DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

18 CFR Part 40

[Docket No. RM22–12–000; Order No. 901]

Reliability Standards To Address Inverter-Based Resources

AGENCY: Federal Energy Regulatory Commission, Department of Energy.

ACTION: Final action.

SUMMARY: The Federal Energy Regulatory Commission (Commission) is directing the North American Electric Reliability Corporation (NERC), the Commission-certified Electric Reliability Organization, to develop new or modified Reliability Standards that address reliability gaps related to inverter-based resources in the following areas: data sharing; model validation; planning and operational studies; and performance requirements. The Commission is also directing NERC to submit to the Commission an informational filing within 90 days of the issuance of this final action that includes a detailed, comprehensive standards development plan providing that all new or modified Reliability Standards necessary to address the inverter-based resource-related reliability gaps identified in this final action be submitted to the Commission by November 4, 2026.

DATES: This rule is effective December 29, 2023.

FOR FURTHER INFORMATION CONTACT:

Eugene Blick (Technical Information), Office of Electric Reliability, Federal Energy Regulatory Commission, 888 First Street NE, Washington, DC 20426, (202) 502–8803, *Eugene.Blick@ferc.gov*.

Felicia West (Legal Information), Office of the General Counsel, Federal Energy Regulatory Commission, 888 First Street NE, Washington, DC 20426, (202) 502–8948, *Felicia.West@ferc.gov*.

SUPPLEMENTARY INFORMATION:

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I. Introduction

1. Pursuant to section 215(d)(5) of the Federal Power Act (FPA),[1] the Federal Energy Regulatory Commission (Commission) directs the North American Electric Reliability Corporation (NERC), the Commission-certified Electric Reliability Organization (ERO), to submit new or modified Reliability Standards [2] that address specific matters pertaining to the impacts of inverter-based resources (IBR) [3] on the reliable operation [4] of the Bulk-Power System.[5] As proposed in the notice of proposed rulemaking (NOPR), we direct NERC to develop new or modified Reliability Standards addressing reliability gaps pertaining to IBRs in four areas: (1) data sharing; (2) model validation; (3) planning and operational studies; and (4) performance requirements.[6] NERC may propose to develop new or modified Reliability Standards that address our concerns in an equally efficient and effective manner; however, NERC's proposal should explain how the new or modified Reliability Standards address the Commission's concerns discussed in this final action.[7]

2. We take this action in light of the rapid change in the mix of generation resources [8] connecting to the Bulk-Power System, including the addition of an ''unprecedented proportion of nonsynchronous resources'' [9] projected to connect over the next decade, including many generation resources that employ inverters, rectifiers, and converters [10] to provide energy to the Bulk-Power System. According to NERC, the rapid integration of IBRs is ''the most significant driver of grid transformation'' on the Bulk-Power System.[11]

3. The Reliability Standards, first approved by the Commission in 2007, were developed to apply to the types of generation resources prevalent at that time—nearly exclusively synchronous generation resources—to ensure the reliable operation of the Bulk-Power System. As a result, the Reliability Standards may not account for the material technological differences between the response of synchronous generation resources and the response of IBRs to the same disturbances on the Bulk-Power System.[12]

4. We also take this action because, as discussed in more detail in section III below, we find that the currently effective Reliability Standards do not ensure that Bulk-Power System planners and operators [13] have the necessary tools to plan for and reliably integrate IBRs into the Bulk-Power System or to plan for IBRs connected to the distribution system that in the aggregate have a material impact on the Bulk-Power System (IBR–DER). IBRs, individually and in the aggregate, and IBR–DERs in the aggregate can have a material impact on the reliable operation of the Bulk-Power System.[14] Additionally, the Reliability Standards do not contain performance requirements that are unique to IBRs and are necessary to ensure that IBRs operate in a predictable and reliable manner.

5. As discussed in greater detail below, we therefore direct NERC, pursuant to section 215(d)(5) of the FPA and § 39.5(f) of the Commission's regulations, to develop new or modified Reliability Standards that address the following specific issues:

- *IBR Data Sharing:* The Reliability Standards must require that generator owners, transmission owners, and

[1] 16 U.S.C. 824o(d)(5) (the Commission may order the Electric Reliability Organization (ERO) to submit to the Commission a proposed Reliability Standard or a modification to a Reliability Standard that addresses a specific matter if the Commission considers such a new or modified Reliability Standard appropriate to carry out FPA section 215).

[2] The FPA defines Reliability Standard as requirements for the operation of existing Bulk-Power System facilities, including cybersecurity protection, and the design of planned additions or modifications to such facilities to the extent necessary to provide for reliable operation of the Bulk-Power System, but the term does not include any requirement to enlarge such facilities or to construct new transmission capacity or generation capacity. *Id.* 824o(a)(3); *see also* 18 CFR 39.1.

[3] This final action uses the term IBR generally to include all generation resources that connect to the electric power system using power electronic devices that change direct current (DC) power produced by a resource to alternating current (AC) power compatible with distribution and transmission grids. IBRs may refer to solar photovoltaic (PV), wind, fuel cell, and battery storage resources.

[4] The FPA defines reliable operation as operating the elements of the Bulk-Power System within equipment and electric system thermal, voltage, and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements. 16 U.S.C. 824o(a)(4); *see also* 18 CFR 39.1.

[5] The Bulk-Power System is defined in the FPA as facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof), and electric energy from generating facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. 16 U.S.C. 824o(a)(1); *see also* 18 CFR 39.1.

[6] *Reliability Standards to Address Inverter-based Res.,* Notice of Proposed Rulemaking, 87 FR 74541 (Dec. 6, 2022), 181 FERC ¶ 61,125, at P 1 (2022) (NOPR).

[7] *See, e.g., Mandatory Reliability Standards for the Bulk-Power Sys.,* Order No. 693, 72 FR 16416 (Apr. 4, 2007), 118 FERC ¶ 61,218, at PP 186, 297, *order on reh'g,* Order No. 693–A, 72 FR 40717 (July 25, 2007), 120 FERC ¶ 61,053 (2007) (''[W]here the Final Rule identifies a concern and offers a specific approach to address the concern, we will consider an equivalent alternative approach provided that the ERO demonstrates that the alternative will address the Commission's underlying concern or goal as efficiently and effectively as the Commission's proposal.'').

[8] The Reliability Standards use both terms ''generation resources'' and ''generation facilities'' to define sources of electric power on the transmission system. This final action uses the term ''generation resources.''

[9] NERC, *2020 Long Term Reliability Assessment Report,* 9 (Dec. 2020), *https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2020.pdf* (2020 LTRA Report).

[10] An inverter is a power electronic device that inverts DC power to AC sinusoidal power. A rectifier is a power electronic device that rectifies AC sinusoidal power to DC power. A converter is a power electronic device that performs rectification and/or inversion. Consistent with NERC's terminology, this order uses the term ''inverter'' to refer to generating facilities that use power electronic inversion, rectification, and conversion. NERC, *Inverter-Based Resource Performance and Analysis Technical Workshop,* 29 (Feb. 2019), *https://www.nerc.com/comm/PC/IRPTF%20Workshops/IRPTF_Workshop_Presentations.pdf.*

[11] NERC, *Inverter-Based Resource Strategy: Ensuring Reliability of the Bulk Power System with Increased Levels of BPS-Connected IBRs,* 1 (June 2022), *https://www.nerc.com/comm/Documents/NERC_IBR_Strategy.pdf* (NERC IBR Strategy).

[12] *See, e.g.,* NERC, *2013 Long-Term Reliability Assessment,* 22 (Dec. 2013), *https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2013_LTRA_FINAL.pdf* (2013 LTRA Report) (finding that reliably integrating high levels of variable resources into the Bulk-Power System would require ''significant changes to traditional methods used for system planning and operation,'' including requiring ''new tools and practices, including potential enhancements to . . . Reliability Standards or guidelines to maintain [Bulk-Power System] reliability.'').

[13] Bulk-Power System planners and operators include planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities, and any other functional entity NERC may identify as applicable to meet the directives in this final action.

[14] NERC reports do not always differentiate between IBRs based on type, or between those subject to Reliability Standards and those located on the distribution system. Where necessary to describe our directives, however, we differentiate between IBRs registered with NERC (or which will be registered pursuant to the Commission's directives in *Registration of Inverter-based Resources,* 181 FERC ¶ 61,124 (2022) (IBR Registration Order)) and therefore subject to the Reliability Standards (*i.e.,* registered IBR), IBRs connected directly to the Bulk-Power System but not registered with NERC and therefore not subject to the Reliability Standards (*i.e.,* unregistered IBRs), and IBRs connected to the distribution system that in the aggregate have a material impact on the Bulk-Power System (*i.e.,* IBR–DER). Although the remaining subset of unregistered IBRs and IBR–DERs in the aggregate will not be subject to the mandatory and enforceable Reliability Standards set forth herein, they may be subject to provision of data and information to their respective transmission owners and distribution providers, as applicable, in accordance with their specific interconnection agreements. We encourage NERC to continue its efforts to review and evaluate whether reliability gaps continue to remain and if new or modified functional registration categories or Reliability Standards are necessary. *See infra* note 365 (discussing NERC's estimate of the percentage of IBRs to be registered under its registration work plan).

distribution providers share validated modeling, planning, operations, and disturbance monitoring data for all IBRs with planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities so that the latter group has the necessary data to predict the behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, and their impact on the reliable operation of the Bulk-Power System.

- *IBR Model Validation:* The Reliability Standards must require that all IBR models are comprehensive, validated, and updated in a timely manner, so that planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities can adequately predict the behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, and their impacts on the reliable operation of the Bulk-Power System.
- *IBR Planning and Operational Studies:* The Reliability Standards must require that planning and operational studies include validated IBR models to assess the reliability impacts of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, on the reliable operation of the Bulk-Power System. The Reliability Standards must require that planning and operational studies assess the impacts of all IBRs within and across planning and operational boundaries for normal operations and contingency event conditions.
- *IBR Performance Requirements:* The Reliability Standards must ensure that registered IBRs will provide frequency and voltage support during frequency and voltage excursions in a manner necessary to contribute toward the overall system needs for essential reliability services.[15] The Reliability Standards must establish clear and reliable technical limits and capabilities for registered IBRs to ensure that all registered IBRs are operated in a predictable and reliable manner during normal operations and contingency event conditions. The Reliability Standards must require that the operational aspects of registered IBRs contribute towards meeting the overall system needs for essential reliability services. The Reliability Standards must include post-disturbance ramp rates and phase lock loop synchronization requirements for registered IBRs.

6. Pursuant to § 39.2(d) of the Commission's regulations,[16] we direct NERC to submit an informational filing within 90 days of the issuance of the final action in this proceeding. NERC's filing shall include a detailed and comprehensive standards development plan explaining how NERC will prioritize the development of new or modified Reliability Standards to meet the deadlines set forth in this final action. We direct NERC to explain in its filing how it is prioritizing its IBR Reliability Standard projects to meet the directives in this final action, taking into account the risk posed to the reliability of the Bulk-Power System, standard development projects already underway, resource constraints, and other factors if necessary.

7. NERC's standards development plan must ensure that NERC submits new or modified Reliability Standards by the following deadlines. First, by November 4, 2024, NERC must submit new or modified Reliability Standards that establish IBR performance requirements, including requirements addressing frequency and voltage ride through,[17] post-disturbance ramp rates, phase lock loop synchronization, and other known causes of IBR tripping or momentary cessation.[18] NERC must also submit, by November 4, 2024, new or modified Reliability Standards that require disturbance monitoring data sharing and post-event performance validation for registered IBRs. Second, by November 4, 2025, NERC must submit new or modified Reliability Standards addressing the interrelated directives concerning: (1) data sharing for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate; and (2) data and model validation for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate. Finally, by November 4, 2026, NERC must submit new or modified Reliability Standards addressing planning and operational studies for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate. We continue to believe this staggered approach to standard development and implementation is necessary based on the scope of work anticipated and that specific target dates will provide a valuable tool and incentive to NERC to timely address the directives in this final action.

8. Although we are not directing NERC to include implementation dates in its informational filing and are leaving determination of the appropriate effective dates to the standards development process, we are concerned that the lack of a time limit for implementation could allow identified issues to remain unresolved for a significant and indefinite period. Therefore, we emphasize that industry has been aware of and alerted to the need to address the impacts of IBRs on the Bulk-Power System since at least 2016. The number of events, NERC Alerts, reports, whitepapers, guidelines, and ongoing standards projects, as discussed in more detail in section III and throughout this final action, more than demonstrate the need for the expeditious implementation of new or modified Reliability Standards addressing IBR data sharing, data and model validation, planning and operational studies, and performance requirements. Thus, in that light, the Commission will take these issues into account when it considers the proposed implementation plan for each new or modified Reliability Standard when it is submitted for Commission. Further, as a general matter, we believe that there is a need to have all the directed Reliability Standards effective and enforceable well in advance of 2030 and direct NERC to ensure that the associated implementation plans sequentially stagger the effective and enforceable dates to ensure an orderly industry transition for complying with the IBR directives in this final action prior to 2030.

II. Background

A. Section 215 of the FPA and the Mandatory Reliability Standards

9. Section 215 of the FPA provides that the Commission may certify an

[15] *See, e.g.,* NERC, *A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability,* vi (Oct. 2014), *https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Concept%20Paper.pdf* (Essential Reliability Services Concept Paper) (listing the essential reliability services necessary to maintain Bulk-Power System reliability).

[16] 18 CFR 39.2(d) (the electric reliability organization shall provide the Commission information as necessary to implement section 215 of the FPA).

[17] *See Standardization of Generator Interconnection Agreements & Procs.,* Order No. 2003, 104 FERC ¶ 61,103, at P 562 n.88 (2003) (defining ride through as ''a Generating Facility staying connected to and synchronized with the Transmission System during system disturbances within a range of over- and under-frequency[/voltage] conditions, in accordance with Good Utility Practice.'').

[18] Momentary cessation is a mode of operation during which the inverter remains electrically connected to the Bulk-Power System, but the inverter does not inject current during low or high voltage conditions outside the continuous operating range. As a result, there is no current injection from the inverter and therefore no active or reactive current (and no active or reactive power). NERC, *Reliability Guideline: BPS-Connected Inverter-Based Resource Performance,* 11 (Sept. 2018), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Inverter-Based_Resource_Performance_Guideline.pdf* (IBR Performance Guideline).

ERO, the purpose of which is to develop mandatory and enforceable Reliability Standards, subject to Commission review and approval.[19] Reliability Standards may be enforced by the ERO, subject to Commission oversight, or by the Commission independently.[20] Pursuant to section 215 of the FPA, the Commission established a process to select and certify an ERO,[21] and subsequently certified NERC.[22]

10. Pursuant to section 215(d)(5) of the FPA, the Commission has the authority, upon its own motion or upon complaint, to order the ERO to submit to the Commission a proposed Reliability Standard or a modification to a Reliability Standard that addresses a specific matter if the Commission considers such a new or modified Reliability Standard appropriate to carry out section 215 of the FPA.[23] Further, pursuant to § 39.5(g) of the Commission's regulations, the Commission may order a deadline by which the ERO must submit a proposed or modified Reliability Standard.[24]

B. Inverter-Based Resources

11. The Bulk-Power System generation fleet has traditionally been composed almost exclusively of synchronous generation resources that convert mechanical energy into electric energy through electromagnetic induction. By virtue of the kinetic energy in their large rotating components, these synchronous generation resources inherently resist changes in system frequency, providing time for other governor controls (when properly configured) to maintain supply and load balance. Similarly, synchronous generation resources inherently provide voltage support during voltage disturbances.

12. In contrast, IBRs do not use electromagnetic induction from machinery that is directly synchronized to the Bulk-Power System. Instead, the majority of installed IBRs use grid-following inverters, which rely on sensed information from the grid (*e.g.,* a voltage waveform) to produce the desired AC real and reactive power output.[25] Due to their inverters, IBRs can track grid state parameters (*e.g.,* voltage angle) in milliseconds and react nearly instantaneously to changing grid conditions. Some IBRs, however, are not configured or programmed to support grid voltage and frequency in the event of a system disturbance, and, as a result, will reduce power output,[26] exhibit momentary cessation, or trip in response to variations in system voltage or frequency.[27] In other words, under certain conditions some IBRs cease to provide power to the Bulk-Power System due to how they are configured and programmed. Nonetheless, some models and simulations incorrectly predict that some IBRs will ride through disturbances, *i.e.,* maintain real power output at pre-disturbance levels and provide voltage and frequency support consistent with Reliability Standard PRC–024–3 (Frequency and Voltage Protection Settings for Generating Resources).[28]

13. IBRs across the Bulk-Power System exhibit common mode failures that are amplified when IBRs act in the aggregate.[29] Thus, both localized and interconnection-wide IBR issues must be identified, studied, and mitigated to preserve Bulk-Power System reliability.[30] Although IBRs are typically smaller-megawatt (MW) facilities, they are at greater risk than synchronous generation resources of ceasing to provide power to the Bulk-Power System in response to a single fault on the transmission or sub-transmission systems. Specifically, such response can occur when individual IBR controls and equipment protection settings are not configured to ride through system disturbances.[31] IBRs that enter momentary cessation may act in aggregate and cause a reduction in power output far in excess of any individual IBR's impact on the Bulk-Power System. The potential impact of IBRs is not restricted by the size of a single facility or an individual balancing authority area, but by the number of IBRs or percent of generation made up by IBRs within a region. In areas of high IBR penetration, this type of aggregate response may have an impact much greater than the most severe single contingency (*i.e.,* the traditional worst-case N–1 contingency) [32] of a balancing authority area, potentially adversely affecting other balancing authority areas within an interconnection.[33] Unless

[19] 16 U.S.C. 824o(c).

[20] *Id.* 824o(e).

[21] *Rules Concerning Certification of the Elec. Reliability Org. & Procs. for the Establishment, Approval, & Enf't. of Elec. Reliability Standards,* Order No. 672, 114 FERC ¶ 61,104, *order on reh'g,* Order No. 672–A, 114 FERC ¶ 61,328 (2006).

[22] *N. Am. Elec. Reliability Corp.,* 116 FERC ¶ 61,062, *order on reh'g and compliance,* 117 FERC ¶ 61,126 (2006), *aff'd sub nom. Alcoa, Inc.* v. *FERC,* 564 F.3d 1342 (D.C. Cir. 2009).

[23] 16 U.S.C. 824o(d)(5).

[24] 18 CFR 39.5(g).

[25] *See, e.g.,* NERC, *2021 Long Term Reliability Assessment Report,* 6 (Dec. 2021), *https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2021.pdf* (2021 LTRA Report) (''IBRs respond to disturbances and dynamic conditions based on programmed logic and inverter controls, not mechanical characteristics.''); *see also generally,* Denholm et al., National Renewable Energy Laboratory, *Inertia and the Power Grid: A Guide Without the Spin,* NREL/TP–6120–73856, v (May 2020), *https://www.nrel.gov/docs/fy20osti/73856.pdf.*

[26] NERC and WECC, *San Fernando Disturbance,* 2 (Nov. 2020), *https://www.nerc.com/pa/rrm/ea/Documents/San_Fernando_Disturbance_Report.pdf* (San Fernando Disturbance Report) (covering the San Fernando event (July 7, 2020)).

