Inverter-Based Resource Performance Requirements

Interconnection Process Working Group (IPWG)
January 31, 2023
Purpose: Frame discussion on opportunities to standardize inverter-based resource (IBR) performance based on IEEE 2800-2022

Key Takeaways:

• MISO has an imperative to get ahead of potential IBR performance issues observed in NERC disturbance reports

• As MISO resource mix incorporates more IBRs, reliability attributes are ensured via standardized performance

• MISO plans to discuss implementation of performance requirements based on IEEE 2800-2022 as soon as March
## 2023 IPWG schedule: Considering IEEE 2800 Inverter Based Resources Performance Requirements

<table>
<thead>
<tr>
<th>Date</th>
<th>Objective</th>
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<tbody>
<tr>
<td>January 31</td>
<td>Inform and educate on need for action</td>
</tr>
<tr>
<td>March 14</td>
<td>Propose performance requirements prioritization [Feedback]</td>
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<tr>
<td>May 2</td>
<td>Review feedback and share implementation plan</td>
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<tr>
<td>June 20</td>
<td>Propose Tariff redlines and/or BPM changes [Feedback]</td>
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<tr>
<td>August 8</td>
<td>Post feedback responses and share final Tariff and BPM language [Post only]</td>
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**Inverter-Based Resource (IBR):** Any source of electric power that is connected to the transmission system (TS) via a power electronic interface, and that consists of one or more IBR unit(s) capable of exporting active power from a primary energy source or energy storage system to a TS.¹

**Inverter:** A power electronic unit that changes direct-current power to alternating-current power.¹²

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¹ IEEE 2800-2022, IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems

Note: The IEEE 2800-2022 “Inverter” definition references the IEEE 1547-2018 definition
Today MISO will share how implementing certain IEEE 2800 performance specifications supports IBR integration

1. The industry has experienced significant **reliability events**, which MISO is learning from and may be able to avoid replicating given low levels of IBRs and an understanding of potential performance issues

2. MISO’s identified system reliability **attributes** can in part be addressed IBRs performance requirements

3. MISO compared **current generator interconnection requirements** against Standard IEEE 2800 seeking **opportunities to incorporate beneficial performance requirements**
NERC is sounding the alarm on need for “Immediate Industry Action on Inverter-Based Resources”

- NERC reports on IBR tripping events illustrate growing impacts and a need to improve IBR performance requirements
- FERC’s November 2022, IBR Notice of Proposed Rulemaking\(^1\) included directives on the same underlying performance issues

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\(^1\) Federal Energy Regulatory Commission, Docket No. RM22-12-0000. Reliability Standards to Address Inverter-Based Resources. Issued November 17, 2022
MISO’s 2022 generator interconnection queue submissions set new records, with IBR making up the vast majority of proposed resources.

Around 96% of capacity is likely inverter-based.
MISO recently initiated an investigation into needed system attributes and how the continued resource transition could alter attribute availability in the coming years.

**ISSUE**

The resource transition continues to accelerate in the MISO region, creating new risks to reliability and market efficiency.

**IMPLICATIONS**

New resources do not have the same characteristics as those they are replacing, leading to the potential scarcity of attributes needed to operate the system.

**HYPOTHESIS**

We need to understand attributes necessary to provide ongoing system reliability and identify/implement methodologies (e.g., visibility, requirements, or market products) that will ensure those attributes are available.

MISO’s initial focus is on understanding the timing and scale of needed reliability attributes along with the risks posed, should certain attributes become scarce.

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<tr>
<th>Initial Analysis Scope</th>
<th>Attribute Identification &amp; Prioritization</th>
<th>Qualitative Attribute Scarcity Analysis</th>
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<td><strong>Reliability</strong></td>
<td>Define attributes via expert interviews, white papers, MISO experience</td>
<td>Timing</td>
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<tr>
<td>Affordability</td>
<td>Prioritize attributes via scarcity analysis</td>
<td>Probability</td>
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<tr>
<td>Sustainability</td>
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<td>Size</td>
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<td>Impact</td>
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While energy and capacity are given significant attention, many critical attributes are required for reliable operations

- Availability
- Fuel assurance
- Long duration energy at high output
- Ramp up capability
- Ramp down capability
- Short minimum down time
- Short minimum run time
- Rapid start-up
- Voltage stability
- Small signal stability
- Voltage control
- Black start
- Detection of short circuit fault
- Regulation
- Contingency reserve

Illustrative list of potential system reliability attributes
The IBR Standard IEEE 2800, published April 2022, offers new standardized capability and performance requirements

- **Minimum technical capability** requirements are defined in the standard
- **Utilization** of defined IEEE 2800 capabilities is left to the Transmission System Owner in the standard
- Additional or modified requirements can be included by the Transmission System Owner

