
- HVRT

Test Scenarios and Cases (Subset of IEEE P2800.2 D4.0)

Scenario	IBR Unit's nameplate rating [kVA]	Number of IBRs connected to MITS	apparent power installed capacity (Sagg) [MVA]	active power installed capacity (Pagg) [MW]	IBR continuous rating (ICR) [MW]	minimum active power capability (pmin) [pu@ICR]	available active power (Pavl) [MW] Note: may be at the DC side of the IBR units	Dispatch / Curtailment [pu@Sagg]	actual active power (Pact, p) [MW]	Measure-ments [pu@Sagg]
P2800.2 Pact = ICR	1 MVA	211	211 MVA	200 MW	200 MW	0.01 * ICR	1.0 * ICR	0.95 pu (200 MW)	1.0 * ICR (200 MW)	P_IBR = 0.95 pu

Reactive power control tests - Table 41/D4.0			
Test number	*Event*	*IBR plant active power*	*IBR plant reactive power*
VC#1 – Negative step	RPA voltage step change as per Figure 41 (D4.0)	ICR	0
VC#1 – Positive step	RPA voltage step change as per Figure 41 (D4.0)	ICR	0

Balanced low-voltage disturbance ride-through tests (EMT and PDT) - Table 43/D4.0					
Test Number	*Fault type*	*Residual voltage (pu)*	*Duration (s)*	*IBR plant active power*	*IBR plant reactive power*
BLVRT#1	3PHG	0.00	0.32	ICR	0

Balanced high-voltage disturbance ride-through tests (EMT and PDT) - Table 44/D4.0					
Test Number		*Balanced voltage at RPA (pu)*	*Duration (s)*	*IBR plant active power*	*IBR plant reactive power*
BHVRT#1		1.20	1.00	ICR	0

Frequency ride-through capability and performance tests - Table 38/D4.0			
Test Number	*Event*	*IBR plant active power*	*IBR plant reactive power*
FT#1	Overfrequency Change as per Figure 45 (D4.0)	ICR	0
FT#4	Underfrequency Change as per Figure 46 (D4.0)	ICR	0

Positive-sequence voltage phase angle change ride-through tests (EMT) - Table 39/D4.0			
Test Number	*Event*	*IBR plant active power*	*IBR plant reactive power*
PAJ#1	RPA positive-sequence voltage angle change equal to +25° (i.e., all three phases jump together/)	ICR	0
PAJ#2	RPA positive-sequence voltage angle change equal to -25°	ICR	0

Table from 3002034299

Model 1
Condition 1

Model 2
Condition 1

Hardware 3
Condition 1

Model 1
Condition 2

Run IBR-CA module for each of the test result from measurements or simulations for test thresholds specific to the standard/grid code and IBR parameters

Note: "condition" can refer to different network conditions, different operating points, different parameterizations, etc.

*Are you aligning **IBR Modeling Guidelines** with IEEE 2800.2-2026, or a similar standard/ grid code?*

Pass/fail for each test

Scenarios	SCR 2.5 PSCAD	SCR 2.5 PSSE	SCR 3.0 PSCAD	SCR 3.0 PSSE	SCR 5.0 PSCAD	SCR 5.0 PSSE	SCR 20 PSCAD	SCR 20 PSSE
Voltage or reactive power control tests (EMT and PDT) for IBR plants without active power absorption capability - Table 41/D4.1								
VC#1 – Negative Step	OK	OK	OK	OK	OK	OK	OK	OK
VC#1 – Positive Step	OK	OK	OK	OK	OK	OK	OK	OK
Balanced low-voltage disturbance ride-through tests (EMT and PDT) for IBR plants without active power absorption capability - Table 43/D4.1								
BLVRT#1	OK	OK	OK	OK	OK	OK	OK	OK
Balanced high-voltage disturbance ride-through tests (EMT and PDT) for IBR plants without active power absorption capability - Table 44/D4.1								
BHVRT#1*	OK	OK	OK	OK	OK	OK	OK	OK
Frequency response capability and performance tests (EMT and PDT) for IBR plants without active power absorption capability - Table 49/D4.1								
FT#1 – OF	OK	OK	OK	OK	OK	OK	OK	OK
FT#4 – UF	OK	OK	OK	OK	OK	OK	OK	OK
Positive-sequence voltage phase angle change ride-through tests (EMT) for IBR plants without active power absorption capability - Table 41/D4.1								
PAJ#1	OK	OK	OK	OK	OK	OK	OK	OK
PAJ#2	OK	OK	OK	OK	OK	OK	OK	OK