[27] *See Essential Reliability Servs. & the Evolving Bulk-Power Sys. Primary Frequency Response,* Order No. 842, 162 FERC ¶ 61,128, at P 19 (2018) (describing NERC's comment that increased IBR deployment alongside retirement of synchronous generation resources has contributed to the decline in primary frequency response); *see also* NERC, *Fast Frequency Response Concepts and Bulk Power System Reliability Needs,* 5 (Mar. 2020), *https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/Fast_Frequency_Response_Concepts_and_BPS_Reliability_Needs_White_Paper.pdf* (Fast Frequency Response White Paper) (explaining that as the instantaneous penetration of IBRs with little or no inertia continues to increase, system rate of change of frequency after a loss of generation will increase and the time available to deliver frequency responsive reserves will shorten, and illustrating the steeper rate of change of frequency and the importance of speed of response).

[28] The NOPR referred to Reliability Standard PRC–024–2; however, Reliability Standard PRC–024–3 became mandatory and enforceable on October 1, 2022. Reliability Standards applicable in the United States, both effective and retired, are available at *https://www.nerc.com/pa/Stand/Pages/USRelStand.aspx.*

[29] NERC, *An Introduction to Inverter-Based Resources on the Bulk-Power System,* 6 (June 2023), *https://www.nerc.com/pa/Documents/2023_NERC_Guide_Inverter-Based-Resources.pdf* (explaining that ''NERC continues to analyze large-scale grid disturbances involving common mode failures in inverter-based resources that, if not addressed, could lead to catastrophic events in the future'').

[30] *See* NOPR, 181 FERC ¶ 61,125 at P 4.

[31] *See, e.g.,* NERC and WECC, *900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report,* 19 (Feb. 2018), *https://www.nerc.com/pa/rrm/ea/October%209%202017%20Canyon%202%20Fire%20Disturbance%20Report/900%20MW%20Solar%20Photovoltaic%20Resource%20Interruption%20Disturbance%20Report.pdf* (Canyon 2 Fire Event Report) (covering the Canyon 2 Fire event (October 9, 2017)) (finding momentary cessation as a major cause for the loss of IBRs when voltages rose above 1.1 per unit or decreased below 0.9 per unit).

[32] The most severe single contingency, or the N–1 contingency, generally refers to the concept that a system must be able to withstand an unexpected failure or outage of a single system component and maintain reliable service at all times. *See, e.g.,* NERC, *Glossary of Terms Used in NERC Reliability Standards,* 17 (Mar. 8, 2023), *https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf* (NERC Glossary) (defining ''most severe single contingency'').

[33] *See, e.g.,* San Fernando Disturbance Report at vi (stating that ''[t]his event, as with past events, involved a significant number of solar PV resources reducing power output (either due to momentary cessation or inverter tripping) as a result of normally-cleared [Bulk-Power System] faults. The widespread nature of power reduction across many

Continued

IBRs are configured and programmed to ride through normally cleared transmission faults, the potential impact of losing IBRs individually or in the aggregate will continue to increase as IBRs are added to the Bulk-Power System and make up an increasing proportion of the resource mix.

14. Simulations conducted by the NERC Resource Subcommittee demonstrate that the risks to Bulk-Power System reliability posed by momentary cessation are greater than any of the actual IBR disturbances that NERC has documented since 2016.[34] These simulations indicate the potential for: (1) normally-cleared, three-phase faults at certain locations in the Western Interconnection to result in upwards of 9,000 MW of solar PV IBRs entering momentary cessation across a large geographic region; (2) transient instability caused by excessive transfer of inter-area power flows during and after momentary cessation; and (3) a drop in frequency that falls below the first stage of under frequency load shedding in the Western Electricity Coordinating Council (WECC) region (traditionally studied as the loss of the two Palo Verde nuclear units in Arizona, which total approximately 2,600 MW). These simulation results indicate that IBR momentary cessation occurring in the aggregate can lead to instability, system-wide uncontrolled separation, and voltage collapse.[35]

15. Although IBRs present risks that Bulk-Power System planners and operators must account for, IBRs also present new opportunities to support the grid and respond to abnormal grid conditions.[36] When appropriately programmed, IBRs can operate during greater frequency deviations (*i.e.,* a wider frequency range) than synchronous generation resources.[37] This operational flexibility—and the ability of IBRs to perform with precision, speed, and control—could mitigate disturbances on the Bulk-Power System. For Bulk-Power System operators to harness the unique performance and control capabilities of IBRs, these resources must be properly configured and programmed to support grid voltage and frequency during normal and abnormal grid conditions and must be accurately modeled and represented in transmission planning and operations models.

C. Notice of Proposed Rulemaking

16. On November 17, 2022, the Commission issued the NOPR in this proceeding, proposing to direct NERC to submit new or modified Reliability Standards addressing four gaps in the currently effective Reliability Standards pertaining to IBRs: (1) data sharing; (2) model validation; (3) planning and operational studies; and (4) performance requirements.[38] The Commission initiated this action in light of the rapid change in the generation resource mix currently underway on the Bulk-Power System and the projected addition of unprecedented numbers of IBRs to the Bulk-Power System.[39] The Commission noted that IBRs provide many benefits, but that IBRs also present new considerations for transmission planning and operation of the Bulk-Power System.[40]

17. The Commission proposed to direct NERC to address the four reliability gaps by developing one or more new Reliability Standards or modifying the currently effective Reliability Standards. The Commission did not propose specific requirements; instead, the Commission identified concerns that the Reliability Standards should address. The Commission sought comments on its identified concerns and whether there were other concerns related to planning for and integrating IBRs that the Commission should direct NERC to address in this or a future proceeding.[41]

18. First, the Commission proposed to direct NERC to develop new or modified Reliability Standards addressing IBR data sharing. The Commission proposed that the new or modified Reliability Standards should ensure that NERC registered entities[42] have the necessary data to predict the behavior of all IBRs, including registered and unregistered IBRs individually and in the aggregate, and IBR–DERs in the aggregate, and their impact on the reliable operation of the Bulk-Power System. The Commission stated that the new or modified Reliability Standards should ensure that generator owners, transmission owners, and distribution providers are required to share validated modeling, planning, operations, and disturbance monitoring data for registered and unregistered IBRs and IBR–DERs in the aggregate with planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities.[43]

19. Second, the Commission proposed to direct NERC to develop new or modified Reliability Standards addressing IBR model validation. The Commission proposed that the new or modified Reliability Standards should ensure that IBR models are comprehensive, validated, and updated in a timely manner, so that they can adequately predict the behavior of registered and unregistered IBRs individually and in the aggregate, and IBR–DERs in the aggregate, and their impacts on the reliable operation of the Bulk-Power System.[44]

20. Third, the Commission proposed to direct NERC to develop new or modified Reliability Standards addressing IBR planning and operational studies. The Commission proposed to direct that the new or modified Reliability Standards ensure that validated IBR models are included in transmission planning and operational studies to assess the reliability impacts on Bulk-Power System performance by registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate. The Commission stated that the Reliability Standards should ensure that planning and operational studies assess the impacts of registered and unregistered IBRs individually and in the aggregate, and IBR–DERs in the aggregate, within and across planning and operational boundaries for normal operations and contingency event conditions.[45]

21. Fourth, the Commission proposed to direct NERC to develop new or modified Reliability Standards addressing IBR performance requirements.[46] The Commission explained that the new or modified Reliability Standards should require that registered IBRs provide frequency and voltage support during frequency and voltage excursions, including post-disturbance ramp rates and phase lock

facilities poses risks to [Bulk-Power System] performance and reliability.'').

[34] *See* NERC, *Resource Loss Protection Criteria Assessment,* (Feb. 2018), *https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/IRPTF_RLPC_Assessment.pdf.*

[35] *Id.* at 1–2, key findings 4, 7, 8.

[36] *See, e.g.,* IBR Performance Guideline at vii (finding that the power electronics aspects of IBRs ''present new opportunities in terms of grid control and response to abnormal grid conditions.'').

[37] *See, e.g.,* Fast Frequency Response White Paper at 11.

[38] NOPR, 181 FERC ¶ 61,125 at P 1.

[39] *Id.* P 2 (citing 2020 LTRA Report).

[40] *Id.*

[41] *Id.* P 6.

[42] NERC identifies and registers Bulk-Power System users, owners, and operators who are responsible for performing specified reliability functions to which requirements of mandatory Reliability Standards are applicable. *See* NERC, *Rules of Procedure,* Section 500 (Organization Registration and Certification) (Aug. 25, 2022), *https://www.nerc.com/AboutNERC/RulesOfProcedure/NERC%20ROP%20effective%2020220825_with%20appendicies.pdf.*

[43] NOPR, 181 FERC ¶ 61,125 at P 5.

[44] *Id.*

[45] *Id.*

[46] *Id.*

loop synchronization, in a manner necessary to contribute toward meeting the overall system needs for essential reliability services.[47] Further, the Commission stated that the new or modified Reliability Standards should establish clear and reliable technical limits and capabilities for registered IBRs to ensure that all registered IBRs are operated in a predictable and reliable manner during both normal operations and contingency event conditions.

22. Finally, the Commission proposed to direct NERC to submit a compliance filing within 90 days of the effective date of the final action in this proceeding. The Commission proposed to direct NERC to include in its compliance filing a detailed, comprehensive standards development and implementation plan explaining how NERC will prioritize the development and implementation of new or modified Reliability Standards. The Commission stated that NERC should explain how it would prioritize its IBR Reliability Standard projects to meet the directives in the final action, taking into account the risk posed to the reliability of the Bulk-Power System, standard development projects already underway, resource constraints, and other factors if necessary.[48]

23. The comment period for the NOPR ended on February 6, 2023, with reply comments due on March 6, 2023. The Commission received 18 initial comments and 3 reply comments.[49]

III. Need for Reform

24. As the Commission explained in the NOPR, a number of events have demonstrated the challenges to transmission planning and operations of the Bulk-Power System posed by gaps in the Reliability Standards specific to IBRs.[50] In this final action, we continue to find that as the resource mix trends towards higher penetrations of IBRs, the need to reliably integrate these resources into the Bulk-Power System is expected to grow, and that the currently effective Reliability Standards do not adequately address IBR reliability risks.[51] The continuing risks that the increasing penetration of IBRs pose to the reliable operation of the Bulk-Power System underscore the need for mandatory Reliability Standards to address these issues on a nationwide basis.

25. NERC, groups such as the Institute of Electrical and Electronics Engineers (IEEE), and other entities have attempted to address IBR-related reliability concerns at the manufacturer, state, local, or individual entity level over the past several years.[52] While the various ongoing IBR-related projects are important efforts, the absence of a comprehensive plan to require that the increasing numbers of IBRs are reliably interconnected, planned for, and operated on the Bulk-Power System limits those individual projects' overall impact. Moreover, these individual efforts could lead to inconsistent results that fail to fully address the gaps identified herein, a concern that could be resolved by addressing all IBR issues through the Reliability Standards. Therefore, to help ensure that a broader range of reliability concerns related to the impacts of IBRs on the Bulk-Power System are addressed, that any necessary new requirements apply nationwide, and that any new rules are mandatory, we find that it is imperative for NERC to develop new or modified Reliability Standards as directed in this final action to address reliability concerns related to IBRs at all stages of interconnection, planning, and operations. However, we note that the directives to NERC in this final action are intended to complement other ongoing NERC and Commission actions to address the impacts of all IBRs on the Bulk-Power System, as well as existing voluntary efforts underway, and are not intended to supersede or interfere with these efforts.

A. Current Actions Are Insufficient To Address IBR Reliability Risks

26. As explained in the NOPR, at least 12 documented events on the Bulk-Power System [53] show IBRs acting unexpectedly and adversely in response to normally cleared transmission line faults on the Bulk-Power System, each highlighting one or more common mode failures of IBRs of various sizes and voltage connection levels.[54]

27. In addition to those 12 documented events discussed in the NOPR, on June 4, 2022, an IBR-related disturbance near Odessa, Texas (the third in this location) occurred. During this disturbance, a normally cleared single-line-to-ground fault resulted in a total loss of 2,555 MW of synchronous and IBR generation, and system frequency dropped to 59.7 Hz.[55] This is the largest (to date) NERC-recorded IBR-related disturbance event and the total loss of generation resources was one and half times larger than the average loss of the 12 preceding reported events. The NERC and Texas Reliability Entity, Inc. (Texas RE) joint report, issued in December 2022, explains that this event is significant because the size of this disturbance nearly exceeded the Texas Interconnection Resource Loss Protection Criteria (*i.e.,* 2,750 MW) defined in Reliability Standard BAL–003–2,[56] which is used to establish the largest credible contingency for frequency stability in an interconnection.[57]

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[47] *Id.* (citing Essential Reliability Services Concept Paper at vi).

[48] *Id.* P 7.

[49] A list of commenters to the NOPR and the abbreviated names used in this final action appear in Appendix A. Interventions are not necessary to file comments in a rulemaking. Nevertheless, Acciona Energy USA Global LLC, Cordelio USA, Inc., Electricity Consumers Resource Council, the Federal Energy Advocate, the Public Utilities Commission of Ohio, Georgia Transmission Corporation, GlidePath Development, LLC, Monitoring Analytics, LLC, and Old Dominion Electric Cooperative filed motions to intervene.

[50] *See* NOPR, 181 FERC ¶ 61,125 at PP 24–26.

[51] *Id.* PP 26–27.

[52] For example, to address gaps in data and model validation and to facilitate sharing and combining of neighboring planning models, ISO New England (ISO–NE) has taken steps to retire obsolete and unapproved models within its own footprint. *See* ISO–NE, *Generator Data Submittal Requirements—Planning, Topic Retiring Obsolete and NERC Non-Approved Models,* 121–125 (Jan. 24, 2023), *https://www.iso-ne.com/static-assets/documents/2023/01/20230124-gen-data-submittal-requirements-planning.pdf.*

[53] The 12 events report an average of approximately 1,000 MW of IBRs entering into momentary cessation or tripping in the aggregate. The 12 Bulk-Power System events are: (1) the Blue Cut Fire (August 16, 2016); (2) the Canyon 2 Fire (October 9, 2017); (3) Angeles Forest (April 20, 2018); (4) Palmdale Roost (May 11, 2018); (5) San Fernando (July 7, 2020); (6) the first Odessa, Texas event (May 9, 2021); (7) the second Odessa, Texas event (June 26, 2021); (8) Victorville (June 24, 2021); (9) Tumbleweed (July 4, 2021); (10) Windhub (July 28, 2021); (11) Lytle Creek (August 26, 2021); and (12) Panhandle Wind Disturbance (March 22, 2022).

[54] NOPR, 181 FERC ¶ 61,125 at P 4.

[55] A power system deviating from 60 Hz indicates there is a generation and load imbalance. When the generation loss is too large, automatic under-frequency load shedding is used to rebalance the power system to prevent cascading failures that lead to blackouts. In Texas, the automatic under-frequency load shed (UFLS) program is set to trigger a sudden loss of load at 59.3 Hz. *See generally* Public Utility Commission of Texas, *Load Shed Protocols for the Electric Reliability Council of Texas (ERCOT) Region,* (Aug. 31, 2022), *https://ftp.puc.texas.gov/public/puct-info/agency/resources/reports/leg/PUC_Load_Shed_Protocols_Study.pdf. See also* NERC Newsroom Announcement *Odessa Disturbance Illustrates Need for Immediate Industry Action on Inverter-Based Resources* (Dec. 8, 2022), *https://www.nerc.com/news/Headlines%20DL/OdessaDisturbance_08DEC22.pdf* (explaining that ''[t]he 2022 Odessa disturbance was a Category 3a event in the NERC Event Analysis Process, and the combined loss of generation nearly exceeded the Texas Interconnection Resource Loss Protection Criteria.'').

[56] *See* Reliability Standard BAL–003–2 (Frequency Response and Frequency Bias Setting), attach. A.

[57] NERC and Texas RE, *2022 Odessa Disturbance,* v (Dec. 2022), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_2022_Odessa_Disturbance_Report%20(1).pdf* (Odessa 2022

Continued

28. In response to the multiple Odessa, Texas disturbances, NERC issued its third level 2 alert on IBR performance issues on March 14, 2023.[58] In the alert, NERC states its level 2 alert is necessary because the disturbances in Odessa, Texas, showed that solar PV IBR resources exhibited ''systemic performance issues'' with the potential to cause widespread outages on the Bulk-Power System.[59] Although the NERC alert pertains specifically to solar PV resources, the alert recommendations may be applicable to Bulk-Power System connected battery energy storage systems. Further, NERC explains that as the penetration of Bulk-Power System-connected IBRs increases, it will be necessary to address performance deficiencies in an ''effective and efficient manner.'' [60] In the March 2023 Alert, NERC sought to gather information from registered generator owners of solar-PV (*i.e.,* IBRs) and to encourage them to implement recommendations to: (1) ensure inverter protection settings, collector system settings, and substation settings are updated or changed to mitigate inadvertent operations; and (2) ensure that facility control modes, fault ride through modes and parameters, and protections are set and coordinated to facilitate Bulk-Power System voltage and frequency ride through.[61]

29. NERC also recently issued another disturbance report covering events in Southwest Utah in the morning of April 10, 2023.[62] NERC explains that the causes of the Southwest Utah disturbance are similar to past solar PV IBR-related events.[63] NERC identifies this event as the ''first major widespread solar [PV] loss to occur in the Western Interconnection outside of California.'' [64]

30. NERC has found that distributed energy resources' (*i.e.,* IBR–DERs') responses to Bulk-Power-System disturbances can cause short term net load increases likely attributed to aggregate IBR–DERs tripping.[65] This behavior and the resulting net load increases can impact Bulk-Power-System performance.[66]

31. NERC has also issued two recent IBR-related Reliability Guidelines. In February 2023 NERC issued an updated guideline on aggregate DER modeling (DER_A model),[67] and in March 2023, NERC issued its first guideline on electromagnetic transient (EMT) modeling and studies for IBRs.[68]

32. NERC also has nine separate projects underway to update its currently effective Reliability Standards relevant to IBRs; however, these projects are still in their early stages and, even if they are completed, the results of these efforts may not fully address the reliability risks that IBRs pose to the Bulk-Power System described above.[69]

33. While we recognize NERC's ongoing efforts, systemic fault ride through deficiencies continue to result in IBRs displaying unexpected and abnormal performance during grid disturbances.[70] In fact, in the March 2023 Alert, NERC states that IBR-related issues continue to occur and has announced plans to issue an alert by the end of 2023 regarding IBR modeling issues.[71]

34. The Commission has also been actively addressing ongoing IBR-related concerns. Concurrently with the NOPR, the Commission issued an order directing NERC to identify and register owners and operators of unregistered IBRs that in the aggregate have a material impact on the reliable operation of the Bulk-Power System.[72] On February 15, 2023, as amended on March 13, 2023, NERC submitted its compliance filing, which included its work plan setting out NERC's planned activities and milestones to register generator owners and operators of IBRs. On May 18, 2023, the Commission approved NERC's work plan and associated implementation milestones.[73]

35. The Commission also recently revised the *pro forma* Large Generator Interconnection Procedures (LGIP), the *pro forma* Large Generator Interconnection Agreement (LGIA), the *pro forma* Small Generator Interconnection Procedures (SGIP), and the *pro forma* Small Generator Interconnection Agreement (SGIA) in Order No. 2023.[74] Some of those revisions address identified deficiencies

Disturbance Report) (covering events in Odessa, Texas on June 4, 2022).

[58] NERC, *Industry Recommendation: Inverter-Based Resource Performance Issues* (Mar. 2023), *https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC%20Alert%20R-2023-03-14-01%20Level%202%20-%20Inverter-Based%20Resource%20Performance%20Issues.pdf* (March 2023 Alert).

[59] *See* NOPR, 181 FERC ¶ 61,125 at P 18 (explaining that the level 2 alerts recommend specific voluntary action to be taken by registered IBRs).

[60] March 2023 Alert at 1.

