



Inverter-Based Resource Modeling Requirements (PAC-2024-2)

Interconnection Process Working Group (IPWG)

June 3, 2025

Purpose & Key Takeaways



Purpose: Propose Inverter-Based Resource (IBR) modeling requirements and request stakeholder feedback

Key Takeaways:

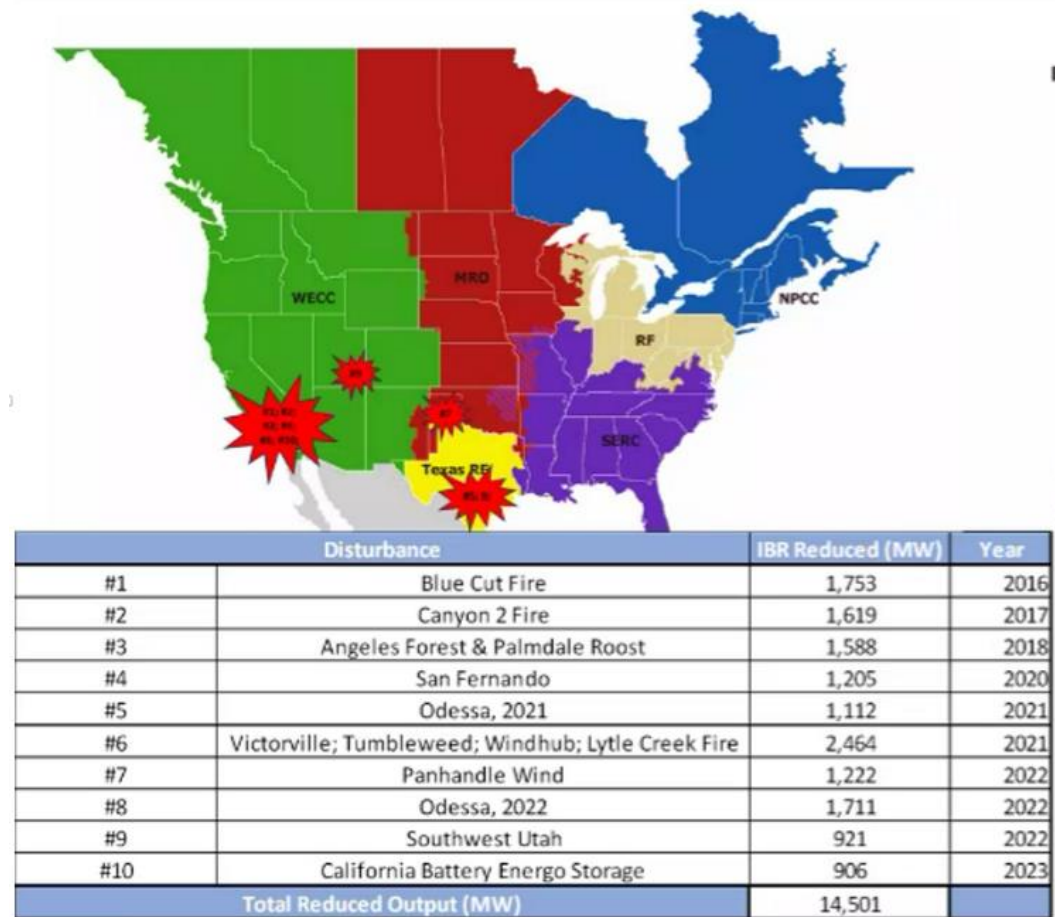
- FERC, NERC, and MISO have each published materials either directing or recommending efforts to address model quality issues affecting reliability
- MISO proposes requirements and a process to test and benchmark dynamics models used in the interconnection process (to become a new BPM-015 Appendix)
- Stakeholder feedback is requested on the proposed requirements MISO posted with today's meeting materials

MISO is seeking input from stakeholders to define IBR modeling requirements, with the goal of finalizing requirements by November 2025

		Date	Objective
IPWVG	{	June 3	Describe need and proposed requirements [Feedback] (30-45 min)
		July 22	Share revised requirements and proposed implementation plan [Feedback]
		September 3	Slippage (post only or present final proposal to go to PAC)
PAC	{	October 8	Present requirements and implementation plan [Feedback]
		November 19	Respond to stakeholder feedback

Reliability events point to modeling deficiencies that require industry attention

- NERC has analyzed 10 large-scale disturbances on the bulk power system (BPS) that involved the widespread and unexpected reduction in output of inverter-based resources (IBR) since 2016
- These 10 disturbances totaled nearly 15,000 MW of unexpected IBR output reduction with approximately 10,000 MW occurring between 2020 and 2024
- The increase of IBR-related events coincides with an increase in IBR penetration across the BPS
- **Two contributing causes to these events are poor modeling and study practices to assess the performance of these resources**



- NERC Industry Recommendation on IBR Quality Deficiencies. Initial distribution: June 4, 2024 [1].