*Balanced voltage at RPA (pu) = 1.15 pu (whereas P2800.2 D4.0 Balanced voltage at RPA (pu) = 1.2 pu)

Legend	OK (green shade) = results are acceptable, i.e., IBR response is stable and conforms with IEEE 2800	[next action] (red shade) = results need more work, i.e., IBR response is unstable or non-conforming with 2800

Table from 3002034299

*How do you plan to **automate IBR conformity assessment** in your interconnection **process**?*

IBR-CA Module ([Version 1.1]) supports PRC-029 Compliance

Flat Run

➢ *For IBR plants with energy storage systems, run certain tests at P = ICR; 0; and ICAR.*

Voltage Ride-Through & TrOV

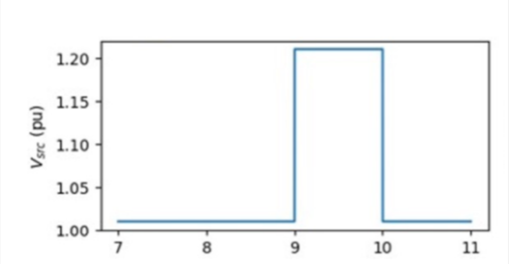
Balanced low-voltage ride through

Unbalanced low-voltage ride through

Balanced high-voltage ride through

Tables 43 & 46 balanced and unbalanced low-voltage ride-through tests

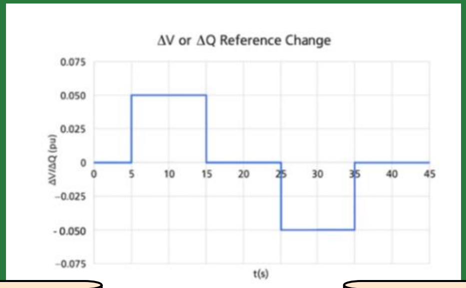
Tables 44 & 47 balanced high-voltage ride-through tests



Balanced high-voltage disturbance signal from infinite source for tests in Table 44

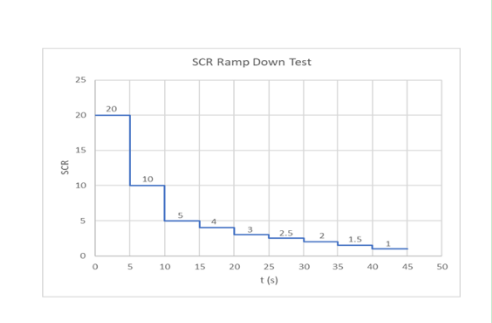
May be used to verify PRC-029-1 R1, R2-2.2, 2.3, 2.3.1, 2.4, 2.5

Voltage Control



May be used to verify PRC-029-1 R2-2.1.2 and 2.1.3.

Short-Circuit Ratio



Primary Frequency Control

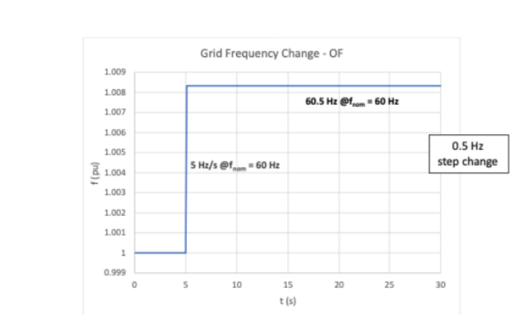


Figure 47 — Example over-frequency response performance test signal and minimum simulation duration (frequency > nominal system frequency)

May be used to verify PRC-029-1 R2-2.1.1.