[61] *Id.*

[62] NERC and WECC, *2023 Southwest Utah Disturbance* (Aug. 2023), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_2023_Southwest_UT_Disturbance_Report.pdf* (Southwest Utah Disturbance Report).

[63] *Id.* at iv.

[64] *Id.*

[65] Multiple Solar PV Disturbances in CAISO: Disturbances between June and August 2021 Joint NERC and WECC Staff Report, 17–18, (Apr. 2022), *https://www.nerc.com/pa/rrm/ea/Documents/NERC_2021_California_Solar_PV_Disturbances_Report.pdf.*

[66] *San Fernando Disturbance: Southern California Event: July 7, 2020 Joint NERC and WECC Staff Report,* 12 (Nov. 2020), *https://www.nerc.com/pa/rrm/ea/Documents/San_Fernando_Disturbance_Report.pdf.*

[67] NERC, *Reliability Guideline: Parameterization of the DER_A Model for Aggregate DER* (Feb. 2023), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_ModelingMerge_Responses_clean.pdf* (2023 DER_A Model Guideline). The DER_A model is the approved steady state and dynamic model that industry has validated and maintained to model IBR–DERs in the aggregate and used to study the potential impacts of IBR–DERs in the aggregate on the Bulk-Power System. The term ''parameterize'' means to adjust the parameter values of a generic model to best reflect the dynamic characteristics of a user-defined model. The parameterization process aims at reducing the difference (error) between the dynamic responses of both the generic and user-defined models. *See, e.g.,* Energy Systems Integration Group, *Parameterization, https://www.esig.energy/wiki-main-page/parameterization-d1/.*

[68] NERC, *Reliability Guideline: Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources—Recommended Model Requirements and Verification Practices* (Mar. 2023), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline-EMT_Modeling_and_Simulations.pdf* (EMT Modeling Guideline).

[69] The current NERC standards development projects underway include: (1) Project 2021–04 (Modifications to PRC–002–2) to ensure that disturbance monitoring data is available and provided by generator owners of IBR facilities; (2) Project 2020–06 (Verifications of Models and Data for Generators) to enhance requirements for model verification; (3) Project 2022–04 (EMT Modeling) to address the inclusion of EMT modeling and studies in relevant Reliability Standards; (4) Project 2022–02 (Modifications to TPL–001–5.1 and MOD–032–1) addressing certain issues regarding appropriate inclusion of IBRs and DERs in planning assessments; (5) Project 2020–02 (Modifications to PRC–024 (Generator Ride-through)) to revise or replace current Reliability Standard PRC–024–3 with a standard that will require ride through performance from all generation resources; (6) Project 2023–02 (Performance of IBRs) to address post-event performance validation ensuring that resources perform the way they are expected or required to perform; (7) Project 2021–01 (Modifications to MOD–025 and PRC–019) to ensure that plant active and reactive power capabilities are accurately provided to planning entities for use in studies; (8) Project 2021–02 (Modifications to VAR–002–4.1) to clarify whether the generator operator of a dispersed power resource must notify its associated transmission operator upon a status change of a voltage controlling device on an individual generating unit; and (9) Project 2023–01 (EOP–004 IBR Event Reporting) to ensure timely reporting of events involving IBRs. *See* NERC, *Reliability Standards Under Development, https://www.nerc.com/pa/Stand/Pages/Standards-Under-Development.aspx.*

[70] March 2023 Alert at 6–7.

[71] *Id.* at 6.

[72] *See* IBR Registration Order, 181 FERC ¶ 61,124 at P 6.

[73] *N. Am. Elec. Reliability Corp.,* 183 FERC ¶ 61,116 (2023) (Order Approving Workplan). On August 16, 2023, NERC submitted its first progress update on its registration workplan. *See* NERC, Filing, Docket No. RD22–4–001 (filed Aug. 16, 2023).

[74] *See Improvements to Generator Interconnection Agreements & Procs.,* Order No. 2023, 88 FR 61014 (Sept. 6, 2023), 184 FERC ¶ 61,054 (2023).

with respect to IBR modeling and ride through performance by requiring that newly interconnecting non-synchronous generators (*i.e.,* IBRs) (1) submit accurate and verified models with a comparable level of accuracy as synchronous generation resources and (2) configure or set control and protection settings to ride through disturbances and continue to support system reliability during abnormal frequency conditions and voltage conditions within any physical limitations of the generating facility.[75]

36. In addition to NERC and Commission efforts, there are several voluntary industry standards and manufacturer certification efforts related to IBRs, such as the IEEE standard 2800–2022 [76] for transmission connected IBRs and IEEE standard 1547–2018 [77] and Underwriters Laboratory (UL) standard UL 1741 [78] for distributed energy resources. These efforts are intended to enhance the operating performance and control capabilities of IBRs; however, these efforts do not apply to all relevant IBRs and require adoption by state or other regulatory authorities to become mandatory and enforceable.[79]

[75] *Id.* PP 1661, 1715.

[76] IEEE, *Standard for Interconnection and Interoperability of Inverter-Based Resources (IBR) Interconnecting with Associated Transmission Electric Power Systems* (Apr. 22, 2022), *https://standards.ieee.org/ieee/2800/10453/* (IEEE 2800–2022) (establishing uniform technical minimum requirements for the interconnection, capability, and performance of IBRs for reliable integration onto the Bulk-Power System).

[77] IEEE, *Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces* (Feb. 15, 2018), *https://standards.ieee.org/ieee/1547/5915/* (IEEE 1547–2018). The IEEE 1547–2018 and more recent 2020 amendment (IEEE 1547a–2020) of this standard enhance operating performance and control capabilities of IBR–DERs. For example, IBR–DERs compliant with the IEEE standard will be equipped with the capability to ride through voltage and frequency fluctuations in support of the reliable operation of the Bulk-Power System.

[78] UL Standard 1741 Edition 3, *Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources Scope, https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=40673.*

[79] The IEEE Standards Association's board approved IEEE–2800–2022 in September 2022. *See* IEEE, *IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems, https://standards.ieee.org/ieee/2800/10453/* (explaining that IEEE–2800–2022 establishes uniform technical minimum requirements for the interconnection, capability, and lifetime performance of IBRs interconnecting with transmission and sub-transmission systems in North America). For IEEE–1547, states have made varied progress in adopting the standard. *See* IEEE, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces, https://sagroups.ieee.org/scc21/standards/1547rev/; see also* Odessa 2022 Disturbance Report at v (explaining that the 2022 Odessa Disturbance ''is a perfect illustration of the need for immediate industry action to ensure reliable operation of the [Bulk-Power System] with increasing penetrations of inverter-based resources.'').

B. Existing Reliability Standards Do Not Adequately Address IBR Reliability Risks

1. Data Sharing

37. The currently effective Reliability Standards do not require owners and/or operators of registered IBRs, transmission owners that have unregistered IBRs on their systems, or distribution providers that have IBR–DERs on their systems to provide planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities with data that accurately represents IBRs. Examples of needed data may include location; capacity; telemetry; steady-state, dynamic, and short circuit modeling information; control settings; ramp rates; equipment status; and disturbance analysis data.[80] Data that accurately represents IBRs is necessary to properly plan for, operate, and analyze IBR performance on the Bulk-Power System.[81] Without data that accurately represents all IBRs, planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities are not able to develop system models that accurately account for the behavior of IBRs on their system, nor are they able to facilitate the analysis of Bulk-Power System disturbances.[82]

38. While Reliability Standard MOD–032–1 (Data for Power System Modeling and Analysis), Requirement R2 requires generator owners to submit modeling data and parameters to their transmission planners and planning coordinators, it does not require generator owners to submit registered IBR-specific modeling data and parameters such as control settings for momentary cessation and ramp rates, which are necessary for modeling steady state and dynamic registered IBR performance for purposes of planning the Bulk-Power System.[83] Nor does Reliability Standard TOP–003–5 (Operational Reliability Data) require generator owners to submit such registered IBR-specific modeling data and parameters to their transmission operators or balancing authorities.[84]

39. Moreover, the currently effective Reliability Standards do not ensure that Bulk-Power System planners and operators receive disturbance monitoring data regarding all generation resources capable of having a material impact on the reliable operation of the Bulk-Power System, including registered IBRs. Such data is needed to adequately assess disturbance events (*e.g.,* a fault on the line) and the behavior of IBRs during those events. Without adequate monitoring capability, the disturbance analysis data for a system event is insufficient to effectively determine the causes of the system event.[85]

40. Limitations on the availability of event data have hampered efforts by NERC, stakeholders, and industry to determine the causes of various events since 2016. In many instances, data were limited and disturbance monitoring equipment was absent because registered IBRs interconnected at lower voltages and fell below the

[80] NOPR, 181 FERC ¶ 61,125 at P 27.

[81] NERC has provided examples of necessary planning and operational IBR data. *See, e.g.,* NERC, *Industry Recommendation: Loss of Solar Resources during Transmission Disturbances due to Inverter Settings—II,* 7–8 (May 2018), *https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_Loss_of_Solar_Resources_during_Transmission_Disturbance-II_2018.pdf* (Loss of Solar Resources Alert II) (describing examples of planning and operational IBR data); NERC and Texas RE, *Odessa Disturbance,* 20–21 (Sept. 2021), *https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf* (Odessa 2021 Disturbance Report) (covering events in Odessa, Texas on May 9, 2021 and June 26, 2021); *see generally* NERC and WECC, *WECC Base Case Review: Inverter-Based Resources* (Aug. 2020), *https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/NERC-WECC_2020_IBR_Modeling_Report.pdf* (Western Interconnection Base Case IBR Review); NERC, *Reliability Guideline: DER Data Collection for Modeling in Transmission Planning Studies* (Sept. 2020), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_Data_Collection_for_Modeling.pdf* (IBR–DER Data Collection Guideline).

[82] NOPR, 181 FERC ¶ 61,125 at P 28.

[83] *See* NERC, *Technical Report, BPS-Connected Inverter-Based Resource Modeling and Studies,* 35 (May 2020), *https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/IRPTF&_IBR_Modeling_and_Studies_Report.pdf* (Modeling and Studies Report) (stating that Reliability Standard MOD–032–1 ''does not prescribe the details that the modeling requirements must cover; rather, the standard requirements leave the level of detail and data formats up to each [transmission planner] and [planning coordinator] to define.'') (footnote omitted).

[84] *See* NOPR, 181 FERC ¶ 61,125 at P 29 (referring to Reliability Standard TOP–003–4, the version of the standard enforceable at that time. Reliability Standard TOP–003–5 became mandatory and enforceable on April 1, 2023).

[85] NERC and WECC, *Multiple Solar PV Disturbances in CAISO,* 13 (Apr. 2022), *https://www.nerc.com/pa/rrm/ea/Documents/NERC_2021_California_Solar_PV_Disturbances_Report.pdf* (2021 Solar PV Disturbances Report) (covering four events: Victorville (June 24, 2021); Tumbleweed (July 4, 2021); Windhub (July 28, 2021); and Lytle Creek (August 26, 2021)) (explaining that the ''analysis team had significant difficulty gathering useful information for root cause analysis at multiple facilities . . . [and] this led to an abnormally large number of 'unknown' causes of power reduction for the plants analyzed'').

MVA threshold.[86] These IBRs therefore did not fall within the thresholds of the currently effective Reliability Standard PRC–002–2 (Disturbance Monitoring and Reporting Requirements) Attachment 1 requirements for equipment installation.[87] Further, the absence of adequate monitoring capability leads to the potential for unreliable operation of generation resources due to the inability to effectively gather disturbance analysis data and develop mitigation strategies to either avoid or recover from abnormal resource performance during disturbance events in the future. While Reliability Standard PRC–002–2 requires the installation of disturbance monitoring equipment at certain key nodes (*e.g.,* stability limited interfaces), and such limited placements have been adequate to provide the data necessary to analyze major system events in the past, NERC has found that the existing disturbance monitoring equipment is not sufficient (*e.g.,* lack of high speed data captured at the IBR or plant level controller and low resolution time stamping of inverter sequence of event recorder information) to analyze the widespread system events that have become more common since 2016.[88]

41. The currently effective Reliability Standards do not require Bulk-Power System planners and operators to receive modeling data and parameters regarding unregistered IBRs that, individually or in the aggregate, are capable of adversely affecting the reliable operation of the Bulk-Power System. Further, the currently effective Reliability Standards do not require that Bulk-Power System planners and operators receive modeling data and parameters that accurately represent IBR–DERs that in the aggregate have a material impact on the reliable operation of the Bulk-Power System.[89] As shown by various reports and guidelines,[90] Bulk-Power System planners and operators do not currently have the data to accurately model the behavior of registered and unregistered IBRs individually and in the aggregate, and IBR–DERs in the aggregate, for steady-state, dynamic, and short circuit studies.

2. Data and Model Validation

42. Bulk-Power System planners and operators need accurate planning, operations, and interconnection-wide models to ensure the reliable operation of the Bulk-Power System. Bulk-Power System planners and operators use electrical component models to build the generation, transmission, and distribution facility models that they combine to build their transmission area model. These models are further combined with those of their neighbors to form the interconnection-wide models, which are used to analyze the reliability of the interconnected transmission system.[91] Each of the planning, operations, and interconnection-wide models consist separately of steady state, dynamic, and short circuit models.

43. Without planning, operations, and interconnection-wide models that accurately reflect resource (*e.g.,* generation and load) behavior in steady state and dynamic conditions, Bulk-Power System planners' and operators' system models[92] are unable to adequately predict resource behavior, including momentary cessation from both registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, and their subsequent impacts on the Bulk-Power System.[93]

44. The currently effective Reliability Standards do not require the use of NERC's approved component models;[94] instead, models are referred to generally in Reliability Standard MOD–032–1, Attachment 1.[95] Without requirements to use approved component models in Bulk-Power System planning and operations system models, resource

[86] NERC, *Improvements to Interconnection Requirements for BPS-Connected Inverter-Based Resources,* at 1 (Sept. 2019) (IBR Interconnection Requirements Guideline) (reporting that the majority of newly interconnecting IBRs are either connecting at voltages less than 100 kV or with capacity less than 75 MVA and therefore do not meet the size criteria in the bulk electric system definition). NERC's Commission-approved bulk electric system definition is a subset of the Bulk-Power System and defines the scope of the Reliability Standards and the entities subject to NERC compliance. *Revisions to Electric Reliability Org. Definition of Bulk Elec. Sys. & Rules of Proc.,* Order No. 773, 141 FERC ¶ 61,236 (2012) *order on reh'g,* Order No. 773–A (May 17, 2013), 143 FERC ¶ 61,053 (2013), *rev'd sub nom. People of the State of N.Y.* v. *FERC,* 783 F.3d 946 (2d Cir. 2015); NERC Glossary at 7–9.

[87] NOPR, 181 FERC ¶ 61,125 at P 32; *see also* Reliability Standard PRC–002–2, Requirement R5.1.1 (specifying dynamic disturbance recording data for generation resource(s) with gross individual nameplate rating greater than or equal to 500 MVA, and gross individual nameplate rating greater than or equal to 300 MVA where the gross plant/facility aggregate nameplate rating is greater than or equal to 1,000 MVA).

[88] *See* NOPR, 181 FERC ¶ 61,125 at P 32 n.74 (citing NERC and WECC, *April and May 2018 Fault Induced Solar Photovoltaic Resource Interruption Disturbances Report,* 23 (Jan. 2019), *https://www.nerc.com/pa/rrm/ea/April_May_2018_Fault_Induced_Solar_PV_Resource_Int/April_May_2018_Solar_PV_Disturbance_Report.pdf* (Angeles Forest and Palmdale Roost Events Report) (covering the Angeles Forest (April 20, 2018) and Palmdale Roost (May 11, 2018) events and explaining that the ''widespread nature of power reduction across many facilities poses risks to [Bulk-Power System] performance and reliability'' and finding that the ''lack of available high-speed data at multiple inverter-based resources has hindered event analysis''); San Fernando Disturbance Report at 7; Odessa 2021 Disturbance Report at 11; NERC, *Odessa Disturbance Follow-up White Paper* (Oct. 2021), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_Odessa_Disturbance_Follow-Up.pdf* (Odessa Disturbance White Paper)).

[89] *See* NOPR, 181 FERC ¶ 61,125 at P 80 (stating that distribution providers should be permitted to provide IBR–DER modeling data and parameters ''in the aggregate or equivalent for IBR–DERs interconnected to their distribution systems (*e.g.,* IBR–DERs in the aggregate and modeled by resource type such as wind or solar PV, or IBR–DERs in the aggregate and modeled by interconnection requirements performance to represent different steady-state and dynamic behavior.''); *see also id.* n.159 (explaining that for IBR–DERs ''a certain degree of simplification may be needed either by model aggregation (*i.e.,* clustering of models with similar performance), by derivation of equivalent models (*i.e.,* reduced-order representation), or by a combination of the two.'').

[90] *See, e.g.,* Commission Staff, *Distributed Energy Resources Technical Considerations for the Bulk Power System Staff Report,* Docket No. AD18–10–000, 11–13 (filed Feb. 15, 2018) (Commission Staff IBR–DER Reliability Report) (explaining that, absent adequate data, many Bulk-Power System models and operating tools will not fully represent the effects of IBR–DERs in aggregate); *see also* IBR–DER Data Collection Guideline at 2 (recommending that transmission planners and planning coordinators update their data reporting requirements for Reliability Standard MOD–032–1, Requirement R1 to explicitly describe the requirements for aggregate IBR–DER data in a manner that is clear and consistent with their modeling practices. The IBR–DER Data Collection Guideline also recommended that transmission planners and planning coordinators establish modeling data requirements for steady-state IBR–DERs in aggregate and coordinate with their distribution providers to develop these requirements.).

[91] *See* Reliability Standard MOD–033–2 (Steady-State and Dynamic System Model Validation).

[92] This final action uses the term ''system models'' to refer collectively to planning and operations transmission area models and interconnection-wide models.

[93] *See* IBR Interconnection Requirements Guideline at 24 (stating that a systemic modeling issue was uncovered regarding the accuracy of the IBR dynamic models submitted in the interconnection-wide base cases following the issuance of the NERC Alert related to the Canyon 2 Fire disturbance).

[94] NERC, *Libraries of Standardized Powerflow Parameters and Standardized Dynamics Models version 1,* 1 (Oct. 2015), *https://www.nerc.com/comm/PC/Model%20Validation%20Working%20Group%20MVWG%202013/NERC%20Standardized%20Component%20Model%20Manual.pdf* (NERC Standardized Powerflow Parameters and Dynamics Models) (explaining that the NERC Modeling Working Group was tasked to develop, validate, and maintain a library of standardized component models and parameters for short-circuit, powerflow, and dynamics cases. The standardized models in these libraries have documentation describing their model structure, parameters, and operation. This information has been vetted by the industry and thus deemed appropriate for widespread use in planning, operations, and interconnection-wide analysis.).