[1] <https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC%20Alert%20Level%20%20-%20Inverter-Based%20Resource%20Model%20Quality%20Deficiencies.pdf>

FERC and NERC is placing increasing focus on the need for accurate models

- FERC order 2023 requires three model types be submitted- UDM, EMT, Standard Library (WECC)
 - "...sufficiently accurate and validated..."
- FERC Order 901 directs NERC to develop new or modified standards that require owners and/or operators to provide accurate data related to facility performance when connected to the BPS. FERC noted that such data is necessary to apply accurate system models so interconnecting utilities can successfully plan, operate and analyze performance of IBRs.
- NERC SAR to revise FAC-001 and FAC-002
 - "Lack of adequate benchmarking of models (e.g. positive sequence phasor domain (PSPD) and electromagnetic transient (EMT) models) against each other and real product performance."
- NERC Level 3 Alert on 5/20/2025 for IBR Performance and Modeling
 - Essential Action #2- Model quality and accuracy; performance tests and conformity

MISO's Reliability Attributes work identified IBR modeling improvements as a needed capability to perform the necessary stability analysis



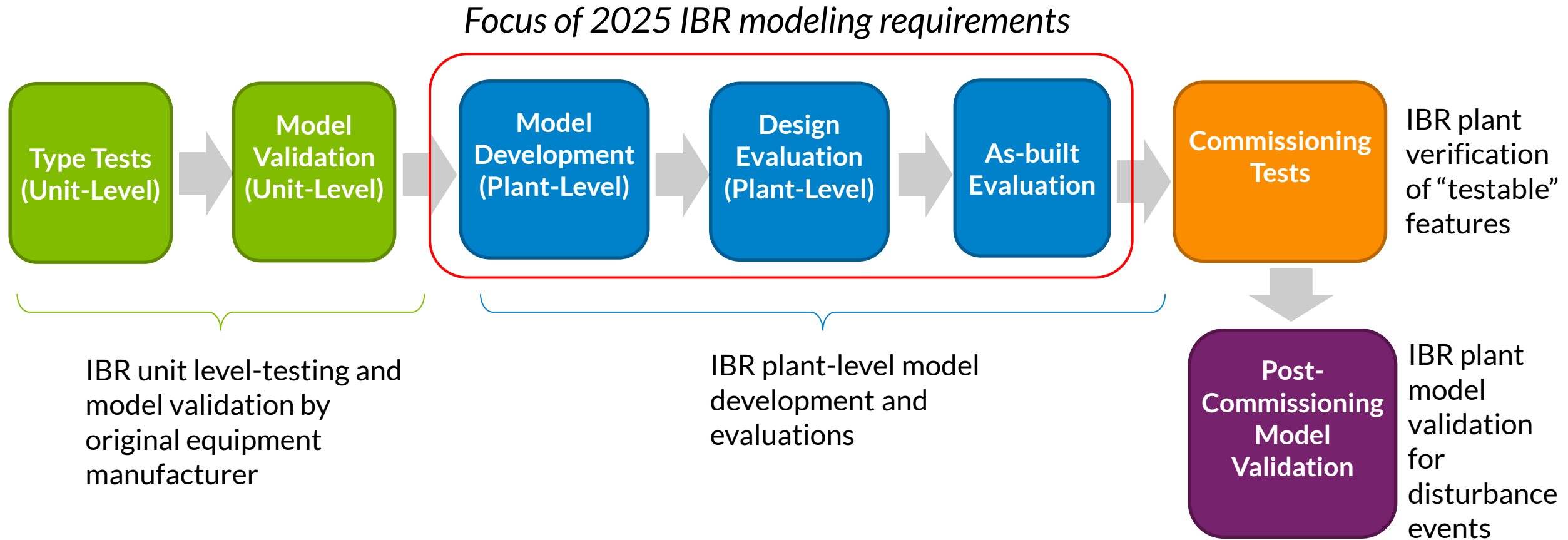
Highlights

- The evolving energy landscape requires MISO and the industry to understand the increasing complexity of the transitioning system and proactively adapt to increasing risk and changing system conditions
- MISO's 2023 analysis highlights the need for market reforms and new requirements to ensure the sufficiency of three priority attributes where near-term risk is most acute: system adequacy, flexibility, and system stability
- The Attribute Roadmap recommends advancing a combination of current and new proposals as well as providing ongoing attributes visibility through regular reporting