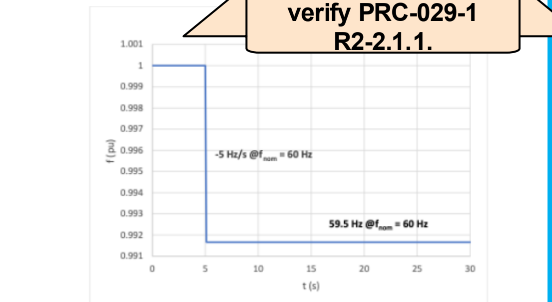
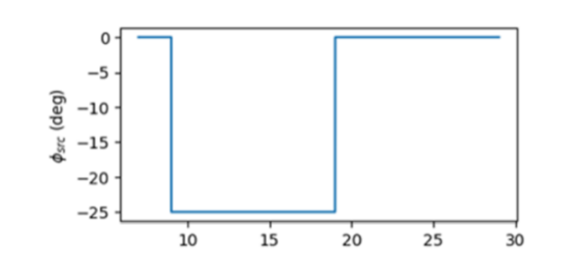


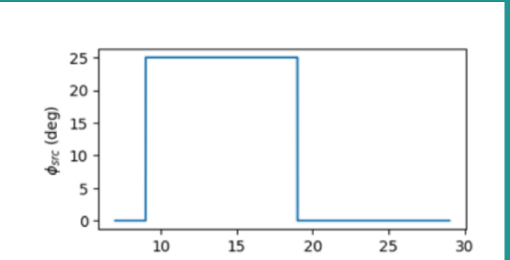
Figure 48 —Example under-frequency response performance test signal and minimum simulation duration (frequency < nominal system frequency)

Phase Angle Jump



Positive-sequence voltage phase angle disturbance signal from infinite source for tests in Table 48

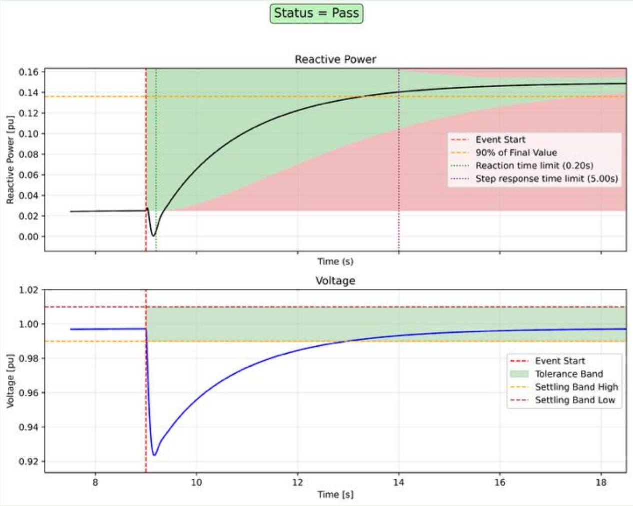
May be used to verify PRC-029-1 R1



Positive-sequence voltage phase angle disturbance signal from infinite source for tests in Table 48

Additional tests that go beyond IEEE 2800.2-2026 and PRC-029-1 will be added in future.

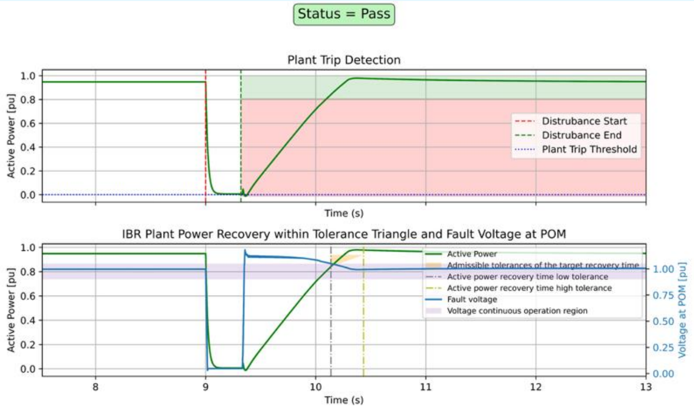
IBR-CA module: Verifying model conformity with a set of input requirements

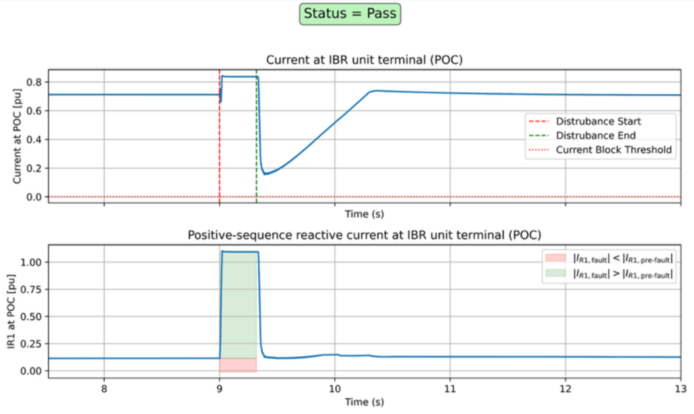


Requirements	Threshold	Detected	Pass/Fail
Reaction time (s)	0.2	0.148	Pass
Step response time (s)	5	4.292	Pass
Damping ratio	0.3	1	Pass
Voltage regulation (±1.0%)	1	0.997	Pass
Overall status			Pass