[95] *See* Reliability Standard MOD–032–1, attach. 1 (explaining that if a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values, and names for all model parameters, and a list of all state variables).

owners may provide modeling data that is based on a user-defined model [96] rather than an approved and industry-vetted model.[97] The use of user-defined models in system models can be problematic because their internal model components cannot be viewed or modified, and thus they produce outputs that cannot be readily explained or verified.[98] Approved generator models that accurately reflect the generator behavior in steady state and dynamic conditions are necessary for Bulk-Power System planners and operators to adequately predict IBR behavior and the subsequent impact of IBRs on the Bulk-Power System.[99]

45. Any generation resource model's performance must be verified by the generator owner using real-world data to confirm that the generation resource model adequately reflects actual as-built settings, historic performance, and/or field-testing data.[100] The currently effective Reliability Standards MOD–026–1 (Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions) [101] and MOD–027–1 (Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions) [102] require each generator owner to verify models and data for specific components of synchronous resources (*e.g.,* generator excitation control systems, plant volt/var control functions, turbine/governor and load controls, and active power/frequency controls), but they do not require a generator owner to provide verified models and data for IBR-specific controls (*e.g.,* power plant central controller functions and protection system settings) to its transmission planner. Additionally, the currently effective Reliability Standards neither require the transmission owner for unregistered IBRs to provide verified dynamic models nor require distribution providers to provide verified dynamic models of IBR–DERs in the aggregate to their transmission planners. Finally, the currently effective Reliability Standards neither require the transmission owner for unregistered IBRs nor the distribution providers for IBR–DERs in the aggregate to submit the respective dynamic models to the applicable registered entities that perform planning and operations functions.

46. Once the generator owners for registered IBRs, transmission owners for unregistered IBRs, and distribution providers for IBR–DERs in the aggregate verify plant models, Bulk-Power System planners and operators must validate and update system models (*i.e.,* planning and operation transmission area models as well as interconnection-wide models) by comparing the provided data and resulting system models against actual system operational behavior. While Reliability Standard MOD–033–2 (Steady State and Dynamic System Model Validation) requires validation using real-world data of the interconnection-wide model,[103] the currently effective Reliability Standards lack clarity as to whether models of registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate are required to represent the real-world behavior of the equipment installed in the field during interconnection-wide disturbances that have exhibited common mode failures of IBRs.[104]

47. Once Bulk-Power System planners and operators validate system models,[105] there must be additional requirements for generator owners, transmission owners, and distribution providers to communicate with Bulk-Power System planners and operators to ensure that any changes to IBR settings, configurations, and ratings are updated. Otherwise, the transmission system models will not adequately represent the behavior of the actual installed equipment.[106] While Reliability Standards MOD–032–1 and MOD–033–2 include iterative updating and validation processes, Reliability Standard MOD–032–1 does not require IBR-specific modeling data and parameters, and Reliability Standard MOD–033–2 does not contemplate the technology-specific performance characteristics of registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate.

48. Once Bulk-Power System planners and operators have validated system models, Bulk-Power System planners and operators need to coordinate with generator owners, transmission owners, and distribution providers so that the system models adequately represent all generation resources—including registered IBRs, unregistered IBRs, IBR–DERs in the aggregate, and synchronous generation—as well as load. Reliability Standards MOD–032–1 and MOD–033–2 do not require the applicable entities to work collaboratively to create interconnection-wide models that

[96] Some commenters use the term ''proprietary'' to describe user-defined models. For purposes of this final action, the terms ''proprietary'' and ''user-defined'' models are synonymous. A user-defined model is a unique manufacturer-specific model that does not appear on the NERC approved component model list. In Order No. 2023, the Commission defined a ''user-defined model'' as any set of programming code created by equipment manufacturers or developers that captures the latest features of controllers that are mainly software-based and represents the entities' control strategies but does not necessarily correspond to any particular generic library model. *See* Order No. 2023, 184 FERC ¶ 61,054 at P 1660.

[97] NERC Standardized Powerflow Parameters and Dynamics Models at 1 (explaining that ''[s]ome of the model structures have information that is considered to be proprietary or confidential, which impedes the free flow of information necessary for interconnection-wide power system analysis and model validation.''); *see also* NERC, *Events Analysis Modeling Notification Recommended Practices for Modeling Momentary Cessation Initial Distribution,* 1 n.4 (Feb. 2018), *https://www.nerc.com/comm/PC/NERCModelingNotifications/Modeling_Notification_-_Modeling_Momentary_Cessation_-_2018-02-27.pdf* (explaining that more detailed vendor-specific models may be used for local planning studies; however, they are generally not allowed or recommended for building interconnection-wide models).

[98] *See, e.g.,* EPRI, *Model User Guide for Generic Renewable Energy System,* 2 (June 2015), *https://www.epri.com/research/products/000000003002006525* (explaining that the ''models presented here were developed primarily for the purpose of general public use and benefit and to eliminate the long standing issues around many vendor-specific models being proprietary and thus neither publicly available nor easily disseminated among the many stakeholders. Furthermore, using multiple user-defined non-standard models within large interconnection studies, in many cases, presented huge challenges and problems with effectively and efficiently running the simulations.'').

[99] NERC Standardized Powerflow Parameters and Dynamics Models at 1 (explaining that there is a growing need for accurate interconnection-wide power flow and dynamics simulations that analyze phenomena such as: frequency response, inter-area oscillations, and interactions between the growing numbers of wide-area control and protections systems).

[100] *Id.* (explaining that the NERC Modeling Working Group was tasked to develop, validate, and maintain a library of standardized component models and parameters for powerflow and dynamics cases. The standardized models in these libraries have documentation describing their model structure, parameters, and operation. This information has been vetted by the industry and thus deemed appropriate for widespread use in interconnection-wide analysis).

[101] *See* Reliability Standard MOD–026–1.

[102] *See* Reliability Standard MOD–027–1.

[103] Reliability Standard MOD–033–2, Requirements R1, R2.

[104] NERC annually assesses the interconnection-wide model quality and publishes a report to help entities responsible for complying with Reliability Standard MOD–032 to resolve model issues and improve the cases. NERC's 2021 Case Quality Metrics Assessment indicates that planners are not able to develop accurate system models (*e.g.,* all interconnections demonstrate either a consistent performance or worsening score in the unacceptable or not recommended model metrics). *See* NERC, *Case Quality Metrics Annual Interconnection-wide Model Assessment,* 26–29 (Oct. 2021), *https://www.nerc.com/pa/RAPA/ModelAssessment/ModAssessments/2021_Case_Quality_Metrics_Assessment-FINAL.pdf.*

[105] This final action uses ''validation'' to mean the confirmation that a model reflects real world operational behaviors and uses ''verification'' to mean a model is properly parameterized and validated.

[106] *See* NOPR, 181 FERC ¶ 61,125 at P 39 n.91.

accurately reflect the real-world interconnection-wide performance and behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate.[107] As a result, the models developed and deployed in compliance with these standards do not contemplate that IBRs can reduce power, trip offline, or enter momentary cessation individually or in the aggregate in response to a single fault on a transmission or sub-transmission system.

3. Planning and Operational Studies

49. Once Bulk-Power System planners and operators have validated registered IBR, unregistered IBR, and IBR–DER aggregate modeling and operational data, the Reliability Standards must require that Bulk-Power System planning and operational studies account for the actual behavior of both registered IBRs and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate. The Reliability Standards do not require Bulk-Power System planning and operational studies to assess the performance and behavior of both registered and unregistered IBRs individually and in the aggregate (*e.g.,* IBRs tripping or entering momentary cessation individually or in the aggregate), as well as IBR–DERs in the aggregate. Reliability Standard TPL–001–5.1 (Transmission System Planning Performance Requirements) requires planning coordinators and transmission planners to plan to ensure reliable operations over a broad spectrum of system conditions and following a wide range of probable contingencies, but it does not require planning coordinators and transmission planners to assess the performance and behavior of registered and unregistered IBRs individually and in the aggregate, or IBR–DERs in the aggregate, during normal and contingency conditions for the reliable operation of the Bulk-Power System.[108]

NERC has stated that the currently effective Reliability Standards do not mitigate the IBR reliability risks because the IBR issues are not properly detected by models and studies.[109] NERC has also found that there is an immediate need to enhance the currently effective Reliability Standards. NERC explains that there is a need to understand the extent of inverter performance risks and modeling deficiencies as well as to gather necessary data for the currently installed fleet.[110]

4. Performance Requirements

50. The currently effective Reliability Standards do not account for the differences in response of registered IBRs and synchronous generation resources during normal and contingency conditions. The frequency of an interconnection depends on the instantaneous balance between load and generation resources, to which all resources contribute during both normal and contingency conditions. For frequency to be maintained, generation resources must remain connected to the grid and continue to support grid frequency (*i.e.,* ride through) during either loss of generation (underfrequency) or loss of load (overfrequency) related frequency deviations. Reliability Standard PRC–024–3 does not require registered IBRs (or any generator) to remain connected to the Bulk-Power System and to continue to inject current and support frequency inside the ''no trip zone.'' [111] Therefore, IBRs could continue to act adversely in response to normally cleared faults by continuing to exhibit momentary cessation and power reduction behaviors.

51. In addition, the currently effective Reliability Standards do not require registered IBRs to continually inject current and support voltage inside the ''no trip zone'' during a voltage excursion.[112] The Reliability Standards also do not contain voltage ride through performance requirements that address the unique protection and control functions of registered IBRs that can cause tripping and momentary cessation, even when the IBR voltage protection settings comply with Reliability Standard PRC–024–3.

52. Finally, the currently effective Reliability Standards do not require all generation resources that momentarily cease operation following a system disturbance to return to pre-disturbance output levels without impeded ramp rates or require that all generation resources maintain voltage phase angle synchronization with the Bulk-Power System grid voltage during a system disturbance. IBRs that lose synchronization with grid voltage (*i.e.,* phase lock loop loss of synchronism) will momentarily cease current injection into the grid during Bulk-Power System disturbance events due to protection and control settings. Such momentary cessation occurrences exacerbate system disturbances and have a material impact on the reliable operation of the Bulk-Power System.[113]

IV. Discussion

53. As discussed below, the Commission finds that the currently effective Reliability Standards do not adequately address the risks posed by the increasing numbers of IBRs connecting to the Bulk-Power System. As noted by NERC in its initial comments, IBRs can introduce significant risks to the Bulk-Power System if not integrated properly, and NERC sees addressing such risks as a high priority for the ERO.[114] While NERC has initiated various projects to address aspects of IBR reliability, we find that the actions we take in this final action are necessary to maintain the reliable operation of the Bulk-Power System. Accordingly, pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposals with some modifications and direct NERC to develop and submit new or modified Reliability Standards that address the impacts of IBRs on the reliable operation of the Bulk-Power System. Given the current and projected increase in the proportion of IBRs within the

[107] Reliability Standard MOD–032–1 is applicable to the following registered entities: (1) balancing authorities, (2) generator owners, (3) planning authorities/planning coordinators, (4) load serving entity, (5) resource planners, (6) transmission owners, (7) transmission planners, and (8) transmission service providers. NERC has deregistered the load serving entity function and has an ongoing standard drafting team project to replace this function as an applicable entity in the Reliability Standards with the distribution provider function. *See* Project–2022–02 Modifications to TPL–001 and MOD–032.

[108] Reliability Standard TPL–001–5.1 (Transmission System Planning Performance Requirements) was approved by the Commission and became effective on July 1, 2023. *See N. Am. Elec. Reliability Corp.,* Docket No. RD20–8–000 (June 10, 2020) (delegated letter order) (approving a NERC-proposed erratum to Reliability Standard TPL–001–5); *Transmission Plan. Reliability Standard TPL–001–5,* Order No. 867, 170 FERC ¶ 61,030 (2020) (approving Reliability Standard TPL–001–5).

[109] *See* Odessa 2021 Disturbance Report at 43 (explaining that ''[p]lants are abnormally responding to [Bulk-Power System] disturbance events and ultimately tripping themselves off-line. These issues are not being properly detected by the models and studies conducted during the generator interconnection study process nor during annual planning assessments.'').

[110] Odessa 2022 Disturbance Report at vii–ix.

[111] Reliability Standard PRC–024–3 is a voltage and frequency protection settings standard that specifies that a generating resource may neither trip nor enter momentary cessation (*i.e.,* cease injecting current) inside the boundaries of the frequency and voltage excursion curves. The area inside the boundaries of the frequency and voltage excursion curves is known as the ''no-trip zone.'' *See also* Reliability Standard PRC–024–3, attach. 1, nn.8, 9.

[112] The NOPR used both terms current and power when proposing to direct NERC to develop new or modified Reliability Standards that address registered IBRs' performance requirements. For clarity in this final action, we only use ''current'' when directing NERC to develop new or modified Reliability Standards that address registered IBRs' performance requirements.

[113] *See* NOPR, 181 FERC ¶ 61,125 at P 4.

[114] NERC Initial Comments at 2.

Bulk-Power System generation fleet, and for the reasons discussed in section III above, we conclude that it is necessary to direct NERC to develop new or modified Reliability Standards that address the following specific matters: (1) generator owner data sharing for registered IBRs, transmission owner data sharing for unregistered IBRs, and distribution provider data sharing for IBR–DERs in the aggregate; (2) data and model validation for registered and unregistered IBRs and IBR–DERs in the aggregate; (3) planning and operational studies for registered and unregistered IBRs individually and in the aggregate and for IBR–DERs in the aggregate; and (4) registered IBR performance requirements.

54. In directing the ERO to submit new or modified Reliability Standards, we do not direct a specific method for addressing the reliability concerns discussed herein. Rather, in this final action we identify issues that should be addressed in the NERC standards development process. Further, NERC has the discretion, subject to Commission review and approval, as to how to address the reliability concerns described below by developing one or more new Reliability Standards or modifying currently effective Reliability Standards. We direct NERC to develop new or modify the currently effective Reliability Standards to address these issues and, when these Reliability Standards are submitted to the Commission for approval, to explain in the accompanying petition how the issues are addressed in the proposed new or modified Reliability Standards. NERC may propose to develop new or modified Reliability Standards that address our concerns in an equally efficient and effective manner; however, NERC's proposal should explain how the new or modified Reliability Standards address the Commission's concerns discussed in this final action.[115]

55. We modify the NOPR proposal and direct NERC to submit an informational filing within 90 days of the issuance of the final action in this proceeding that includes a detailed, comprehensive standards development plan explaining how NERC will prioritize the development of new or modified Reliability Standards to meet the deadlines set out below, taking into account the risk posed to the reliability of the Bulk-Power System, standard development projects already underway, resource constraints, and other factors if necessary.

56. As discussed below, we are persuaded by commenters' suggestions regarding the proposed staggered groupings for new or modified Reliability Standards, and we modify the NOPR proposal to adopt NERC's proposed staggered grouping that would result in NERC submitting new or modified Reliability Standards in three stages.[116] Therefore, in its comprehensive standards development plan, NERC must submit new or modified Reliability Standards by the following deadlines. First, by November 4, 2024, NERC must submit new or modified Reliability Standards that establish IBR performance requirements, including frequency and voltage ride through, post-disturbance ramp rates, phase lock loop synchronization, and other known causes of IBR tripping or momentary cessation. NERC must also submit, by November 4, 2024, new or modified Reliability Standards that require disturbance monitoring data sharing and post-event performance validation for registered IBRs. Second, by November 4, 2025, NERC must submit new or modified Reliability Standards addressing the interrelated directives concerning: (1) data sharing for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate; and (2) data and model validation for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate. Finally, by November 4, 2026, NERC must submit new or modified Reliability Standards addressing planning and operational studies for registered IBRs, unregistered IBRs, and IBR–DER in the aggregate. NERC may expedite its development plan and submit new or modified Reliability Standards prior to the deadlines.

57. While the NOPR proposed directing NERC to include implementation dates (*i.e.,* when the standards would become mandatory and enforceable) in its standards development plan, we are persuaded by NERC's comments that the implementation of new or modified Reliability Standards is better determined through the NERC standards drafting process. Therefore, we do not adopt the NOPR proposal to direct NERC to include implementation dates in its standards development plan. Rather, the Commission will consider the justness and reasonableness of each new or modified Reliability Standard's implementation plan when it is submitted for Commission approval.[117] However, as discussed above, the number of events, NERC Alerts, reports, whitepapers, guidelines, and ongoing standards projects demonstrate the need for the expeditious implementation of new or modified Reliability Standards addressing IBR data sharing, data and model validation, planning and operational studies, and performance requirements.[118] Accordingly, the Commission will take these issues into account when it considers the proposed implementation plan for each new or modified Reliability Standard when it is submitted to the Commission for review. Moreover, as a general matter, we believe that there is a need to have all of the directed Reliability Standards effective and enforceable well in advance of 2030, at which time IBRs are projected to account for a significant share of the electric energy generated in the United States.[119]

58. We address below in further detail issues raised in the NOPR and in comments regarding: (A) Commission authority to direct the ERO to develop new or modified Reliability Standards under FPA section 215(d)(5); (B) data sharing, including registered IBR data, disturbance monitoring data, unregistered IBR data, and data for IBR–DERs in the aggregate; (C) data and model validation, including approved models, dynamic model performance, validation of system models, and coordination; (D) planning and operational studies; (E) performance requirements; and (F) the informational filing and associated timeline for Reliability Standard development.

A. Commission Authority To Direct the ERO To Develop New or Modified Reliability Standards Under Section 215 of the FPA

59. In the NOPR, the Commission preliminarily found that the currently

[115] *See, e.g.,* Order No. 693, 118 FERC ¶ 61,218 at PP 186, 297.

[116] In the NOPR, the Commission proposed a staggered approach that would result in NERC submitting new or modified Reliability Standards in three stages. *See* NOPR, 181 FERC ¶ 61,125 at PP 8, 73. In the final action, we are changing the *content* of the three staggered filings.

[117] *See* Order No. 672, 114 FERC ¶ 61,104 at P 333 (''In considering whether a proposed Reliability Standard is just and reasonable, the Commission will consider also the timetable for implementation of the new requirements, including how the proposal balances any urgency in the need to implement it against the reasonableness of the time allowed for those who must comply.'').

[118] *See supra* P 7.

[119] *See, e.g.,* U.S. Energy Information Admin., *Annual Energy Outlook 2023* (Mar. 16, 2023), *https://www.eia.gov/outlooks/aeo/narrative/index.php#TheElectricityMixinth* (projecting that renewables will account for a significant portion of the electric energy generated in the United States by 2030). The U.S. Energy Industry Association defines the major types of renewable energy sources to include resources such as biomass, hydropower, geothermal, wind, and solar (*e.g.,* Stirling cycle, solar PV, and concentric solar). *See https://www.eia.gov/energyexplained/renewable-sources/.* Of these resources, solar PV and wind generation are IBRs.

effective Reliability Standards do not adequately address the impacts of IBRs on the reliable operation of the Bulk-Power System.[120] The NOPR stated that this constitutes a reliability gap in the areas of: (1) data sharing; (2) model validation; (3) planning and operational studies; and (4) performance requirements. To carry out section 215 of the FPA, the NOPR proposed to direct NERC to develop and submit for approval new or modified Reliability Standards that address IBRs and their impacts on the reliable operation of the Bulk-Power System.