- The voltage stability assessment recommended MISO “**ensure appropriate model quality review procedures and tools are in place**”
- Accurate, usable models are a pre-requisite for risk assessments related to IBR dynamic responses

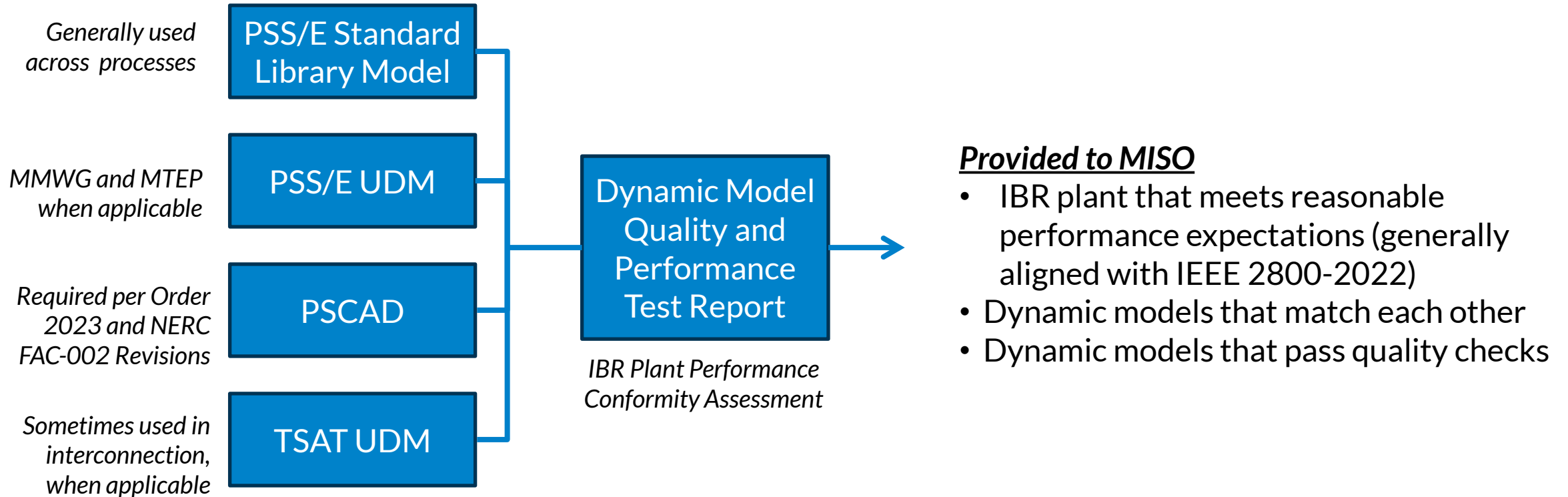
The scope of proposed modeling requirements focus on plant-level dynamic responses during the interconnection study phase



The conformance assessment process is under development in standard working group IEEE P2800.2. Additional considerations are included such as post-commissioning monitoring, and periodic tests and verifications

To meet evolving reliability needs, MISO proposes requiring a “modeling package” upon interconnection request

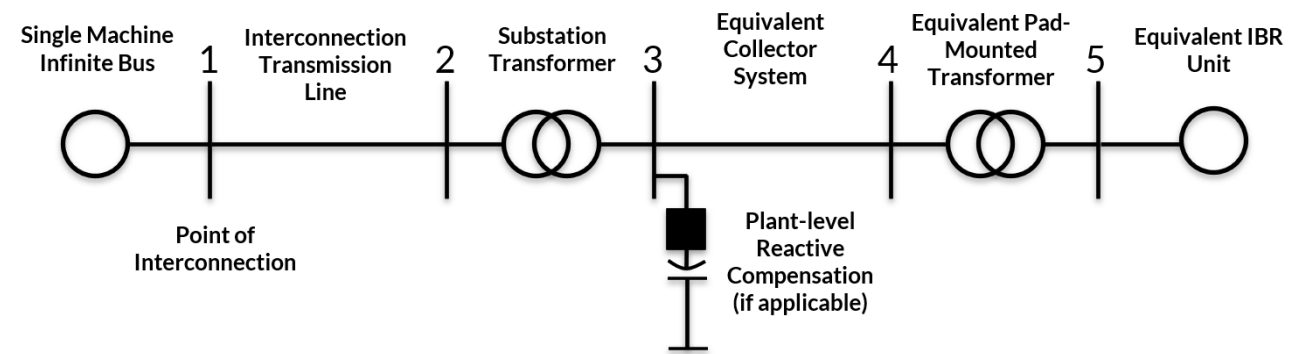
MISO is not proposing a change to model usage.