Reason
The IBR plant has the capability to regulate the steady-state voltage at the RPA to the reference value. Check for dynamic metrics Table 5 | The IBR plant has the capability to meet or exceed the performance (Table 5).

Example: voltage control





Did the IBR plant trip?	Not Trip
Did the IBR plant get into a current-blocking mode?	No
Did the IBR units exchange current with an incremental current dependent on the applicable voltages at the PoC?	Pass
Did the IBR units exchange current with an incremental current dependent on the applicable voltages at the PoC?	Pass
During LVRT, did the IBR units exchange current per Section 7.2.2.3.4?	Pass
Overall status:	Pass
Active power output restored after voltage ride-through according to Section 7.2.2.6?	Yes
Overall status:	Pass

The IBR plant rode through and the IBR unit(s) exchanged current per Section 7.2.2.3.3 and Section 7.2.2.3.4.

The active power is restored per Section 7.2.2.6.

Example: balanced low-voltage ride through

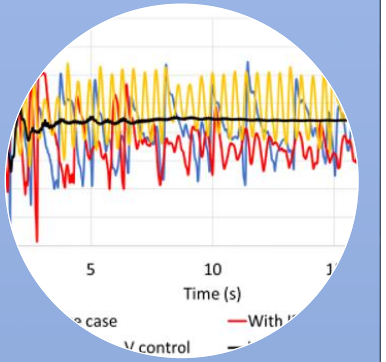
This tool is 1x out of ~20x deliverables of ARP project set PS173A "Modeling and Analytics for Emerging Technologies"

Summary and related EPRI offerings

Click here to return to Welcome and Agenda

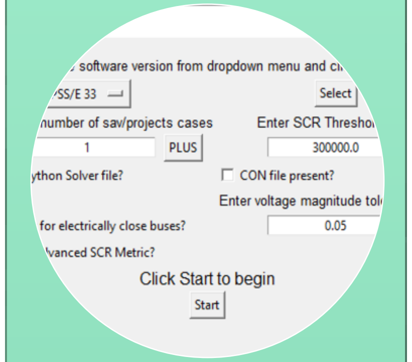
PS173A Modeling and Analytics for Emerging Technologies

Develop innovative planning and protection methods, tools and models along with analytics that help members reliably integrate emerging resources into the grid



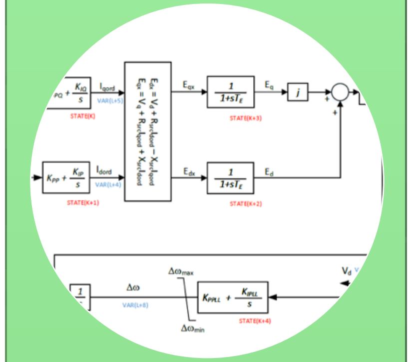
Grid Forming Inverters

- Develop models
- Evaluate need
- Ascertain impact
- GFM-ID Process



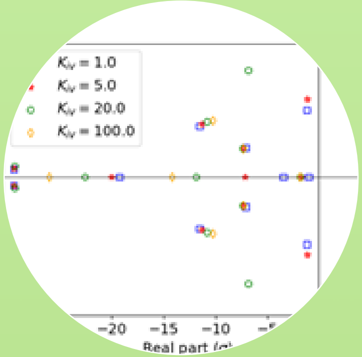
Grid Strength Assessment

- Release tool with commercial software vendors
- Evaluate metrics
- Identify locations for detailed study