1. Comments

60. NERC supports the Commission's efforts and agrees that the currently effective Reliability Standards must be enhanced to address the reliability risks posed by IBRs.[121] Further, NERC and the majority of commenters that responded on this topic generally support the four topic areas for new or modified Reliability Standards (*i.e.,* data sharing, model validation, planning and operational studies, and performance requirements) that the Commission outlined in the NOPR.[122]

61. Commenters agree that IBRs affect the reliable operation of the Bulk-Power System and that some modifications to the currently effective Reliability Standards are warranted.[123] For example, IRC states that IBRs may have an impact on the reliability of the Bulk-Power System regardless of their size, registration status, or their interconnection level (*i.e.,* connected to transmission or distribution).[124] ACP/SEIA agree there is a need for clarity and consistency for IBRs and their Reliability Standard obligations.[125] EPRI states that its research and collaboration has shown that uniform technical performance requirements, including ride through requirements, can support system reliability.[126] Indicated Trade Associations agree that it is necessary to manage the impact of the increase of IBRs on the Bulk-Power System through new or modified Reliability Standards.[127]

62. Ohio FEA, noting that the majority of IBR-related events discussed in the NOPR predominantly took place in Texas and California, defers to the Commission's findings regarding gaps in the currently effective Reliability Standards for IBRs and emphasizes that it is the Commission's role within its FPA section 215 authority to protect Bulk-Power System reliability by directing NERC to develop new or modified Reliability Standards.[128] Nevertheless, Ohio FEA also notes that the definition of ''Bulk-Power System'' does not include facilities used in the local distribution of electric energy; and Ohio FEA emphasizes that there is a dividing line between the Commission's authority over the Bulk-Power System and its authority over its distribution system.[129] Further, Ohio FEA cautions that there could be potential conflicts in the reliability objectives, standards, and guidelines related to IBRs on the transmission system versus the distribution system.[130]

2. Commission Determination

63. We find that the directives in this final action are a valid exercise of the Commission's authority pursuant to FPA section 215(d)(5). The plain language of the statute authorizes the Commission to order the development of a Reliability Standard that ''addresses a specific matter if the Commission considers such a new or modified Reliability Standard appropriate to carry out this section.'' [131]

64. We determine that directing NERC, as the ERO, to address the specific matters pertaining to IBRs and their impact on the reliable operation of the Bulk-Power System is appropriate to carry out FPA section 215. As the NOPR stated, and as discussed in section III above, there are multiple ERO findings of the reliability impacts of IBRs, including guidelines, white papers, assessments, event reports, and NERC Alerts, among others. Further, NERC has already begun efforts to address IBR reliability issues through projects to improve the mandatory Reliability Standards.[132] As Bulk-Power System events continue to occur and the risks that IBRs can pose to reliable operation of the Bulk-Power System are demonstrated, there is an urgent need to develop and implement mandatory Reliability Standards to address these issues on a nationwide basis.

65. Section 215 of the FPA defines ''reliability standard'' as a requirement to provide for reliable operation of the Bulk-Power System.[133] FPA section 215 defines ''reliable operation'' to mean operating Bulk-Power System elements within their thermal, voltage, and stability limits to prevent or avoid instability, uncontrolled separation, or cascading failures as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements.[134] We are aware of the Commission's jurisdictional boundaries as noted by Ohio FEA. Thus, the directives in this final action are to NERC as the ERO to develop new or modified Reliability Standards to require the reliable operation of the Bulk-Power System. While certain directives pertain to registered entities such as distribution providers obtaining aggregate data for IBR–DERs, the final action does not impose any requirements on non-registered entities or facilities used in the local distribution of electric energy.[135] Regarding Ohio FEA's concerns about the need for coordination between transmission system operators and distribution providers regarding their different performance requirements,[136] as the Commission has explained, the IBR Registration Order and NERC's related work plan do not address the registration of IBR–DERs.[137] NERC has committed to examine potential impacts of IBR–DERs on the reliable operation of the Bulk-Power System; thus, we would expect that as a part of NERC's communication plan it would consider how to address related coordination issues between transmission operators and distribution providers.[138]

[120] NOPR, 181 FERC ¶ 61,125 at P 68.

[121] NERC Initial Comments at 7.

[122] *See, e.g., id.;* AEP Initial Comments at 2; Bonneville Initial Comments at 1; CAISO Initial Comments at 1; NYSRC Initial Comments at 1.

[123] *See, e.g.,* AEU Initial Comments at 2 (agreeing the IBRs may cause adverse reliability impacts and contribute reliability benefits to the Bulk-Power System); InfiniRel Initial Comments at 1 (stating that ''[n]ew or modified Reliability Standards are necessary to address the IBR-related reliability gaps'').

[124] IRC Initial Comments at 2.

[125] ACP/SEIA Initial Comments at 4.

[126] EPRI Initial Comments at 4.

[127] Indicated Trade Association Comments at 1.

[128] Ohio FEA Initial Comments at 4.

[129] *Id.* at 5.

[130] Ohio FEA notes that transmission system operators prefer generators to ride-through short duration transmission faults, while distribution system operators typically prefer generators to trip off during distribution faults. Ohio FEA Initial Comments at 6.

[131] 16 U.S.C. 824o(d)(5).

[132] *See supra* P 32.

[133] 16 U.S.C. 824o(a)(3).

[134] *Id.* 824o(a)(4).

[135] *Id.* 824o(a)(1).

[136] Ohio FEA notes that transmission system operators prefer generators to ride-through short duration transmission faults, while distribution system operators typically prefer generators to trip off during distribution faults. Ohio FEA Initial Comments at 6.

[137] *See* Order Approving Workplan, 183 FERC ¶ 61,116 at P 48 (citing IBR Registration Order, 181 FERC ¶ 61,124 at P 1 n.1 (stating that the order does not address IBRs connected to the distribution system)). *See also id.* P 1 n.2 (citing 16 U.S.C. 824o(a)(1), which explains that the term ''Bulk-Power System'' does not include facilities used in the local distribution of electric energy).

[138] *See Id.* P 15 (explaining that NERC's communication plan outlines how NERC will coordinate with key stakeholders).

B. Data Sharing

66. In the NOPR, the Commission preliminarily found that the existing Reliability Standards are inadequate to ensure that sufficient data of registered IBRs and unregistered IBRs, and data of IBR–DERs in the aggregate, are provided to the registered entities responsible for planning, operating, and analyzing disturbances on the Bulk-Power System.[139] The Commission observed that the currently effective Reliability Standards, such as TOP–003–5 (Operational Reliability Data) and IRO–010–4 (Reliability Coordinator Data Specification and Collection),[140] require the data recipient to specify a list of data to be provided, and obligates other identified registered entities to provide the specified data. The Commission preliminarily found that these and other currently effective data-related Reliability Standards do not require generator owners, generator operators, transmission owners, and distribution providers to provide data that represents the behavior of both registered and unregistered IBRs individually and in the aggregate, as well as data of IBR–DERs in the aggregate, at a sufficient level of fidelity for Bulk-Power System planners and operators to accurately plan for, operate during, and analyze disturbances on the Bulk-Power System.[141]

67. To address this data sharing gap in the currently effective Reliability Standards, the Commission proposed to direct NERC to develop new or modified Reliability Standards that identify: (1) the registered entities that must provide certain data of registered IBRs and unregistered IBRs, as well as IBR–DER data in the aggregate; (2) the recipients of that registered IBR, unregistered IBR, and IBR–DER in the aggregate data; (3) the minimum categories or types of registered IBR, unregistered IBR, and IBR–DER in the aggregate related data that must be provided; and (4) the timing and periodicity for the provision of registered IBR, unregistered IBR, and IBR–DER in the aggregate data needed for modeling, operations, and disturbance analysis to the appropriate registered entities and the review of that data by those entities.[142]

1. Registered IBR Data Sharing

68. In the NOPR, the Commission proposed to direct NERC to develop new or modified Reliability Standards that require generator owners and generator operators of registered IBRs to provide registered IBR-specific modeling data and parameters (*e.g.,* steady-state, dynamic, and short circuit modeling information, and control settings for momentary cessation and ramp rates) that accurately represents IBRs to their planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities that are responsible for planning and operating the Bulk-Power System.[143] The Commission explained that this approach would provide the registered entities responsible for planning and operating the Bulk-Power System with accurate data on registered IBRs.[144]

a. Comments

69. Commenters generally support the proposed directive to require IBR generator owners and generator operators to provide registered IBR-specific modeling data and parameters to planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities.[145]

70. NERC states that poor or inadequate IBR data, models, and information have proven to be a significant issue. For example, generator owners may provide modeling data and information that is generic or based on default parameters that do not reflect the as-built facility.[146] NERC states that providing adequate modeling data and information is critical to create and maintain models that represent necessary modeling data quality and accuracy, adding that data accuracy, completeness, usability, and fidelity should be explicitly defined, tested, and verified by all applicable entities, particularly for modeling information used in reliability studies.[147]

71. Indicated Trade Associations and APS explain that the currently effective Reliability Standards may not ensure that transmission planners or operators have all necessary criteria and metrics to plan for and reliably integrate certain IBRs on the Bulk-Power System.[148] CAISO explains that its experience shows that modern IBRs are capable of complying with data sharing and data and model validation requirements.[149] Further, CAISO supports national standards establishing data sharing, and data and model validation guidelines, as a patchwork approach would be inefficient (*e.g.,* a significant number of IBRs participating in the CAISO's markets are not bound by the currently effective Reliability Standards and CAISO's standards do not bind across the Western Electricity Coordinating Council).[150]

72. SPP states that it has heard from IBR owners that they have concerns that some IBR data (and IBR–DER data) may be considered proprietary by manufacturers and difficult to obtain. Nevertheless, SPP contends that such concerns should not obstruct reliability improvements and suggests that the final action should provide the correct incentive for IBR owners to either use equipment that meets data sharing requirements (*i.e.,* equipment that is not proprietary) or develop agreements or other protections for IBR data that is considered proprietary.[151]

73. ACP/SEIA suggest modifying the directives to require generator owners and operators to share IBR data. ACP/SEIA recommend that, rather than mandating specific modeling and data submissions, planning entities should have flexibility to identify the data they need for their operations and planning activities, and that the new or modified Reliability Standards should ensure that the data requested is reasonable and necessary for improving reliability.[152]

74. AEU and ACP/SEIA ask that, in addition to data provision requirements for generator owners and operators, the Commission direct NERC to specify data sharing requirements from transmission owners to generator owners.[153] For example, AEU explains that generator owners and operators also require data from transmission owners to support accurate modeling and performance, *e.g.,* short circuit data, grid data for offshore wind, information on other power electronic devices around the IBR plant, and voltage harmonics.[154] AEU adds that putting requirements on transmission owners would be consistent with revisions being developed for NERC's Modeling, Data, and Analysis (MOD) Reliability Standards.[155]

75. ACP/SEIA, Mr. Plankey, and Ohio FEA raise security concerns and the

[139] NOPR, 181 FERC ¶ 61,125 at P 76.

[140] Reliability Standard TOP–003–5 and Reliability Standard IRO–010–4 became effective April 1, 2023.

[141] NOPR, 181 FERC ¶ 61,125 at P 76.

[142] *Id.* P 77.

[143] *Id.* P 78.

[144] *Id.*

[145] *See, e.g.,* NERC Initial Comments at 8; CAISO Initial Comments at 24.

[146] NERC Initial Comments at 8.

[147] *Id.* at 8–9.

[148] Indicated Trade Associations Initial Comments at 4–5; APS Initial Comments at 2 (indicating it largely supports Indicated Trade Associations Initial Comments but providing additional comments on specific topics).

[149] CAISO Initial Comments at 7.

[150] *Id.* at 30–31.

[151] SPP Initial Comments at 2.

[152] ACP/SEIA Initial Comments at 11–12.

[153] AEU Initial Comments at 4; ACP/SEIA Initial Comments at 12–13.

[154] AEU Initial Comments at 4.

[155] *Id.* at 5.

need for accountability and protection of data sharing.[156] Ohio FEA recommends that NERC's Electricity Information Sharing and Analysis Center (E–ISAC) could serve as a facilitator for IBR data sharing.[157]

b. Commission Determination

76. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require registered IBR generator owners and operators to provide IBR-specific modeling data and parameters (*e.g.,* steady-state, dynamic, and short circuit modeling information, and control settings for momentary cessation and ramp rates) that accurately represent the registered IBRs to their planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities that are responsible for planning and operating the Bulk-Power System. As several commenters indicate, ensuring the sharing of appropriate IBR modeling data is critical to create and maintain the models used in reliability studies, and in turn to ensure that Bulk-Power System transmission planners or operators are able to plan for, operate, and reliably integrate IBRs onto the Bulk-Power System.

77. With regard to AEU and ACP/SEIA's comments that the Commission direct NERC to specify data sharing requirements from transmission owners to generator owners and operators, we believe that this request may already be addressed through each transmission planner's existing processes. For example, the New York Independent System Operator (NYISO) and CAISO both have processes for obtaining such data after demonstrating a need for the specific information requested and that the required information protection and non-disclosure agreements are signed.[158] Nevertheless, to support accurate modeling and performance, we direct NERC to consider during its standards development process AEU and ACP/SEIA's suggested data sharing requirements when developing the framework, criteria, and necessary data exchange requirements to meet the registered IBR data sharing directive.

78. Commenters raised general concerns that mandating specific modeling and data submissions would reduce the flexibility and discretion of transmission planners and operators to identify the information they need. We find that, given the need for IBRs to operate in a predictable and reliable manner to ensure the reliable operation of the Bulk-Power System, it is necessary to establish uniform, minimum categories or types of data that must be provided so that Bulk-Power System planners and operators can predict the behavior of all IBRs. As discussed in more detail in section IV.C of this final action, we are also directing NERC to develop new or modified Reliability Standards that require the use of approved industry IBR models that accurately reflect the behavior of all IBRs during steady state, short-circuit, and dynamic conditions.

79. With regard to SPP's comment that some IBR data (and IBR–DER data) may be considered proprietary (user-defined) by manufacturers and difficult to obtain, we believe that the directives in this final action should facilitate the provision of IBR data and address these concerns further in the determination section IV.C.1 of this final action.

80. The Commission did not propose in the NOPR to address new cyber or physical security protections of IBRs beyond those in existing applicable Reliability Standards. Therefore, while we decline to direct NERC to develop IBR-specific cyber or physical security Reliability Standards for IBRs in this effort, NERC should evaluate whether there are gaps that must be addressed. We decline to direct that the NERC E–ISAC facilitate all IBR data sharing, as these suggestions fall outside the scope of this proceeding.

2. Disturbance Monitoring Data Sharing

81. In the NOPR, the Commission proposed to direct NERC to develop new or modified Reliability Standards that include technical criteria for disturbance monitoring equipment installed at buses and elements of registered IBRs to ensure disturbance monitoring data is available to Bulk-Power System planners and operators for analyzing disturbances on the Bulk-Power System and to validate registered IBR models.[159]

a. Comments

82. NERC, ACP/SEIA, CAISO, Indicated Trade Associations, and NYSRC support the proposed directive regarding disturbance monitoring data.[160] NERC agrees that disturbance monitoring data is fundamental for model validation and post-event analysis activities, and to identify reliability risks. NERC and Indicated Trade Associations both point to NERC Project 2021–04 (Modifications to Reliability Standard PRC–002–2), a NERC standard development project to modify disturbance monitoring and reporting requirements so that Bulk-Power System-connected IBRs are monitored in order to better assess disturbances.[161] NERC explains that the currently effective Reliability Standard PRC–002–2 was originally written with synchronous generation in mind, as that was the predominant form of generation in use at the time.[162] Thus, NERC explains that it is necessary to update currently effective Reliability Standard PRC–002–2 so that it requires registered IBRs to provide minimum disturbance monitoring data [163] to the planning coordinator or reliability coordinator, Regional Entity, or NERC.

83. CAISO encourages the Commission to direct NERC to consider requiring IBRs to provide additional data, whether through telemetry collections or other automated platform integrations, to enhance real-time visibility of Bulk-Power System operations.[164]

84. ACP/SEIA agree with the proposed disturbance monitoring directive but caution that there is a need to balance the burden to the generator of collecting and providing the data with the benefit of that data to reliability, *e.g.,* requiring high-speed data collection from every inverter at a plant is unnecessary because each inverter would provide nearly identical data.[165]

b. Commission Determination

85. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal to direct NERC to include in the new or modified Reliability Standards technical criteria to require registered IBR generator owners to install disturbance monitoring equipment at their buses

[156] ACP/SEIA Initial Comments at 12; Mr. Plankey Initial Comments at 1; Ohio FEA Initial Comments at 9.

[157] Ohio FEA Initial Comments at 9.

[158] *See* NYISO, *What to expect when submitting a CEII Request form* (Sep. 9, 2021), *https://nyiso.force.com/MemberCommunity/s/article/What-to-expect-when-submitting-a-CEII-Request-form;* CAISO, *Application access, http://www.caiso.com/participate/Pages/ApplicationAccess/Default.aspx* (explaining that the process for secure planning and market systems data are available upon compliance with the applicable submission instructions and submittal of a non-disclosure agreement).

[159] NOPR, 181 FERC ¶ 61,125 at P 78.

[160] *See* NERC Initial Comments at 9; ACP/SEIA Initial Comments at 12; CAISO Initial Comments at 39–40; Indicated Trade Associations Initial Comments at 6; NYSRC Initial Comments at 2.

[161] NERC Initial Comments at 9; Indicated Trade Associations Initial Comments at 6.

[162] *See* NERC Initial Comments at 9.

[163] Disturbance monitoring data collection may include sequence of events recording, digital fault recording, synchronized phasor measurement unit recording, inverter oscillography recording data, and inverter and plant-level fault codes.

[164] CAISO Initial Comments at 40.

[165] ACP/SEIA Comments at 12.

and elements, to require registered IBR generator owners to provide disturbance monitoring data to Bulk-Power System planners and operators for analyzing disturbances on the Bulk-Power System, and to require Bulk-Power System planners and operators to validate registered IBR models using disturbance monitoring data from installed registered IBR generator owners' disturbance monitoring equipment.[166] We agree with NERC that updating Reliability Standard PRC–002–2 to apply to registered IBRs for disturbance monitoring data collection, including recording sequence of events, digital faults, synchronized phasor measurements, inverter oscillography, inverter and plant-level fault codes, and data retention, could be one way to accomplish this directive. We further agree with the findings in NERC reports (*e.g.,* a lack of high-speed data captured at the IBR or plant-level controller and low-resolution time stamping of inverter sequence of event recorder information has hindered event analysis) and direct NERC through its standard development process to address these findings.[167]

86. As a general matter, we agree with ACP/SEIA regarding the need to balance the burden to generator owners of collecting and providing data collected by disturbance monitoring equipment with the benefit of that data to reliability. Thus, in developing the directed data collection requirements, we direct NERC to consider the burdens of generators collecting and providing data, while assuring that Bulk-Power System operators and planners have the data they need for accurate disturbance monitoring and analysis.[168] Likewise, regarding CAISO's request that the Commission direct NERC to consider requiring registered IBRs to provide additional data, we agree that such data collections may be warranted, and direct NERC to consider through its standards development process whether additional IBR data points (*e.g.,* telemetry collections or other automated platform integrations) are needed to further enhance real-time visibility of Bulk-Power System operations.