FERC Order 2023 requires three model types: a standard library model, UDM, and EMT model.

Model requirements contain general provisions related to usability, model topology, and file packaging

- General Requirements for all models
- Requirements for Standard Library Models
- Requirements for PSS[®]E UDMs
- Requirements for TSAT[™] UDMs
- Requirements for PSCAD[™] Models



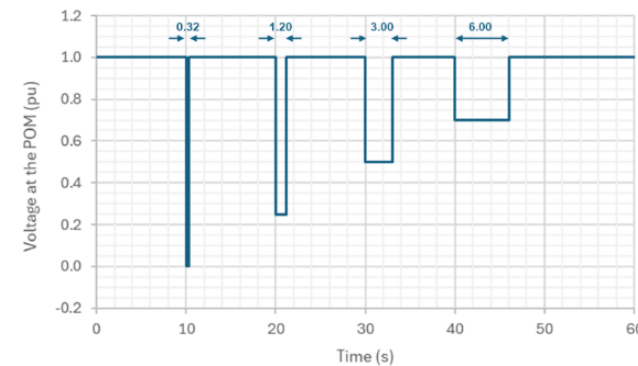
MISO proposes a set of tests intended to evaluate the dynamic performance related to known deficiencies and risks

5.1.6 Low-Voltage Ride-Through (LVRT) Tests

- Initialization
- Balanced Fault Ride-Through
- Small Voltage Disturbance
- Small Frequency Disturbance
- High Voltage Ride-Through
- Low Voltage Ride-Through
- High Frequency Ride-Through
- Low Frequency Ride-Through
- Protection Verification
- Short Circuit Ratio (SCR)

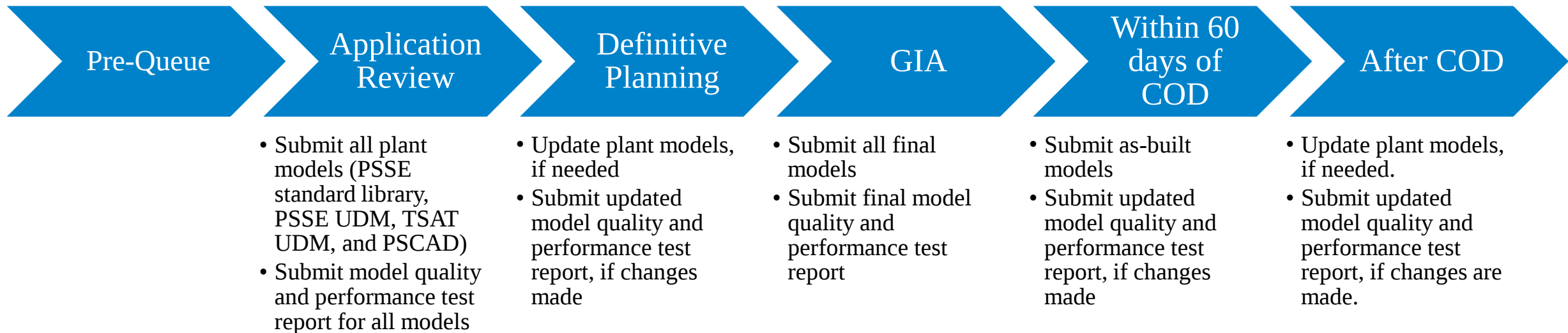
Test No.	Disturbance	IBR Plant Initial Condition			Grid Initial Condition		Pass/Fail
		Active Power at the POM	Reactive Power at the POM	Voltage at the POM (pu)	Infinite Bus Voltage	SCR	
5.1.6-1	Low voltage	Pmax	Qmax	Figure 6	N/A	N/A	

Time Duration (s)	Voltage Level at the POM (pu)
0.32	0.00
1.20	0.25
3.00	0.50
6.00	0.70



The proposed requirements include model documentation, attestations, and a test report

MISO posted the proposed modeling requirements along with the [June 3 IPWG Meeting Materials](#) and is requesting stakeholder feedback.