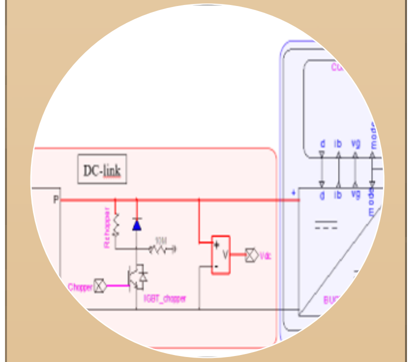
IBR Simulation Models

- Improved robustness
- Improved plant controller
- Hybrid plants



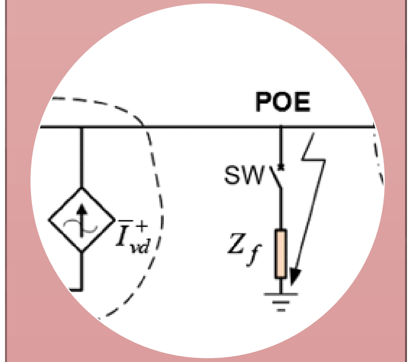
IBR Stability

- Methods to evaluate non-resonance stability
- Metrics to compare +SEQ and EMT models



IBR Short Circuit Models

- Uncontrolled transient fault response
- SC model validation & conformity assessment
- GFM SC model



Protection Guidelines

- SC network equivalencing
- Convergence properties of high IBR networks
- Impact of GFM on protection

Deepak Ramasubramanian (dramasubramanian@epri.com), Evangelos Farantatos (efarantatos@epri.com)

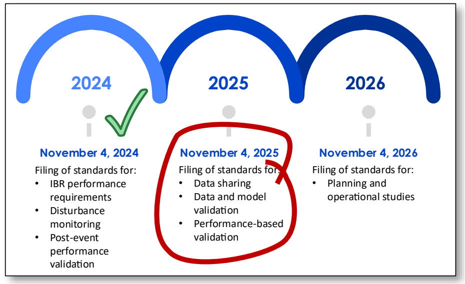
Application of IBR Standards – Collaborative Forum

PROGRAMs	40, 173, 206, 207, 221
TASK FORCE	MOD
COORDIN.	EDCS/GEN

Motivation

SPN #[3002032085](3002032085); 2025-2027; $75k (SDF-eligible)

New **IBR interconnection and reliability standards** apply to **plant owners/ developers** and will shape design and operation of IBR plants. Same standards are being adopted and enhanced by **transmission companies**. Increased **collaboration** between and within these groups could help **mitigate compliance risks and improve operational efficiency**.



Project Highlights

- Support ***interpretation*** of various IBR standards (***IEEE and NERC***) and ***provide conformity/compliance procedures***
- Provide generic IBR model parameters for existing grid-following (GFL) and advanced ***grid-forming (GFM)*** IBRs that conform with IEEE 2800, NERC Reliability Standards, etc.
- Provide application examples:
  - Use of ***conformity assessment tool***
  - ***Guidelines*** for ***utilization*** of IBR capabilities
- Provide ***thought leadership*** and ***facilitate development*** of IBR standards

Provide a collaborative forum, (via regular meetings), to exchange challenges and learnings, considering new and existing plants

Deliverables & Contact

- [Virtual Meetings, Trainings, Technology Transfer]
  - Regular collaboration meetings
  - Informational material: recordings/slides on IBR Stds
  - Development and revision of IBR Stds
- [Technical Updates] Various reports, including:
  - PDT and EMT model parameters
  - IBR plant performance verification procedures;
  - Guidelines to utilize/configure IBR capabilities;
  - Conformity assessment in interconnection process;

Contact

- Jens C. Boemer at 206.471.1180 jboemer@epri.com
- Curtiss Fox at 704.595.2391 cfox@epri.com

Related EPRI Work

PS173A ARP → Tool Delivery

IBR Forum → Application

(1) **IBR CA Module –** ***Inverter Based Resource Conformity Assessment Module***

v1.1 (2026) 3002034778

Need

- Ability to **assess performance of IBR plants** to **verify conformity** against any standards/grid codes that may be present and based on specified criteria.

Objective

- **Develop and deliver** an **IBR Conformity Assessment Module** that can be used to assess IBR plant response, either based on **verified plant-level models** or by use of **on-site disturbance monitoring** and field measurements.

Scope

- 1. Define **list of tests, measurements, and criteria** to be used to assess IBR plant performance and verify conformity.
  2. Develop **software modules** that can apply and carry out the conformity assessment in automated ways.
  3. Can use responses from **both generic and user defined IBR models** in **both time and frequency domain** simulations.
  4. Can use IBR measurements from on-site digital fault recording (**DFR**) and dynamic disturbance recording (**DDR**).