3. Unregistered IBR and IBR–DER Data Sharing

87. In the NOPR, the Commission preliminarily found that the currently effective Reliability Standards do not ensure that Bulk-Power System planners and operators receive modeling data and parameters regarding unregistered IBRs that, individually or in the aggregate, are capable of adversely affecting the reliable operation of the Bulk-Power System. The Commission also preliminarily found that the currently effective Reliability Standards do not require that Bulk-Power System planners and operators receive modeling data and parameters regarding IBR–DERs that in the aggregate are capable of adversely affecting the reliable operation of the Bulk-Power System. The Commission preliminarily determined that planning coordinators and other entities need modeling data and parameters for both unregistered IBRs and IBR–DERs in the aggregate to assure greater accuracy in modeling.[169]

88. The Commission proposed to direct NERC to submit new or modified Reliability Standards addressing IBR data sharing that require transmission owners to provide modeling data and parameters (*e.g.,* steady-state, dynamic, and short circuit modeling information, and control settings for momentary cessation and ramp rates) to appropriate registered entities (*e.g.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities) for unregistered IBRs in their transmission owner areas where unregistered IBRs individually or in the aggregate materially affect the reliable operation of the Bulk-Power System.[170] The Commission similarly proposed to direct NERC to develop new or modified IBR data sharing Reliability Standards that require distribution providers to provide modeling data and parameters to appropriate registered entities (*e.g.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities) for IBR–DERs in the aggregate connected in their distribution provider areas where those IBR–DERs in the aggregate materially affect the reliability of the Bulk-Power System and are not otherwise subject to compliance with Reliability Standards.[171]

89. The Commission stated that this approach would be similar to that taken in other Reliability Standards that require transmission owners and distribution providers to provide certain planning and operational data received from unregistered entities to appropriate registered entities (*e.g.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities).[172] The Commission recognized that, given the small size and location of many of the IBR–DERs on the distribution system, it may not be practical for distribution providers to provide modeling data and parameters to model individual IBR–DERs directly.[173] The Commission instead proposed that the new or modified Reliability Standards should permit distribution providers to provide modeling data and parameters of IBR–DERs in the aggregate or equivalent for IBR–DERs interconnected to their distribution systems (*e.g.,* IBR–DERs in the aggregate and modeled by resource type such as wind or solar PV, or IBR–DERs in the aggregate and modeled by interconnection requirements performance to represent different steady-state and dynamic behavior) to appropriate registered entities (*i.e.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities).[174]

[166] *See* NERC, *NERC Inverter-Based Resource Performance Task Force (IRPTF)Review of NERC Reliability Standards White Paper,* at 1 (Mar. 2020), *https://www.nerc.com/pa/Stand/Project202104ModificationstoPRC0022DL/Review_of_NERC_Reliability_Standards_White_Paper_062021.pdf* (explaining that PRC–002–2 should be revised to require disturbance monitoring equipment in areas not currently contemplated by the existing requirements, specifically in areas with potential inverter-based resource behavior monitoring benefits); *see also* Odessa Disturbance White Paper at 5 (explaining there are standard features for modern inverters that should be enabled within IBR plants to better understand their response to grid events and improve overall fleet performance).

[167] *See supra* note 88.

[168] *See* Order No. 693, 118 FERC ¶ 61,218 at P 188 (in directing NERC to address or consider NOPR comments, the Commission explained that it ''does not direct any outcome other than that the comments receive consideration'').

[169] NOPR, 181 FERC ¶ 61,125 at P 79.

[170] *Id.*

[171] *Id.* (citing NERC, *Reliability Guideline: Parameterization of the DER_A Model,* 8–16 (Sept. 2019), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_A_Parameterization.pdf* (2019 DER_A Model Guideline) (retired)).

[172] *Id.* P 80 (noting that this approach is consistent with certain currently effective Reliability Standards and citing Reliability Standard IRO–010–2 (Reliability Coordinator Data Specification and Collection), Requirement R1 (providing that ''[t]he Reliability Coordinator shall maintain a documented specification for the data . . . *including non-[bulk electric system] data*''(emphasis added)), Requirement R2 (providing that ''[t]he Reliability Coordinator shall distribute its data specification to entities''), Requirement R3 (providing that ''[e]ach . . . Transmission Owner, and Distribution Provider receiving a data specification in Requirement R2 shall satisfy the obligations of the documented specifications''); Reliability Standard PRC–006–3 (Automatic Underfrequency Load Shedding), Requirement R8 (requiring that a UFLS entity, *i.e.,* relevant transmission owner and distribution provider, ''provide data to its Planning Coordinator(s)''). Reliability Standard IRO–010–4 (Reliability Coordinator Data Specification and Collection) became effective April 1, 2023; Reliability Standard PRC–006–5 (Automatic Underfrequency Load Shedding) became effective April 1, 2021.

[173] *Id.*

[174] *Id.* (citing NERC, *Distributed Energy Resources: Connection Modeling and Reliability*

Continued

a. Comments

90. Commenters generally support the NOPR's proposed directive to require transmission owners to collect and share unregistered IBR data and to require distribution providers to collect and share modeling data and parameters of IBR–DERs in the aggregate.[175] However, several commenters raise concerns that transmission owners and distribution providers may not be able to collect all the requested data.[176]

91. NERC, AEU, IRC, and ISO–NE support the Commission's directive to revise the currently effective Reliability Standards to require that adequate and accurate data is available for all Bulk-Power System-connected resources (including unregistered IBRs).[177] NERC notes that experience has demonstrated that, without all of the relevant protections and controls being modeled and validated, the resulting interconnection and long-term planning studies will not identify possible performance issues.[178] NERC recommends that if no distribution provider is registered on a specific system, the transmission owner should coordinate with the relevant transmission planner, planning coordinator, balancing authority, transmission operator, and/or reliability coordinator for developing, submitting, and validating aggregate DER models (inclusive of IBR–DER) in planning or operational studies.[179]

92. IRC also supports Reliability Standards that facilitate the provision of IBR-related data from registered entities to reliability coordinators, planning coordinators, and other registered entities responsible for the safe and reliable operation of the Bulk-Power System.[180] To ensure the appropriate data is provided, IRC requests that the final rule specify the data to be submitted by all types of IBRs (*i.e.,* registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate) and transmission devices using similar technologies.[181]

93. ISO–NE supports the Commission's proposed directive and asserts that, for smaller IBR–DERs, distribution providers are in the best position to provide aggregate models that include behind-the-meter resources.[182] ISO–NE notes that, in the absence of this aggregate data, it uses assumptions based on industry documents and benchmarking to actual events, which may not always reflect the realities of IBRs.[183] Ohio FEA supports the Commission's proposals and states that the lack of visibility into operating assets behind the meter, including ride through of IBR–DERs, is an ongoing issue.[184]

94. AEU states that distribution providers are best situated to fulfill Reliability Standard requirements related to the aggregate impact of IBR–DERs and cautions against any direct assignment of responsibility to owners or operators of individual IBR–DERs.[185]

95. CAISO, Indicated Trade Associations, and SPP generally support the proposed directive but caution that transmission owners and distribution providers should only be required to collect and share information that they can reasonably obtain, and that certain data may be difficult to obtain.[186] CAISO encourages the Commission to direct NERC to address the potential ''compliance trap'' and suggests that if the Commission is going to shift the compliance burden to transmission owners and distribution providers from the IBR generator owner or operator, there should be consistent mechanisms in place for transmission owners and distribution providers to receive such information.[187]

96. APS, AEP, LADWP, and SCE/PG&E raise concerns with the proposed directive requiring transmission owners to collect and share unregistered IBR data and distribution providers to collect and share IBR–DER data due to the lack of mechanisms or leverage in place to require the provision of the underlying data from unregistered entities.[188] For example, AEP explains that it does not have access, as a transmission owner, to all of the data necessary to model the behavior of unregistered IBRs, nor does it have access, as a distribution provider, to all the data needed to accurately model IBR–DERs in the aggregate.[189]

97. SCE/PG&E contend that it is inappropriate for NERC to develop new Reliability Standards that place a compliance burden on transmission owners and distribution providers for unregistered IBRs and IBR–DERs in the aggregate. SCE/PG&E explain that transmission owners and distribution providers would not have the requisite information to comply with the Reliability Standards and that the transmission owners and distribution providers would need to develop new procedures and provide oversight and enforcement for unregistered IBRs and IBR–DERs. SCE/PG&E further state that balancing authorities, rather than transmission owners and/or distribution providers, should be held responsible for oversight and enforcement as they have the greatest visibility into the operation of IBRs on the grid.[190]

98. APS suggests alternatives to the proposed IBR–DER directive. APS has concerns with the proposal to require distribution providers to share information provided by an unregistered entity because the IBR–DER customer may be unable or unwilling to provide the data voluntarily.[191] Therefore, APS recommends that the Commission not direct NERC to require distribution providers to collect and share IBR–DER data, but instead defer to the stakeholder process during the standards development process to determine who will provide the data, how the aggregate IBR–DER model will be developed, and how the model will be validated.[192]

99. APS and Indicated Trade Associations oppose a directive requiring transmission owners and distribution providers to collect and share data from unregistered IBRs and IBR–DERs in the aggregate. Indicated Trade Associations emphasize that, while it may be appropriate to specify the types of data to be submitted, a registered entity cannot provide data that the registered entity itself does not have and has no ability to collect.[193]

Considerations, 7 (Feb. 2017), *https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Distributed_Energy_Resources_Report.pdf* (NERC DER Report); 2019 DER_A Model Guideline).

[175] *See generally* NERC Initial Comments at 9; AEU Initial Comments at 5; ACP/SEIA Initial Comments at 11–12 (although cautioning against mandating specific modeling and data submissions to allow entities to identify and request the data and modeling that best meets their needs); IRC Initial Comments at 2–3; ISO–NE Initial Comments at 2; NYSRC Initial Comments at 2; Ohio FEA Initial Comments at 2, 9.

[176] *See* AEP Initial Comments at 4; APS Initial Comments at 4; Trade Associations Initial Comments at 11–12; and SCE/PG&E Initial Comments at 10–11.

[177] NERC Initial Comments at 9; AEU Initial Comments at 4, 7; IRC Initial Comments at 2; ISO–NE Initial Comments at 2.

[178] NERC Initial Comments at 13.

[179] *Id.*

[180] IRC Initial Comments at 2.

[181] *Id.* at 3.

[182] ISO–NE Reply Comments at 2, 5.

[183] ISO–NE Initial Comments at 2.

[184] Ohio FEA Initial Comments at 2, 9.

[185] AEU Initial Comments at 7.

[186] CAISO Initial Comments at 31; Indicated Trade Associations Initial Comments at 9; SPP Initial Comments at 2.

[187] CAISO Initial Comments at 32, 38.

[188] APS Initial Comments at 4; AEP Initial Comments at 2; LADWP Reply Comments at 2; SCE/PG&E Initial Comments at 6.

[189] AEP Initial Comments at 4.

[190] SCE/PG&E Initial Comments at 6–7.

[191] APS Initial Comments at 4.

[192] *Id.* at 4.

[193] Indicated Trade Associations Initial Comments at 10.

APS believes that the unregistered IBRs and IBR–DERs may be unable or unwilling to provide the data voluntarily and consistently, and that transmission owners will have little to no leverage to compel delivery of data from the unregistered entities; thus, these requirements are more effectively shouldered by the IBR owners.[194] Indicated Trade Associations explain that, in most if not all cases, a transmission owner or distribution provider has only the information provided to it during the interconnection approval process and interconnection agreements may not require the IBRs to provide modeling data. Indicated Trade Associations explain that in such a case, transmission owners and distribution providers may not have the contractual right to add requirements to provide data unilaterally and retroactively. In addition, Indicated Trade Associations clarify that some IBR–DERs on the distribution system interconnect under utility retail tariffs without a separate interconnection agreement. Indicated Trade Associations aver that transmission owners and distribution providers should not be held responsible for an unregistered IBR owner that does not or cannot provide the data, and that any directives regarding unregistered IBR and IBR–DER data sharing and model validation should recognize this limitation.[195]

100. Alternatively, Indicated Trade Associations propose that the Commission could either convene a forum to consider the benefits of applying the new Reliability Standards to distribution providers with IBR–DERs in their footprints, or direct NERC to submit a study on the challenges for development and implementation of those new or modified Reliability Standards. Indicated Trade Associations also support NERC's request for flexibility in determining appropriate requirements with respect to collecting and modeling IBR–DER data. In the alternative, Indicated Trade Associations ask the Commission to limit the obligations shouldered by the distribution providers to what is feasible.[196]

101. Indicated Trade Associations recommend giving consideration to collecting data from existing registered generator owners and operators that also own some IBR–DERs.[197]

[194] APS Initial Comments at 4.

[195] Indicated Trade Associations Initial Comments at 10–13.

[196] *Id.* at 9, 12–13.

[197] *Id.* at 2.

b. Commission Determination

102. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal, with modification. Specifically, as proposed in the NOPR, we direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that require: (1) transmission owners to provide to Bulk-Power System planners and operators modeling data and parameters for unregistered IBRs in their transmission owner areas that, individually or in the aggregate, materially affect the reliable operation of the Bulk-Power System and (2) distribution providers to provide to Bulk-Power System planners and operators modeling data and parameters for IBR–DERs in the aggregate in their distribution provider areas where the IBR–DERs in the aggregate materially affect the reliable operation of the Bulk-Power System.[198]

103. However, we find persuasive the comments explaining that certain data may be challenging or infeasible for the transmission owner or distribution provider to obtain.[199] We recognize that there may be limitations on the ability of certain transmission owners to provide all data about unregistered IBRs that Bulk-Power System transmission planners and operators may need for the reliable operation of the Bulk-Power System. Likewise, there may be limitations on the ability of certain distribution providers to provide all data about IBR–DERs in the aggregate that Bulk-Power System transmission planners and operators may need for the reliable operation of the Bulk-Power System. We therefore modify the NOPR proposal, as discussed below.

104. Recognizing that there may be instances in which transmission owners are unable to gather adequate unregistered IBR modeling data and parameters to create and maintain unregistered IBR models in their transmission owner areas, we modify the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require each transmission owner, if unable to gather accurate unregistered IBR data or unable to gather unregistered IBR data at all, to provide instead to the Bulk-Power System planners and operators in their areas: (1) an estimate of the unregistered IBR modeling data and parameters, (2) an explanation of the limitations of the availability of data, (3) an explanation of the limitations of any data provided by unregistered IBRs, and (4) the method used for estimation. We believe that this directive appropriately balances commenters' concerns about data accessibility and burden with the established need for transmission owners to provide unregistered IBR modeling data and parameters to Bulk-Power System planners and operators in their transmission owner area. We recognize that estimated modeling data and parameters are approximations of actual modeling data and parameters. We further acknowledge that there is some degree of error in estimated modeling data and parameters. However, on balance we believe that requiring such estimates with explanation of any limitations is an improvement from not having any data at all; and that even estimates will increase the overall adequacy of models and improve the reliability of the Bulk-Power System. To support this data collection, we further direct NERC to consider commenters suggestions to implement a process or mechanism by which transmission owners would receive modeling data and parameters.[200]

105. We also recognize that there may be instances where distribution providers are similarly unable to gather adequate modeling data and parameters from IBR–DERs.[201] Accordingly, to account for instances in which distribution providers are unable to gather adequate modeling data and parameters of IBR–DERs to create and maintain IBR–DER models, we modify the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require that each distribution provider, if unable to gather accurate IBR–DERs data in the aggregate or unable to gather IBR–DERs data in the aggregate at all, provide instead to

[198] *See supra* note 14 (noting that although the remaining subset of unregistered IBRs and IBR–DERs in the aggregate will not be subject to the mandatory and enforceable Reliability Standards set forth herein, they may be subject to provision of data and information to their respective transmission owners and distribution providers, as applicable, in accordance with their specific interconnection agreements; and encouraging NERC to continue its efforts to review and evaluate whether reliability gaps continue to remain and if new or modified functional registration categories or Reliability Standards are necessary).

[199] *See, e.g.,* AEP Initial Comments at 2; APS Initial Comments at 4; Indicated Trade Associations Initial Comments at 10; SCE/PG&E Initial Comments at 6, 7.

[200] *See, e.g.,* AEP Initial Comments at 2; SCE/PG&E Initial Comments at 6–7.

[201] For example, there may be no distribution providers that meet the NERC Registration Criteria in a given area (*e.g.,* greater than 75 MW of peak load directly connected to the bulk-electric system, facilities that are used in protection systems or programs for the protection of the bulk-electric system, etc.), *see* NERC Rules of Procedure App. 5B (Statement of Compliance Registry Criteria) 6–7, (Jan. 19, 2021), *https://www.nerc.com/FilingsOrders/us/RuleOfProcedureDL/Appendix%205B.pdf.*

the Bulk-Power System planners and operators in their areas: (1) an estimate of the modeling data and parameters of IBR–DERs in the aggregate,[202] (2) an explanation of the limitations of the availability of data, (3) an explanation of the limitations of the data provided by IBR–DERs, and (4) the method used for estimation. In support of above, we further direct NERC to consider commenters' suggestions to implement a process or mechanism by which distribution providers would receive modeling data and parameters.[203]

106. Finally, as noted by commenters, we recognize that there may be instances where IBR–DERs are connected to an entity that does not meet the criteria for registration with NERC as a distribution provider. For those areas with IBR–DERs that in the aggregate materially affect the reliable operation of the Bulk-Power System but do not have an associated registered distribution provider, we direct NERC to determine the appropriate registered entity responsible for providing data of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, or, when unable to gather such accurate IBR–DERs data, to provide instead to the Bulk-Power System planners and operators in their areas: (1) an estimate of the modeling data and parameters of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, (2) an explanation of the limitations of the availability of data, (3) an explanation of the limitations of any data provided by the IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, and (4) the method used for estimation.

107. We believe that requiring transmission owners and distribution providers to collect required data for unregistered IBRs, and IBR–DERs in the aggregate, will result in greater consistency than the piecemeal approach proposed by Indicated Trade Associations, in which some data for unregistered IBRs and IBR–DERs in the aggregate would also be provided by registered generator owners and operators. Further, we believe that transmission owners and distribution providers are in a better position to collect and estimate required data for unregistered IBRs and IBR–DERs in the aggregate that are directly connected to their respective areas than balancing authorities. We anticipate that the need for estimated data for unregistered IBRs connected to the Bulk-Power System, as opposed to actual data, and thus the burden of collecting such data, will decrease over time due to the model provision requirements in the *pro forma* LGIP and *pro forma* SGIP, as adopted in Order No. 2023,[204] and the ongoing NERC activities to register IBR generator owners and operators.[205] As transmission providers modify their interconnection agreements in compliance with Order No. 2023, we expect that the need to estimate data will decrease because validated models for smaller sized resources will begin to be submitted to transmission providers with interconnection requests under the Commission's *pro forma* SGIP. NERC's registration of previously unregistered IBRs should result in more IBRs providing data and validated models pursuant to applicable Reliability Standards.[206]

108. Regarding CAISO's concern regarding the potential ''compliance trap'' where planners and operators rely on third-party data [207] and IRC's request that the final rule specify the data to be submitted by all IBRs (*i.e.,* registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate) and transmission devices using similar technologies, we direct NERC to determine through its standards development process the minimum categories or types of data that must be provided to transmission planners, transmission operators, transmission owners, and distribution providers necessary to predict the behavior of all IBRs and to ensure that compliance obligations are clear.[208] As discussed in more detail in section IV.C of this final action, we are also directing NERC to develop new or modified Reliability Standards that require the use of approved industry IBR models that accurately reflect the behavior of all IBRs during steady state, short-circuit, and dynamic conditions. By contrast, we believe that a directive to task distribution providers as the appropriate registered entity to collect and share the modeling data and parameters of IBR–DERs in the aggregate is preferable to deferring to the stakeholder process as suggested by APS. The distribution provider, as the entity providing and operating the lines between the transmission and distribution systems,[209] is the entity best situated to have access to the data necessary for accurate estimation and, other than Indicated Trade Associations that suggested the piecemeal approach already discussed above, no commenter identified other potential entities as an equally efficient option.

109. We also decline to either convene a forum to consider the benefits of applying the new Reliability Standards to distribution providers with IBR–DERs in their footprints, or direct NERC to submit a study on the challenges for development and implementation of those new or modified Reliability Standards as suggested by Indicated Trade Associations. As identified in the NOPR and expounded upon in this final action, there is a pressing need to address the gap posed by the currently effective Reliability Standards. Bulk-Power System planners and operators need to receive modeling data and parameters regarding IBR–DERs that in the aggregate are capable of adversely affecting the reliable operation of the Bulk-Power System. The additional process proposed by commenters will unnecessarily delay resolution of the identified gap. Further, regarding various comments suggesting specific timing for requiring data provision, we believe that determining when data would be available and required to be provided is better addressed during the standards development process. We encourage NERC to continue its efforts to review and evaluate whether reliability gaps continue to remain and if new or modified functional registration categories or Reliability Standards are necessary to ensure the reliable operation of the Bulk-Power System. NERC may choose to revise, or the Commission may direct further

[202] *See supra* note 89.