- Model test need to be updated at each stage when the plant controls or equipment change.
- MISO understands MOD-026 and MOD-27 are being revised and affect the “after COD” model verification and validation.

Stakeholder Feedback Request

- MISO is requesting feedback on the **Recommended IBR Modeling Requirements (PAC-2024-2)** by June 17, 2025
 - Please provide feedback on the proposed BPM-015 Appendix
 - technical aspects of modeling requirements, including proposed tests
 - proposed process elements for enacting IBR modeling requirements
- Feedback requests and responses are managed through the Feedback Tool on the MISO website:
<https://www.misoenergy.org/engage/stakeholder-feedback/>



Questions?

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Appendix

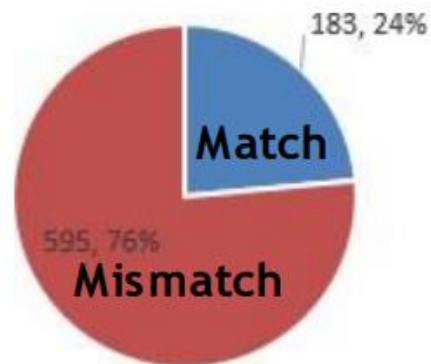
Links to previous 2024 MISO presentations:

- [20240130 IPWG Item 04 IBR Performance Requirements](#)
- [20240312 IPWG Item 04c IBR Performance Requirements IEEE 2800 \(PAC-2024-2\)](#)
- [20240502 IPWG Item 04a IBR Performance Requirements IEEE 2800 \(PAC-2024-2\)](#)

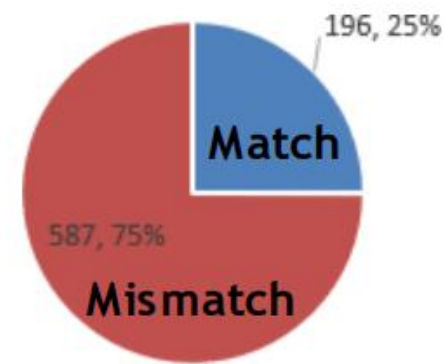
NERC surveys of GO-reported data indicate that IBR plants are not configured to ride-through disturbances as required

GOs: Models Reflecting Reported Controls and Parameters – Voltage Ride Through Control

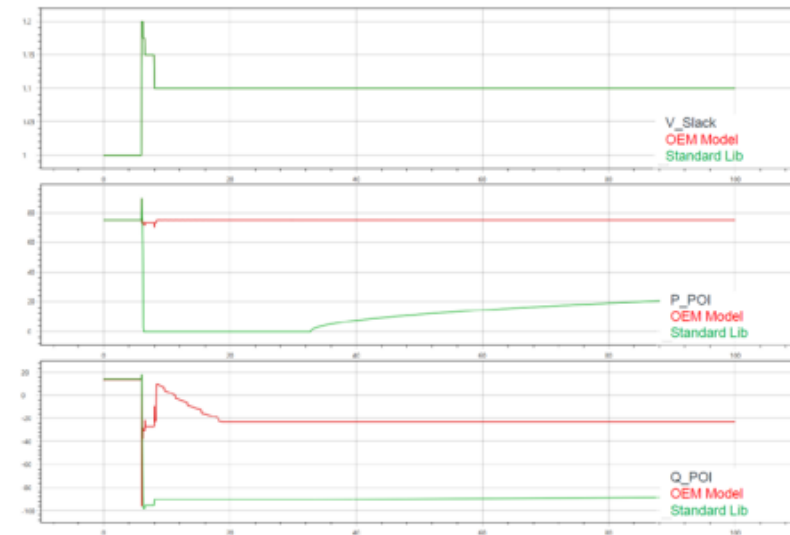
LV Threshold Setting



HV Threshold Setting

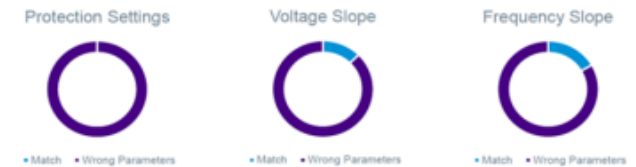
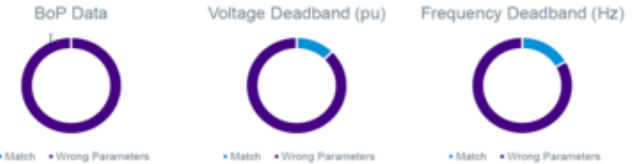