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<th>Tests and Verification</th>
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<td>Control prioritization</td>
<td>Fast frequency response</td>
<td>Plant-level evaluation and modeling</td>
<td>High fidelity performance monitoring</td>
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<tr>
<td>Control responses</td>
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<td>Commissioning tests</td>
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<td>Applicability</td>
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<td>Type tests</td>
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<tr>
<th>Power Quality</th>
<th>Reactive Power – Voltage Control</th>
<th>Tests and Verification</th>
<th>Modeling, Validation, Measurement Data, and Performance Monitoring</th>
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<tr>
<td>Harmonic voltage limits</td>
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<td>Process and criteria for model validation</td>
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<tr>
<td>Harmonic current limits</td>
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<td>Transient overvoltage limits</td>
<td>Reactive power functions</td>
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<td>Validated models</td>
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<td>Rapid voltage change</td>
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<td>Flicker limitations</td>
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**Note:** Grey text indicates significant exceptions or caveats
MISO kicked off an IEEE 2800 adoption effort in support of the Reliability Imperative and evolving system attribute needs

**Objective:** Leverage recent industry developments surrounding IBR performance needs and capabilities, namely the publication of IEEE 2800-2022, with an aim to mitigate undesirable reliability events outlined in recent NERC disturbance reports and to position MISO for beneficial use of other IBR attributes (e.g., fast frequency response)

- By defining standard minimum performance requirements, MISO benefits from industry standardization and lessons learned in other jurisdictions
- Most performance issues identified by recent NERC disturbance reports could be remedied by IEEE 2800 compliance
MISO performed outreach to peers and industry experts to capture a wide range of perspectives

**Peer ISOs/RTOs**
- Experienced significant IBR reliability events starting ~5 years ago with larger events serving as “wake up call”
- IEEE 2800 covers capabilities to address IBR reliability issues but is ineffective without enforceable compliance steps
- IEEE 2800 can drive consistent plant performance and simplify some technical challenges
- Clause-by-clause adoption or recreation of standard concepts in requirements
- May go above and beyond IEEE 2800 requirements for some functions (e.g., phase angle jump)

**Transmission Owners**
- Adopting parts of IEEE 2800 through Local Planning Criteria updates (e.g., dynamic active and reactive power responses)
- Some TOs’ 2800 adoption is coupled with EMT modeling requirements with model verification being a major component of the effort

**Standards Organizations**
- While a wholesale NERC adoption of IEEE 2800 is not anticipated, ISO/RTO and TO adoption is highly encouraged based on needs outlined in NERC Disturbance Reports and Reliability Guidelines¹
- Standard compliance along with model verification and validation are most pressing future issues

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In the past, MISO has updated interconnection requirements as industry best practices emerge

In 2020, prompted by new NERC Guidelines, MISO updated generator requirements:

• **Momentary cessation** prohibited
• **Phase jump** immunity introduced
• **Monitoring** and recording events to 1 ms resolution
• **Rate of change of frequency** protection prohibited except for equipment protection
The team has followed a gaps analysis approach to focus potential recommendations

Step 1

IEEE 2800 Requirement (“Shall”) Compared against MISO Tariff / GIA

Determination:
• Gap
• No Gap

Step 2

Recommend implementation priority and timing for gaps, based on factors that may include:
• MISO reliability need
• Stakeholder perspectives
• OEM readiness
• Test and verification feasibility
• Tariff implications

MISO’s approach was inspired by similar work from EPRI and ERCOT¹

Preliminary potential opportunities to refine interconnection requirements were identified for further investigation and stakeholder discussion

- Range of available settings
- Measurement accuracy
- Prioritization of functions
- Ramping for control parameter change
- Responding to external control inputs
- Voltage control - specific control parameters and remote control
- Constant reactive power
- Reactive power capability at zero active power
- Current injection through voltage ride-through – balanced and unbalanced
- ROCOF ride-through
- Transient overvoltage ride-through
- Consecutive voltage deviation ride-through
- Restore output after voltage ride-through
- Fast frequency response – over frequency and under frequency
- Remote configurability

Note: MISO gaps/opportunities vary in nature from unspecified capabilities to refinements in already required capabilities or functional performance settings

: Indicates a gap identified by peer ISO/RTO. MISO’s view of peer gaps is non-exhaustive.
At the next IPWG meeting, MISO will propose prioritization and timing of the performance requirements

- MISO will share information on several reliability perspectives used for prioritization
- MISO anticipates Tariff redlines to the Generator Interconnection Agreement may be needed
- Proposed implementation will draw on concepts and parameters from IEEE 2800-2022
- MISO recognizes that additional work is needed after finalizing requirements to validate resource performance
Questions?

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Additional Resources


IEEE 2800-2022, IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems

Available for purchase at: https://standards.ieee.org/ieee/2800/10453/

Joint NERC-NATF-NAGF-EPRI Webinar for Transmission Owners, Planners, Operators, and Engineers.


Webinar: https://www.epri.com/research/programs/067417/events/621D26F1-00A5-4F90-8AA8-C68959393DBC