(2) *Application of IBR Standards* – ***Collaborative Forum***

More information at: 3002032085

Need

- New **IBR interconnection and reliability standards** apply to **plant owners/ developers** and will shape design and operation of IBR plants. Same standards are being adopted and enhanced by **transmission companies**.

Objective

- **Provide a collaborative forum** to exchange challenges and learnings, considering **new and existing plants.** Improve operational efficiency and **mitigate compliance risks.**

Scope

- 1. Support ***interpretation*** of various IBR standards (***IEEE and NERC***) and ***provide conformity/compliance procedures***
  2. Provide generic IBR model parameters for existing grid-following (GFL) and advanced ***grid-forming (GFM)*** IBRs that conform with IEEE 2800, NERC Reliability Standards, etc.
  3. Provide application examples:
     - Use of ***conformity assessment tool***
     - ***Guidelines*** for ***utilization*** of IBR capabilities
  4. Provide ***thought leadership*** and ***facilitate development*** of IBR standards

EPRI deliverable — Evolving Interconnection Standards for IBRs

Technical Brief [3002034224] (Program 173D members only)

- Updates on North American and international voluntary standards
- Summary of EPRI P173 Tech Transfer activities related to BPS-connected IBR standards

Table of Contents

EPRI

TECHNICAL BRIEF

Evolving Interconnection Standards for Inverter-Based Resources

Opportunities, Challenges, and Stakeholder Impacts

KEY POINTS

1. As of the end of 2025, more than 20 Independent and Transmission System Operators (ISOs/TSOs) and utilities have adopted large parts of IEEE Std 2800-2022, a voluntary interconnection standard for wind, solar, and storage plants connected to the bulk power system (BPS). Some of these entities have specified related IBR modeling guidelines to support verification of plant performance.
2. A forthcoming IEEE P2800.2 recommended practice will specify harmonized test and verification procedures for conformity assessment of IBR plants. Its comprehensive risk management framework for IBR interconnection is aligned with leading compliance requirements in countries with high penetrations of IBRs.
3. Development of a new IEEE P2800.1 recommended practice that specifies and harmonizes functional capabilities and performance of grid-forming (GFM) equipment begins in 2026. It will complement the plant-level IEEE 2800 standard which will be revised in parallel, based on industry lessons learned during its adoption.
4. The confluence of emerging voluntary standards and mandatory compliance for GFM IBRs in many countries may culminate in the development of a new International Electrotechnical Commission (IEC) Technical Specification that could create a framework for specification and testing of GFM equipment.
5. EPRI's IBR Identification and Conformity Assessment Tool can support a plant-level conformity assessment by evaluating the dynamic response of an IBR, obtained from model-based simulations or field measurement. The tool can also identify GFM properties based on lab measurements.

WHY AND HOW EPRI SUPPORTS STANDARDS DEVELOPMENT

1. **Transfer technology and knowledge effectively:** Voluntary industry standards play a crucial role in specifying and harmonizing technical requirements, procedures, and guidelines for the interconnection of inverter-based and distributed energy resources (IBRs and DERs). Leveraging EPRI research and development (R&D) to inform standards development is an impactful way to transfer technology and knowledge to the industry. .
2. **Support EPRI members in navigating the evolving IBR standards landscape:** Staying on top of IBR standards developments between day-to-day tasks can be a challenge and often requires an extraordinary amount of time and commitment. Summaries and analyses of emerging standards provide EPRI members perspective on how standards can impact or help with their professional responsibilities, including potential standards adoption.
3. **Inform planning and execution of EPRI R&D:** Observing, contributing to, and—at times—leading voluntary industry standards development helps EPRI align its annual and multi-year R&D cycle with emerging industry needs. As a result, EPRI's research can stay ahead of and inform emerging standards development.