- 15,000 MW of unexpected reduction in IBR resources since 2016
 - Approximately 10,000 MW of unexpected reduction since 2020
 - Analysis of the models of affected facilities revealed systemic model inaccuracies
- Real world case study from a Major Manufacturer also showed systemic model inaccuracies



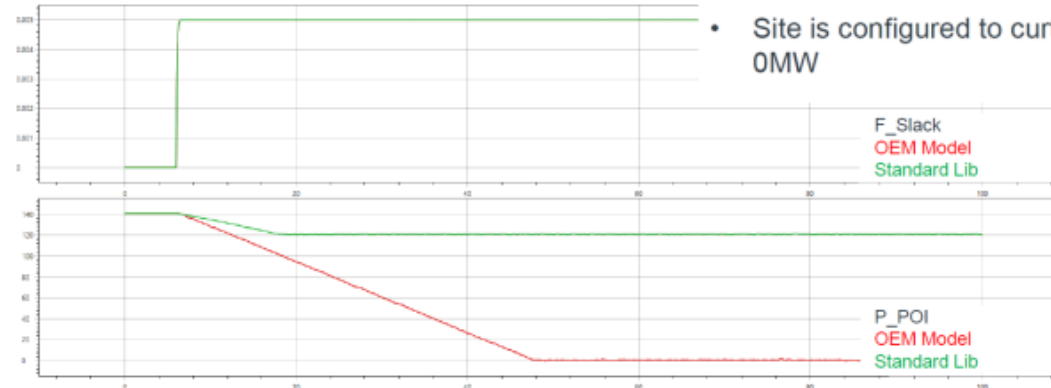
Notes:

- HVRT
- Plant curtailed
- P Response unstable and numerical not working in PSSE
- Q response not matching site response and recovery state



Notes:

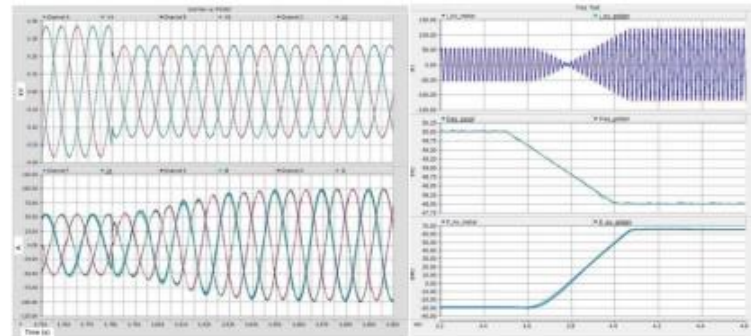
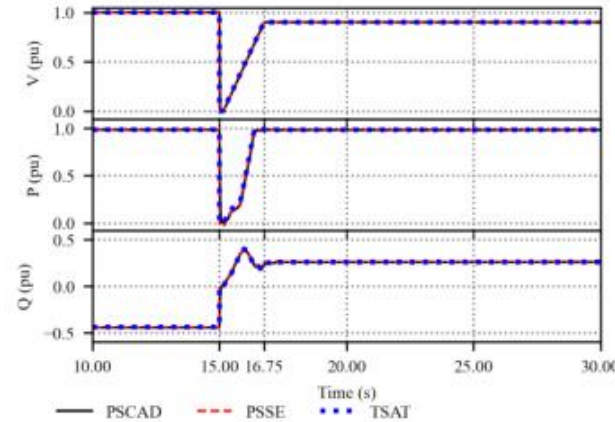
- Frequency step-up 0.005pu
- Plant curtailed to 140MW
- Site is configured to curtail to 0MW



Source: Thomas Grau – Director, Vestas – February 2024 IRPS Meeting

RELIABILITY | RESILIENCE | SECURITY

- All models should be:
 - Detailed and accurate representations of expected or as-built facilities
- Positive sequence library models, positive sequence user-defined models (UDMs), and electromagnetic transient (EMT) models should be:
 - Verified by the equipment manufacturer to be accurately parameterized to represent site-specific (or to-be installed) controls, settings, and protections
 - Validated against actual product performance and benchmarked against each other