[203] *See infra* P 147 (identifying the EPRI DER Settings Database as one potential technical source for IBR–DER estimation data).

[204] Order No. 2023, 184 FERC ¶ 61,054 at P 1659 (revising 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 specified modeling information).

[205] *See* Order Approving Workplan, 183 FERC ¶ 61,116 at P 1 (approving NERC's plan to modify its Rules of Procedure related to registration and to identify and register IBR generator owners and operators that fall below the thresholds for the bulk-electric system definition). NERC's Commission approved bulk electric system definition is a subset of the Bulk-Power System and defines the scope of the Reliability Standards and the entities subject to NERC compliance. *Revisions to Electric Reliability Org. Definition of Bulk Elec. Sys. & Rules of Proc.,* Order No. 773, 141 FERC ¶ 61,236 (2012), *order on reh'g,* Order No. 773–A, (May 17, 2013), 143 FERC ¶ 61,053 (2013), *rev'd sub nom. People of the State of N.Y.* v. *FERC,* 783 F.3d 946 (2d Cir. 2015); NERC Glossary at 7–9.

[206] NERC's August 16, 2023, Compliance Filing sets forth NERC's proposed registration plan indicating that implementation of the plan will result in registration of 97.5 percent of Bulk-Power System connected IBRs of the total IBR nameplate capacity MWs installed in 2021 of transmission and sub-transmission IBRs.

[207] CAISO Initial Comments at 38.

[208] *See* Order No. 672, 114 FERC ¶ 61,104 at PP 322, 325 (requiring that Reliability Standards be clear and unambiguous as to what is required and who is required to comply).

[209] *See* NERC Rules of Procedure, App. 5B at 6.

revisions to, registration or Reliability Standards to ensure the provision of adequate modeling data and parameters from unregistered IBRs and/or IBR–DERs in the aggregate.

C. Data and Model Validation

110. In the NOPR, the Commission preliminarily found that the currently effective Reliability Standards are inadequate to ensure that Bulk-Power System planners and operators: (1) have the steady state, dynamic, and short circuit models of the elements that make up generation, transmission, and distribution facilities that accurately reflect the generation resource's behavior in steady state and dynamic conditions; (2) have dynamic models (*i.e.,* models of equipment that reflect the equipment's behavior during various grid conditions and disturbances) that accurately represent the dynamic performance of all generation resources, including momentary cessation when applicable; (3) can validate and update resource models by comparing the provided data and resulting models against actual operational behavior to achieve and maintain accuracy of their transmission planning and operations models; and (4) have interconnection-wide models that represent all generation resources, including: (a) synchronous generation resource models; (b) load resource models; and (c) registered and unregistered IBR models, as well as IBR–DERs modeled in the aggregate. The Commission further stated that Bulk-Power System planners and operators need accurate planning, operations, and interconnection-wide models to ensure reliable operation of the system.[210]

111. Therefore, the Commission proposed to direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that would ensure that all necessary models are validated. Specifically, the Commission proposed to direct NERC to modify the Reliability Standards to require: (1) generator owners to provide validated registered IBR models to the planning coordinators for interconnection-wide, planning, and operations models; (2) transmission owners to provide validated unregistered IBR models to the planning coordinators for interconnection-wide, planning, and operations models; and (3) distribution providers to provide validated models of IBR–DERs in the aggregate to the planning coordinators for interconnection-wide, planning, and operations models. Further, the Commission proposed that the new or modified Reliability Standards should require models of individual registered and unregistered IBRs, as well as IBR–DERs in the aggregate, to represent the dynamic behavior of these IBRs at a sufficient level of fidelity for Bulk-Power System planners and operators to perform valid facility interconnection, planning, and operational studies on a basis comparable to synchronous generation resources.[211]

1. Approved Component Models

112. In the NOPR, the Commission preliminarily found that without approved generation models that accurately reflect generation resource behavior in steady state and dynamic conditions, Bulk-Power System planners and operators are unable to adequately predict IBR behavior and their subsequent impact on the Bulk-Power System.[212] The Commission found that the currently effective Reliability Standards only refer broadly to models in Reliability Standard MOD–032–1, Attachment 1, rather than requiring the use of NERC's approved component models, which would provide more accurate information about resource behavior. Thus, the Commission proposed to direct NERC to develop new or modified Reliability Standards that require the use of approved industry generic library IBR models that accurately reflect the behavior of IBRs during both steady state and dynamic conditions.

113. The Commission elaborated that NERC could reference its approved component model list in the Reliability Standards and require that only those models be used when developing planning, operations, and interconnection-wide models. The Commission further stated that the proposed directives were consistent with the recommendations in the NERC reports.[213]

a. Comments

114. AEP, CAISO, ISO–NE, LADWP, and NYSRC generally support the proposed directive to require the use of approved industry generic library IBR models [214] (*e.g.,* NERC's approved model list) instead of user-defined models.[215] As an owner of registered IBRs, unregistered IBRs, and IBR–DERs, AEP confirms that transmission owners and distribution providers need consistent and accurate data to properly model IBR behavior.[216]

115. CAISO supports the use of approved industry generic library IBR models but suggests that, instead of the NERC approved model list, the WECC models should be used when developing national standards for model development and validation.[217] CAISO explains that the WECC models have been the subject of numerous research projects undertaken for the purpose of validating various components and suggests that NERC and its stakeholders could use this experience when developing standards for model development and validation.[218] CAISO notes that even unregistered IBRs are required to provide dynamic models from the manufacturer using the latest WECC approved dynamic models.[219]

116. LADWP explains that it is challenging for transmission providers to obtain accurate IBR model information, and often the supplied modeling data is generic and neither adequate nor high fidelity.[220] NYSRC supports establishing validation processes for IBR projects and plant component models and ensuring that detailed verifiable models and data are available for planning and operational studies.[221] NYSRC explains that such component models may include individual solar, wind, or storage devices, plant protection systems, plant controllers, ancillary equipment, and interconnection equipment (transformers and transmission lines). NYSRC also suggests that the Commission allow for and consider making clear in any resulting rules or requirements that provide for mandatory delivery by equipment manufacturers and project developers of detailed, equipment specific, verifiable manufacturer's models and data necessary for planning and operational studies.[222]

[210] NOPR, 181 FERC ¶ 61,125 at P 82.

[211] *Id.* P 83.

[212] *Id.* P 86 (citing NERC Standardized Powerflow Parameters and Dynamics Models).

[213] *Id.*

[214] Various commenters reference the type of transmission power system models used for transmission steady state and dynamic assessments with a variety of synonymous names. These conventional transmission power system simulation models may be referred to as root mean square models or positive-sequence models. These synonymous model names are sometimes used in combinations and appended to the terms generic or standardized library models. This final action uses the most simplified term ''generic library model'' to describe the approved collection of industry transmission power system models used for steady state, dynamic, and short-circuit assessments.

[215] AEP Initial Comments at 3; CAISO Initial Comments at 1; ISO–NE Reply Comments at 2–3; LADWP Reply Comments at 3 NYSRC Initial Comments at 4.

[216] AEP Initial Comments at 3–4.

[217] CAISO Initial Comments at 29.

[218] *Id.*

[219] *Id.* at 26.

[220] LADWP Reply Comments at 3.

[221] NYSRC Initial Comments at 3.

[222] *Id.*

117. NERC opposes requiring entities to rely solely on standardized generic library models because such models may not be able to fully represent IBR behaviors.[223] Instead, NERC supports establishing an acceptable model list that identifies which models to use for specific types of studies.[224] NERC explains that while user-defined models have some drawbacks, the Commission should not preclude their use. NERC also notes that entities may rely on different modeling practices or types of models and, therefore, recommends an approach that combines: (1) a positive sequence standard library model; (2) a positive sequence user-defined model; (3) a detailed EMT model; and (4) a model benchmarking report that compares all models.[225] NERC adds that entities should correctly parameterize all of these models when performing benchmarking testing to reflect the as-built equipment installed in the field and include an explanation to the receiving entity of any limitations with the models.[226]

118. Regarding the use of user-defined models, EPRI states that both generic library models and user-defined models are important to use—provided that both types of models are appropriately parameterized and validated. EPRI further explains that user-defined models may be more accurate in certain kinds of studies that require unique controls or protection strategies, which generic models may not have. EPRI therefore suggests that the Commission consider requiring both validated user-defined models and validated generic library models.[227]

119. While ACP/SEIA generally support the Commission's proposed directive to require NERC to develop Reliability Standards that address modeling of IBRs, they recommend giving the transmission service provider the discretion to require user-defined models, generic library models (with site-specific parameterization), or both.[228]

120. ISO–NE explains that it only accepts a user-defined model if there is no generic library model that could be used.[229] ISO–NE explains that it has found that user-defined models are not uniform and may conflict with other user-defined models. Accordingly, ISO–NE supports the Commission's proposal to require the use of approved industry generic library models or, if the Commission declines to proceed with the proposed directive, asks that the final rule either not require the use of user-defined models or allow entities to preclude their use.[230]

121. Although the Commission did not propose to include directives addressing EMT models, multiple commenters suggest that the Commission include requirements for EMT models in the final rule.[231]

b. Commission Determination

122. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require the use of approved industry generic library IBR models that accurately reflect the behavior of IBRs during steady state, short-circuit, and dynamic conditions when developing planning, operations, and interconnection-wide models. For example, the new or modified Reliability Standards could reference the NERC approved component model list, which defines the models that may be used, and those models that may not be used, for specific types of studies.[232] This approved component model list includes WECC's IBR models. Without requiring the use of approved industry generic library models, Bulk-Power System planners and operators may not be able to create system models that adequately predict IBR behaviors and subsequent impacts on the Bulk-Power System.[233]

123. We decline to modify the NOPR proposal to allow NERC the discretion to include alternatives to approved industry generic library models in any new or modified Reliability Standards, and we similarly decline to modify the NOPR proposal to allow transmission providers the discretion to diverge from the approved nation-wide component model list. While Order No. 2023 allows interconnection customers to submit novel user-defined models with their interconnection requests,[234] the risks associated with the use of user-defined models in the interconnection context are substantially different than in the Bulk-Power System operations and planning context. Specifically, interconnection studies require the transmission provider to study impacts from integrating a new resource on their system; these internal models are not typically shared or combined with models from neighboring systems. In contrast, in the transmission planning and operations context, planning coordinators, transmission planners, transmission operators, and balancing authorities combine models on both a regional and interconnection-wide basis to assess and mitigate impacts from a number of system conditions and contingencies on their portion of the Bulk-Power System. In the event of non-convergence or other problems with the model, a user-defined model, if not appropriately parameterized and not submitted with open-source code or dynamic link library and code files, may not allow internal model components to be viewed or modified, which would impede the ability of planning coordinators, transmission planners, transmission operators, and balancing authorities to remediate any issues. Accordingly, while user-defined models may be acceptable to an individual transmission provider when building its own models and studying its own system, which we are not prohibiting here, the use of a standard set of approved industry generic library models is essential to creating Bulk-Power System planning and operations system models (*i.e.,* combining models between neighboring entities and for interconnection-wide models) so that Bulk-Power System planners and operators can adequately predict behaviors and subsequent impacts to the reliable operation of the Bulk-Power System.

124. We direct NERC to determine through its standards development process which nation-wide approved component models are needed to build IBR plant models for steady state, short-circuit, and dynamics studies. We acknowledge NERC's comment that user-defined models may be helpful for specific local reliability studies; however, the user-defined model cannot be used in place of nation-wide approved component models for regional analysis or interconnection-wide analysis because the user-defined model may cause non-convergence and other issues.[235] However, NERC may

[223] NERC Initial Comments at 15–16.

[224] *Id.*

[225] *Id.* at 16.

[226] *Id.*

[227] EPRI Initial Comments at 17.

[228] ACP/SEIA Initial Comments at 12–13.

[229] ISO–NE Reply Comments at 3.

[230] *Id.*

[231] *See, e.g.,* NERC Initial Comments at 13; ACP/SEIA Initial Comments at 12; SPP Initial Comments at 3; EPRI Initial Comments at 18; Indicated Trade Associations Initial Comments at 7 (although also noting that EMT modeling can be burdensome to industry); ISO–NE Initial Comments at 2–3.

[232] *See* NERC Standardized Powerflow Parameters and Dynamics Models.

[233] NOPR, 181 FERC ¶ 61,125 at P 36.

[234] *See* Order No. 2023, 184 FERC ¶ 61,054 at P 1660.

[235] *See* NERC, *Libraries of Standardized Powerflow Parameters and Standardized Dynamics Models,* Ver. 1 at 1 (Oct. 15, 2015), *https://www.nerc.com/comm/PC/Model%20Validation%20Working%20Group%20MVWG%202013/NERC%20Standardized%20Component%20Model%20Manual.pdf* (explaining that since Bulk-Power System planning and operations system models are constructed using

allow the submission of user-defined models alongside the approved industry generic IBR model. Various entities do not accept user-defined models or only accept them for limited instances along with the open-source code which then allows internal model components to be viewed and modified. For example, PJM does not accept user-defined models and requires generic models for model verification in accordance with currently effective Reliability Standards MOD–026–1 and MOD–027–1.[236] NYISO accepts a user-defined model in limited instances but requires either the open-source code (allowing anyone to access the internal model) or dynamic link library data and code files (compiled code that must be decompiled to view the internal model) that must be supplied for existing power flow software and in perpetuity.[237]

125. Accordingly, we direct NERC to develop new or modified Reliability Standards that require the sole use of nation-wide approved component generic library models for system models to facilitate the exchange of neighboring entities' respective planning and operation models and to build interconnection-wide models. One example of a way NERC could meet this directive would be to require an equivalent generic library model along with all submissions of user-defined models so that the generic library model can be used when combining neighboring transmission system models and in interconnection-wide models.

126. With respect to NERC's recommendation for model benchmarking, we direct NERC to determine through its standards development process whether the development of benchmark cases to test model performance and a subsequent report comparing model performance are needed and at what periodicity.

127. Many commenters request that the Commission consider requiring the inclusion of EMT models in the new or modified Reliability Standards. In Order No. 2023, the Commission required interconnection customers to submit EMT models with their interconnection requests only if the transmission provider performs an EMT study as part of its interconnection study process.[238] We decline here, however, to direct NERC to require EMT models at this time because EMT models are typically used to examine the electromagnetic transient behavior of individual generation resources and to study plant-to-plant interactions. EMT models are not used to build interconnection-wide models or perform respective studies and, as such, requiring their inclusion would not address the reliability gaps identified in section III above, which are the subject of the directives in this final action. However, we note that NERC has existing and ongoing Reliability Standards projects that include EMT studies,[239] and we encourage NERC and stakeholders to continue working in this area.

2. Verification of IBR Plant Dynamic Model Performance

128. In the NOPR, the Commission proposed to direct NERC to require the generator owners of registered IBRs and the transmission owners that have unregistered IBRs on their systems to provide dynamic models that accurately represent the dynamic performance of facilities of registered IBRs and facilities of unregistered IBRs, including momentary cessation and/or tripping, and all ride through behavior to the planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities. The Commission further proposed to direct NERC to require distribution providers that have IBR–DERs on their systems to ensure that the aggregated dynamic models (*i.e.,* plant models that describe the behaviors of all IBRs installed and controlled at a single electrical location) provided to the planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities accurately represent the dynamic performance of IBR–DER facilities in the aggregate, including momentary cessation and/or tripping, and all ride through behavior (*e.g.,* IBR–DERs in the aggregate modeled by interconnection requirements performance to represent different steady-state and dynamic behavior).[240]

129. In the NOPR, the Commission noted that the currently effective Reliability Standards do not require generator owners to provide verified models and data for IBR-specific controls (*e.g.,* power plant central controller functions and protection system settings), do not require transmission owners to provide verified dynamic models for unregistered IBRs, and do not require distribution providers to provide verified dynamic models for IBR–DERs in the aggregate. The Commission therefore proposed to direct NERC to develop new or modified Reliability Standards that account for the technological differences between IBRs and synchronous generation resources.

a. Comments

130. Commenters generally support the proposed NOPR directive that the new or modified Reliability Standards require that entities verify all IBR models.[241] For example, NERC confirms that the currently effective Reliability Standards, such as MOD–026–1 and MOD–027–1, which pertain to model verification, could be enhanced by requiring entities to verify that the models are of sufficient accuracy and to make corrections in a timely manner.[242] Additionally, NERC states that it has recommended that the Project 2020–06 (Verifications of Models and Data for Generators) standard drafting team employ a more comprehensive model validation process. This includes equipment manufacturer engagement (*e.g.,* by attesting to model quality), submitting as-built protection and controls, hardware-in-the-loop testing, testing/operations data, and considering future IEEE P2800.2 model validation and verification procedures.[243]

thousands of individual component models, there can be problems when using models that are proprietary or confidential, because it ''impedes the free flow of information necessary for interconnection-wide power system analysis and model validation.'' Further, the document recommends ''an industry-wide forum for discussing the validity of these various model structures'' and that ''industry should agree upon standardized component model structures and associated parameters for particular types of equipment.'').

[236] *See* PJM, *Guidance for NERC MOD–026–027 Generation Owner Preparation & Submittal,* 5 (Aug. 28, 2022), *https://www.pjm.com/-/media/library/whitepapers/compliance/20220828-guidance-for-go-to-prepare-nerc-mod-026-027-and-submittal.ashx* (explaining that ''user-defined models are not acceptable. PJM requires submittal of generic models with appropriate due diligence made to closely match unit performance'').

[237] *See* NYISO, *Reliability Analysis Data Manual,* 22 (Dec. 2022), *https://www.nyiso.com/documents/20142/2924811/M-24-RAD-Att%20B-v2022-12-07-Final.pdf/d91ccb08-d34b-1890-c85a-baa21712d9d4* (explaining that if a user-defined model is provided then a technical justification must accompany the model along with the open-source code of the model; if the open-source code cannot be provided then all dynamic link library data and code files must be supplied for existing power flow software and all future versions of the power flow software).

[238] *See* Order No. 2023, 184 FERC ¶ 61,054 at P 1659.

[239] *See* NERC Initial Comments at 14 (describing multiple EMT modeling projects including a taskforce, Reliability Standards Project 2022–04 (EMT Modeling), and a reliability guideline).

[240] NOPR, 181 FERC ¶ 61,125 at P 84.

[241] Although the NOPR and this final action use ''verification'' to mean the model is properly parameterized and validated, and ''validation'' to mean the confirmation that models reflect real world operational behaviors, commenters use the terms verification and validation interchangeably in their responses.

[242] NERC Initial Comments at 12 (stating that NERC Project 2020–06 (Verifications of Models and Data for Generators) is already developing revisions to enhance requirements for model verification).

[243] *Id.* at 17.