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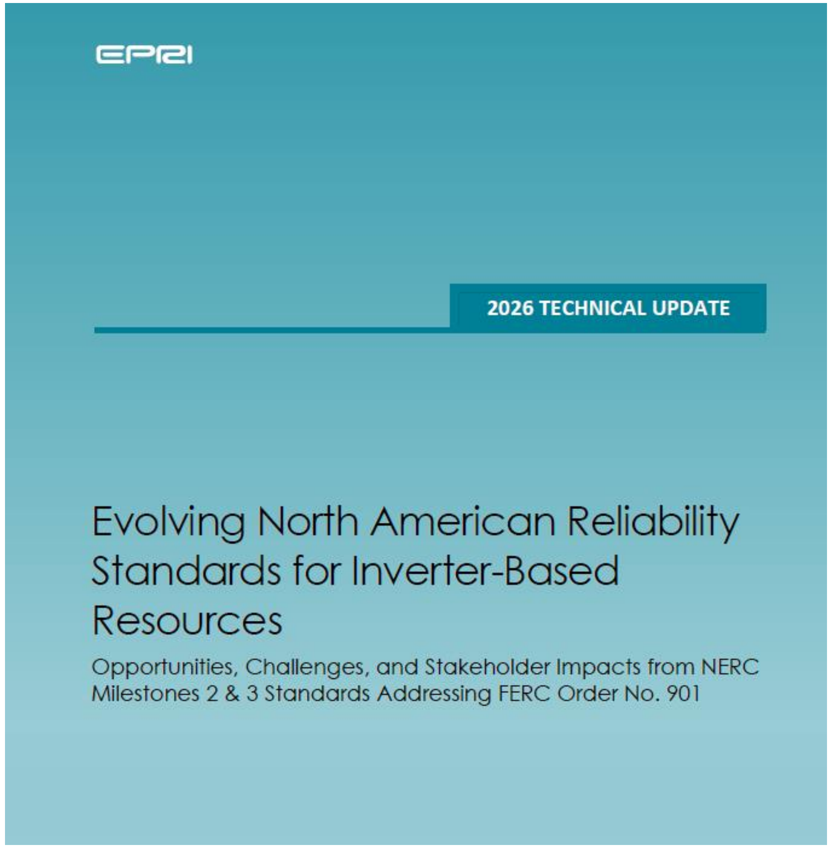
EPRI deliverable — Evolving North American Reliability Standards

CONTENTS

Technical Brief 3002033180

- Updates on North American Reliability Standards (NERC)
- **Review and updates on NERC Milestones 2 and 3**
- **Outlook to ongoing Milestone 4**



EPRI deliverable — Reliable Interconnection and Integration of IBRs

CONTENTS

Technical Brief 3002033675

- Provides an overview of the regulatory landscape for IBRs in the US for interconnection requirements and processes
- Explores interconnection modeling and studies as well as commissioning activities

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2026 TECHNICAL REPORT

Reliable Interconnection and Integration of Inverter-Based Resources into North American Bulk Power Systems

Status, Challenges, and Potential Solutions

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Solutions offered by EPRI for IBR Plant Conformity

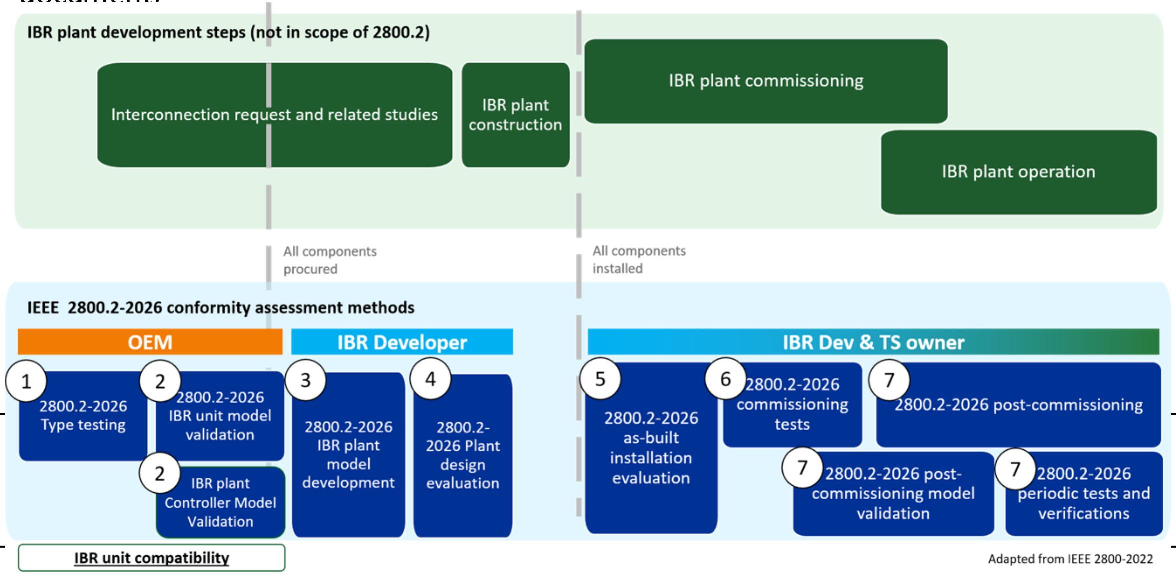
Risks for OEMs
- Non-standardized or special-purpose capability expectations
- Insufficient or unclear verification procedures
- Non-standardized or superfluous parts of IBR plant documentation (too much to create or document)
- Handling of prototypes