FERC Order 2023 – Modeling Directives

iii. Commission Determination

1659. We adopt the NOPR proposal to revise Attachment A to Appendix 1 of the *pro forma* LGIP and Attachment 2 of the *pro forma* SGIP to require each interconnection customer requesting to interconnect a non-synchronous generating facility to submit to the transmission provider: (1) a validated user-defined RMS positive sequence dynamic model; (2) an appropriately parameterized generic library RMS positive sequence dynamic model, including a model block diagram of the inverter control system and plant control system, that corresponds to a model listed in a new table of acceptable models or a model otherwise approved by WECC; and (3) a validated EMT model, if the transmission provider performs an EMT study as part of the interconnection study process.

Three model types required:

1. UDM phasor domain
2. Generic phasor domain
3. EMT

<https://www.ferc.gov/media/order-no-2023>

Many of the proposed tests are tied to areas of IEEE 2800 MISO adopted in Tariff

Category	Performance Capability	Priority
General	Measurement accuracy	Highest
	Range of Available Settings	Lower
	Prioritization of Functions	
	Ramping for control parameter change	
Monitoring, Control, and Scheduling	Responding to external control inputs	Lower
	Remote Configurability	
Voltage Support	Reactive capability at Zero Active Power	Medium
	Constant Reactive Power	
	Current injection during voltage ride-through	
Dynamic Responses and Reliability Services	Frequency Ride-Through	Highest
	ROCOF Ride-Through	
	Voltage Ride-Through	
	Transient Overvoltage Ride-Through	
	Return-to-Service (Enter Service)	
	Restore Output After Voltage Ride-Through	
	Voltage Phase Angle Jump Ride-Through	
	Consecutive Voltage Deviation Ride-Through	Medium
	Underfrequency Fast Frequency Response	
	Overfrequency Fast Frequency Response	
	Primary Frequency Response	

* Test included; analysis not explicitly defined.

* N/A for dynamic modeling

Striking a Balance in Model Requirements Testing



No modeling requirements and testing

- No model quality checks or performance conformity testing
- Easy and streamlined
- Highest reliability risk

2019-2022 Initiatives	Initiated by Assembly G in the 2019-2021 term	Initiated by Assembly G in the 2022-2024 term	Exception
A.1. Innovation			
A.1.1. Enhance level of Accessibility			
A.1.2. Apply Accessibility and Inclusion	x		
B. Economic Development			
B.1. Enhance Economic and Environmental Capacity			
B.1.1. General Economic			
B.1.2. Hospitality and HR Services			
B.1.3. Marketing Services			
B.1.4. Healthcare/Investigation of IT			
B.1.5. Creative Sector			
B.1.6. Innovation, Incubation			
B.1.7. Innovation with 7th Learning			
B.1.8. Support Program (Capital)		x	
B.1.9. Support Program (Capital)		x	
B.1.10. Support Program (Capital)		x	
B.1.11. Support Program (Capital)		x	
B.1.12. Support Program (Capital)		x	
B.1.13. Support Program (Capital)		x	
B.1.14. Support Program (Capital)		x	
B.1.15. Support Program (Capital)		x	
B.1.16. Support Program (Capital)		x	
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B.1.19. Support Program (Capital)		x	
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B.1.98. Support Program (Capital)		x	
B.1.99. Support Program (Capital)		x	
B.1.100. Support Program (Capital)		x	

Exhaustive modeling requirements and testing

- Test all applicable IEEE 2800 clauses (>70 tests)
- Lots of work on IC and MISO (slows/burdens process)
- Lowest reliability risk



Recommendation: Subset of tests that are most relevant and useful

Different models are used by different processes at MISO, the reason for requiring four model types

Type	Use	MISO Model Owner
PSS/E UDM ¹	MMWG interconnection-wide model	Modeling
	MTEP	Modeling
TSAT UDM ¹	DPP	Generator Interconnection
PSS/E Standard Library Model	DPP	Generator Interconnection
	MTEP	Modeling
	Online stability analysis (DSAS)	Forward Reliability Engineering Services
	MMWG interconnection-wide model	Modeling

[1] For resource models, MISO currently only uses one OEM UDM. UDMs are also used to represent VSCs associated with HVDC lines. FERC Order 2023 will require submission of UDM for all generator interconnection requests.