Risks for IBR owners
- Insufficient IBR plant design
- Insufficient IBR plant model
- Insufficient IBR plant documentation

Risks for IBR developers
- Insufficient or unclear TS owner requirements, mis-interpretations
- Procurement of equipment not compatible with requirements
- Insufficient or invalid OEM documentation or models
- Insufficient or invalid TS owner grid information or models
- Lose position in queue due to material modification
- Non-standardized or superfluous parts of IBR plant documentation (too much to create or document)

Risks for TS owners
- Insufficient IBR plant design
- Insufficient IBR plant model
- Insufficient IBR plant documentation
- Non-standardized or superfluous parts of IBR plant documentation (too much to process or analyze)

Risks for IBR operators
- Insufficient IBR plant design—utilization
- Insufficient IBR plant model
- Insufficient IBR plant documentation



Offerings for OEMs
- IBR-ID Tool
- IBR-CA Module
- IBR Forum
- Tech updates on mandatory and voluntary standards
- Interpretations

Offerings for IBR developers
- IBR-ID Tool
- IBR-CA Module
- IBR Forum
- Tech updates on mandatory and voluntary standards
- Interpretations

Offerings for TS owners
- IBR-ID Tool
- IBR-CA Module
- IBR Forum
- Interpretations
- Tech updates on mandatory and voluntary standards

Offerings for IBR Operators
- IBR Forum
- Tech updates on mandatory and voluntary standards

Slido Questions and Discussion

Click here to return to
Welcome and Agenda

Slido for Q&A on Today's Webinar

Use the Slido to share your questions with EPRI.

Open through July 10th.

Please use the Slido instead of the Webex chat.

https://app.sli.do/event/qD3UFvQK1xqaLfCGXBH18K

or go to slido.com and enter code: **EPRI-VFTT**

Summary of Slido Q&A

Q&A word cloud

slido

Summary of Slido Q&A

1. *As a project developer, which standards are most important for me to know about?*
   - For NERC standards, refer to the NERC IBR Strategy
   - For IEEE standards, that could be IEEE 2800-2022 and IEEE 2800.2-2026 for all **IBR plants** for now, and IEEE P2800.1 for **GFM IBR units** in the future.
   - For more information about ongoing revision of IEEE 2800 and development of P2800.1, refer to this website.

2. *Conformity with the IEEE 2800 standard may not be sufficient for meeting utility- and site-specific interconnection and performance requirements all cases. How do the IBR standards developed by NERC in response to FERC 901 fill potential gaps?*
   - FERC O901 mandated NERC to revise their reliability standards to address reliability concerns related to IBRs. As such, NERC created new (e.g., PRC-029) and modified existing standards (e.g., MOD-026) that are mandatory to entities specified in each standard.
   - Voluntary standards like IEEE 2800/.2 with its in-depth verification procedures can provide guidance on *how* to achieve compliance of NERC standards.

Summary of Slido Q&A

3. *What should be considered when IBRs have a large computational load in same facility?*
   - This may be addressed in the ongoing revision of IEEE 2800-2022.
   - There is also a new series of IEEE standards for interconnection of data centers, IEEE 4200/.x series of standards (e.g., P4200). The requirements and conformity assessment framework of those could be aligned with IEEE 2800 for co-located facilities.
   - NERC Project 2026-02 Computational Loads is developing mandatory standards.

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Thank You!

Please reach out to us with specific questions or if you wish to discuss how we can provide further support…