131. EPRI supports dynamic model verification and generally recommends that the new or modified Reliability Standards use the precise language and definitions as published in the industry standards and aligning requirements with leading international practice and grid codes.[244] EPRI points to the IEEE P2800.2 test and verification procedures currently under development as an example of how NERC may align with industry requirements for IBR plant model verification. Specifically, EPRI explains that the IEEE P2800.2 working group is developing a recommended practice for test and verification procedures that will include procedures, criteria, and definitions.[245]

132. To ensure the appropriate dynamic model data is provided, IRC requests that the final rule specify that the data to be submitted by transmission devices using similar technologies include data to study IBR dynamic behavior (*e.g.,* data for EMT studies).[246] Further, IRC suggests including the equipment testing and field tests as a part of model validation to show that the models accurately represent the equipment as installed in the field. IRC also recommends including requirements to model and study IBR installations to capture certain adverse control interactions that would be unseen by IBR owner modeling efforts but would still create reliability issues seen by the reliability coordinators, transmission planners, or planning authorities.[247]

133. CAISO supports the proposed directive to require NERC to ensure that the new or modified Reliability Standards account for verification of IBR plant dynamic model performance. CAISO emphasizes that the new or modified Reliability Standards should include requirements that enable the registered entities responsible for planning and operating the Bulk-Power System to validate data of registered IBRs and unregistered IBRs and data of IBR–DERs in the aggregate, by comparing the provided data and resulting models with actual performance and behavior.[248]

134. NERC, AEU, EPRI, and ACP/SEIA express concerns about the availability of verified IBR dynamic models. EPRI explains that transmission providers may need to reevaluate or restudy interconnection requests because site-specific verified plant models may not be available at the time of the facility interconnection studies, and the restudy would therefore create delays to the generator interconnection process.[249] Further, ACP/SEIA and LADWP raise concerns with the timelines for when such model data should be required. For example, ACP/SEIA note that as plant settings change, it may be difficult to provide fully validated models during the interconnection process and, therefore, EMT models should only be required once equipment details and settings are final, which occurs at the end of the interconnection process.[250] LADWP similarly notes the challenge of obtaining accurate model information if the interconnection customer has not actually purchased its equipment for use in a project.[251] NERC and AEU recommend that the Commission clarify in the final rule that a registered IBR would not be subject to the dynamic model requirements until the facility has completed the facility interconnection process and achieved commercial operation.[252] AEU supports focusing the requirements proposed in the NOPR on the fidelity of models and data provided at the completion of the facility interconnection process and on the model validation steps that can be taken following a plant commissioning.[253] ACP/SEIA recommend that the Commission direct NERC to develop a process for registered generators, including IBRs, to provide validated models to transmission planners in a reasonable timeframe following completion of the facility interconnection process.[254]

135. ISO–NE requests that the Commission make clear that generator owners, transmission owners, and distribution providers—and not transmission planners or transmission operators—should provide validated models to planning coordinators. ISO–NE requests that the Commission make clear that generator owners, transmission owners, and distribution providers should provide validated models to planning coordinators, and not transmission planners or transmission operators. ISO–NE and IRC also request that the Commission state in the final rule that model validation should include equipment testing and field tests that show the models accurately represent the equipment and control settings as installed in the field.[255] Finally, ISO–NE asks the Commission to direct NERC to add distribution providers as an applicable entity for Reliability Standard MOD–032–1 so planning coordinators and transmission planners are able to obtain IBR–DER information.[256]

136. EPRI also expresses concerns about model parameterization and recommends that the Reliability Standards require generator owners, transmission owners, and distribution providers to share verified and appropriately parameterized modeling.[257]

137. NERC, APS, and Indicated Trade Associations caution that it may be difficult to verify models for unregistered IBRs and IBR–DERs in the aggregate because transmission owners and distribution providers do not own the assets they would need to address and, therefore, flexibility may be warranted.[258] NERC suggests that, in lieu of mandating that an entity provide a validated model, the Commission could require the transmission owner, distribution provider, transmission planner, or planning coordinator to work collaboratively with state regulators to identify, implement, and perform an effective model validation approach for IBR–DERs in the aggregate.[259] Additionally, the planning coordinator could, as part of system validation in Reliability Standard MOD–033–2, work with the distribution provider, transmission planner, reliability coordinator, transmission operator, and balancing authority to capture disturbance information such that the representation of IBR–DERs in the aggregate in their models can be validated against system performance.[260]

138. Indicated Trade Associations and APS express concerns about distribution providers verifying models for IBR–DERs in the aggregate. APS states that the current method does not account for distributed energy resource parameters for running field tests to verify the accuracy of the model and that field test methodologies do not exist to verify the aggregate IBR–DERs at the feeder level.[261] APS asserts that, even if the distribution providers provide an

[244] EPRI Initial Comments at 8.

[245] *Id.* at 19–20 (referring to IEEE, *Test and Verification of BPS-connected Inverter-Based Resources,* P2800–2, *https://sagroups.ieee.org/2800-2/*).

[246] IRC Initial Comments at 3.

[247] *Id.* at 4.

[248] CAISO Initial Comments at 30.

[249] EPRI Initial Comments at 22.

[250] ACP/SEIA Initial Comments at 12.

[251] LADWP Reply Comments at 3.

[252] NERC Initial Comments at 12; AEU Initial Comments at 6.

[253] AEU Initial Comments at 6.

[254] ACP/SEIA Initial Comments at 13.

[255] ISO–NE Initial Comments at 3; IRC Initial Comments at 4.

[256] ISO–NE Initial Comments at 4.

[257] EPRI Initial Comments at 12–13.

[258] NERC Initial Comments at 32; APS Initial Comments at 5; Indicated Trade Association Reply Comments at 2.

[259] NERC Initial Comments at 32.

[260] *Id.*

[261] APS Initial Comments at 5.

aggregated approximation based on a generic model without engaging manufacturers and solar developers, the root cause will not be addressed because distribution providers do not have sufficient information to create models.[262] Noting that distribution providers do not have the ability to monitor whether the individual IBR–DERs have been altered, APS indicates that it would be difficult for distribution providers to know the precise mix of IBR–DERs when developing aggregate IBR–DER modeling.

139. SPP expresses concerns with the types of models that are proposed to be verified (*i.e.,* regular power flow models and dynamic models). SPP requests that the Commission require EMT model verification because only some IBR behaviors can be recognized and evaluated in an EMT study. Specifically, SPP requests that the Commission direct NERC to identify all three model types (power flow, dynamic, and EMT) in new Reliability Standards as the models that should be verified.[263]

b. Commission Determination

140. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require the generator owners of registered IBRs, transmission owners that have unregistered IBRs on their system, and distribution providers that have IBR–DERs on their system to provide models that represent the dynamic behavior of these IBRs at a sufficient level of fidelity to provide to Bulk-Power System planners and operators to perform valid interconnection-wide, planning, and operational studies on a basis comparable to synchronous generation resources.

141. We also direct NERC to require the generator owners of registered IBRs and the transmission owners that have unregistered IBRs on their system to provide to the Bulk-Power System planners and operators (*e.g.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities) dynamic models that accurately represent the dynamic performance of registered and unregistered IBRs, including momentary cessation and/or tripping, and all ride through behavior. Recognizing that there may be instances in which transmission owners are unable to gather accurate unregistered IBR modeling data and parameters to create and maintain accurate unregistered IBR dynamic models in their transmission owner areas, we modify the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require each transmission owner, if unable to gather accurate unregistered IBR data or unable to gather unregistered IBR data at all, to provide instead to the Bulk-Power System planners and operators in their areas, dynamic models of unregistered IBRs using estimated data in accordance with this final action's section IV.B.3 data sharing directives. Further, we direct NERC to require distribution providers to provide to the planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities aggregated dynamic models that adequately represent the dynamic performance of IBR–DERs on their systems that in the aggregate have a material impact on the Bulk-Power System, including momentary cessation and/or tripping, and all ride through behavior (*e.g.,* IBR–DERs in the aggregate modeled by interconnection requirements performance to represent different steady-state and dynamic behavior). Recognizing that there may be instances in which distribution providers are unable to gather data that accurately represents IBR–DERs in the aggregate, we modify the NOPR proposal and direct NERC to include in the proposed new or modified Reliability Standards a requirement that the distribution provider, if unable to gather data of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, provide to the Bulk-Power System planners and operators (*i.e.,* the data recipients) a dynamic model using estimated data for IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, in accordance with this final action's section IV.B.3 data sharing directives. Furthermore, we acknowledge that there may be areas with IBR–DERs in the aggregate that materially impact the reliable operation of the Bulk-Power System but do not have an associated registered distribution provider. Therefore, we modify the NOPR proposal and direct NERC to determine the appropriate registered entity responsible for providing adequate data and parameters of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, and to identify the registered entities for coordinating, verifying, and keeping up to date the respective dynamic models. Finally, NERC must ensure that the proposed new or modified Reliability Standards account for the dynamic performance of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System.

142. Regarding ISO–NE's request, we decline to direct NERC to require generator owners, transmission owners, and distribution providers to provide validated models to planning coordinators, and not transmission planners or transmission operators; we believe all Bulk-Power System planners and operators (*i.e.,* planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities) need validated models. Additionally, we agree with ISO–NE's request to direct NERC to add distribution providers as an applicable entity for Reliability Standard MOD–032–1 so planning coordinators and transmission planners are able to obtain IBR–DER information. We believe this is addressed through directives in section IV.B.3. that require NERC to submit new or modified Reliability Standards to address this issue. We decline to explicitly direct NERC to make the modification to Reliability Standard MOD–032–1 because NERC may address this concern in an equally efficient and effective manner.

143. Regarding EPRI's recommendation to require appropriately parameterized plant models, we agree that the model verification process of an IBR model should include steps to ensure that responsible entities provide both verified and appropriately parameterized models.[264] Additionally, we agree with IRC's recommendation that the plant model verification process should include requirements for equipment to be represented as installed in the field. While we decline to include this level of detail in the directive to NERC, we nonetheless direct NERC to establish a standard uniform model verification process. A uniform model verification process will ensure that all entities use the same set of minimum requirements to verify that all generation resource (*i.e.,* synchronous and non-synchronous) models are complete and that the models accurately represent the dynamic behavior of all generation resources at a sufficient level of fidelity for Bulk-Power System planners and operators to perform valid interconnection-wide, planning, and operational studies. Therefore, we direct NERC to define the model verification

[262] *Id.*

[263] SPP Initial Comments at 3.

[264] We believe that the model verification process should ensure that the IBR model inputs are appropriately parameterized as well as confirming that the in-field equipment behavior is consistent with model behavior.

process and to require consistency among the model verification processes for existing Reliability Standards (*e.g.,* FAC–002, MOD–026, and MOD–027) and any new or modified Reliability Standards.[265]

144. As the Commission indicated in the NOPR, the DER_A model represents an appropriate basis on which to develop new or revised modeling standards for IBR–DERs.[266] In the NOPR, the Commission referenced the DER_A model as a potential solution to address the requirements for distribution providers to share modeling data and parameters regarding IBR–DERs in the aggregate and cited the use of the DER_A model as a way to implement the requirement to develop new or modified Reliability Standards.[267] The DER_A model represents IBR–DERs in the aggregate and NERC recommends it as the approved steady state and dynamic model.[268] WECC and EPRI have verified and updated the DER_A model [269] to model IBR–DERs in the aggregate and have used it to study the potential impacts of IBR–DERs in the aggregate on the Bulk-Power System. Since 2016, NERC has issued six Reliability Guidelines on the DER_A model.[270] For example, NERC's 2020 IBR–DER Data Collection Guideline explains how the distribution provider may be able to use publicly available data to provide estimated aggregate IBR–DER modeling data and parameters to the Bulk-Power System planners and operators that they may in turn use as inputs into the DER_A model.[271]

145. NERC has provided transmission planners and planning coordinators with guidance on how to perform varying extents of DER_A model verification using differing amounts of estimated and measured data to ensure the aggregate impacts from the DER_A model reflects actual Bulk-Power System disturbance behaviors.[272] Further, NERC's 2023 DER_A Model Guideline provides transmission planners and planning coordinators with a set of recommendations for developing the parameters for the DER_A dynamic model, and the recommendations can also be extrapolated to transmission operators, reliability coordinators, and other entities performing stability simulations of the Bulk-Power System where an aggregate representation of DERs (*i.e.,* both synchronous resources and IBR–DERs) is required. This guideline also provides examples on how the DER_A model parameters can be modified to account for a mixture of legacy and newer IBR–DERs.[273]

146. Accordingly, we direct NERC to develop new or modified Reliability Standards that require the use of the DER_A model or successor models to represent the behaviors of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System at a sufficient level of fidelity for Bulk-Power System planners and operators to create valid planning and operations and interconnection-wide models and to be able to perform respective system studies. For example, the new or modified Reliability Standards could require models of IBR–DERs (*i.e.,* DER_A model) to adequately reflect the steady-state and dynamic aggregate resource performance in both a transmission area and across the interconnection. Additionally, estimated modeling data and parameters of IBR–DERs that in the aggregate (*i.e.,* DER_A model) have a material impact on the Bulk-Power System could be used where measured and collected data is not available. We believe requiring the DER_A model will address NERC's request for entities to work collaboratively with the state regulators to identify, implement, and perform an effective model validation approach for IBR–DERs in the aggregate as opposed to requiring validated models of IBR–DER in the aggregate that can have a material impact on the reliable operation of the Bulk-Power System.

147. Further, to address commenters' concerns about situations when distribution providers are unable to gather and provide data of IBR–DERs in the aggregate, we note the existence and suggest, but decline to direct, the use of the EPRI DER Settings Database.[274] The EPRI DER Settings Database contains the full set of configuration parameters that establish the behavior of DERs arranged in a single file, a so-called utility-required profile, which is easily exchanged between parties or used across an entire region. For example, ISO–NE coordinated with Massachusetts utilities to establish a single New England Required Utility Profile applicable to all DERs in ISO–NE.[275]

148. The ability to efficiently store and exchange DER settings files is particularly useful to help DER developers and manufacturers to know the requirements that exist within each distribution provider's service territory. NERC's 2023 DER_A Model Guideline also references the EPRI DER Settings Database as a solution for readily exchanging and managing large amounts of IBR–DER settings used to build dynamic models.[276] We encourage NERC's standard drafting team to consider the EPRI DER Settings Database as a useful resource in the standards development process when developing the necessary data exchange requirements for IBR–DERs that in the aggregate have a material impact on the Bulk-Power System.

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[265] We note NERC's statement that through Project 2020–06 (Verifications of Models and Data for Generators), it is already working to develop revisions to enhance requirements for model verification under MOD–026 and MOD–027. *See* NERC Initial Comments at 12, 17.

[266] NOPR, 181 FERC ¶ 61,125 at P 79 n.157, P 80 n.159.

[267] *Id.*

[268] *See* NERC Standardized Powerflow Parameters and Dynamics Models.

[269] *See* EPRI, *The New Aggregated Distributed Energy Resources (der_a) Model for Transmission Planning Studies: 2019 Update* (Mar. 2019) *https://www.epri.com/research/products/000000003002015320* (describing the specifications of the model and presenting the results of the benchmark tests conducted by EPRI during the approval process of the model through WECC's Modeling and Validation Working Group).

[270] The six NERC DER_A model guidelines are: (1) NERC, *Reliability Guideline: Modeling Distributed Energy Resources in Dynamic Load Models* (Dec. 2016), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_-_Modeling_DER_in_Dynamic_Load_Models_-_FINAL.pdf* (retired); (2) NERC, *Reliability Guideline: Distributed Energy Resources Modeling* (Sept. 2017), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_-_DER_Modeling_Parameters_-_2017-08-18_-_FINAL.pdf* (retired); (3) 2019 DER_A Model Guideline; (4) IBR–DER Data Collection Guideline; (5) NERC, *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies* (Mar. 2021), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline%20_DER_Model_Verification_of_Aggregate_DER_Models_used_in_Planning_Studies.pdf* (Aggregate DER Model Verification Guideline); and (6) 2023 DER_A Model Guideline.

[271] IBR–DER Data Collection Guideline, 1–2 n.37 (recommending that distribution providers are the best suited to provide DER information to transmission planners and planning coordinators for modeling purposes).

[272] *See generally* Aggregate DER Model Verification Guideline.

[273] *See generally* 2023 DER_A Model Guideline.

[274] *See* EPRI, *DER Performance Capability and Functional Settings Database,* Ver. 2.1 (2021), *https://dersettings.epri.com/* (EPRI DER Settings Database*)* (a public web-based repository for the settings that utilities require for interconnection of DER. The database facilitates multiple DER setting files, and various metadata, *e.g.,* DER types, IEEE standard 1547-specified performance categories, sizes, etc.).

[275] *See* Massachusetts Technical Standards Review Group, *Common Technical Standards Manual,* 16 n.9 (Dec. 22, 2022), *https://www.mass.gov/doc/tsrg-common-guideline-2022-12-22/download; see also* ISO–NE, *Default New England Bulk System Area Settings,* 1 (2022), *https://www.mass.gov/doc/draft-in-progress-default-new-england-bulk-system-area-settings-requirement/download* (as of June 1, 2022, these ISO–NE requirements apply to all DER applications. Additionally, DER projects must be compliant with the latest revision of IEEE–1547–2018 (as amended by IEEE–1547a–2020)).

[276] *See* 2023 DER_A Model Guideline at 18–19.

149. We acknowledge NERC's, AEU's, EPRI's, and ACP/SEIA's concerns about the verified IBR dynamic models being unavailable until completion of the facility interconnection process; however, in Order No. 2023 the Commission rejected a request to afford interconnection customers an extended period of time to meet the modeling requirements.[277] Order No. 2023 requires an interconnection customer to provide the required models within the deadlines established in the *pro forma* LGIP and *pro forma* SGIP. Pursuant to those provisions, if the interconnection customer does not cure such a deficiency within the 10 business day cure period, the interconnection request will be considered withdrawn pursuant to section 3.7 of the *pro forma* LGIP and section 1.3 of the *pro forma* SGIP. Order No. 2023 requires that the existing 10 business day cure period be consistently applied to all interconnection request deficiencies and that having an extended cure period for model deficiencies would potentially introduce delays in the interconnection process.[278] Therefore, verified IBR dynamic models should be available prior to the completion of the facility interconnection process. Moreover, although the Reliability Standards will apply to a different (albeit overlapping) set of entities than Order No. 2023, we believe consistency is needed between the complimentary proceedings and therefore direct NERC to include in the new or modified Reliability Standards a similar model verification process timeline consistent with Order No. 2023 modeling deadline requirements.

150. Regarding the IRC and SPP concerns about EMT model data availability and verification, as we decline to require the use of EMT models (as explained in section IV.C.1), we also decline to direct NERC to explicitly require EMT data and verified EMT models for the same reasons.

3. Validating and Updating System Models

151. In the NOPR, the Commission explained that, after all IBR models are verified, Bulk-Power System planners and operators must validate and update transmission system models by comparing the provided data and resulting system models against actual system operational behavior. The Commission added that, while Reliability Standard MOD–033–2 requires data validation of the interconnection-wide model, the Reliability Standards lack clarity as to whether models of registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate are required to represent the real-world behavior of the equipment installed in the field.[279]

152. The Commission therefore proposed to direct NERC to develop new or modified Reliability Standards that require planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities to validate, coordinate, and update in a timely manner the verified data and models of registered IBRs, unregistered IBRs, and IBR–DERs by comparing their data and resulting models against actual operational behavior. Further, the NOPR proposed this validation, coordination, and update directive to achieve and maintain necessary system models that accurately reflect performance and behaviors of registered IBRs and unregistered IBRs individually and in the aggregate, as well as performance and behaviors of IBR–DERs in the aggregate.[280]

a. Comments

153. NERC, NYSRC, CAISO, and AEP support the proposed directive for planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities to validate, coordinate, and update transmission planning and transmission operations system models.[281] NERC explains that its experience has shown that interconnection and long-term planning studies cannot identify possible performance issues without ''all of the relevant protections and controls being modeled and validated.'' [282] ACP/SEIA explains that new models and validation should not be required for modifications that do not reflect any material electrical performance impact.[283]

154. NERC agrees that transmission planners, planning coordinators, and reliability coordinators should have planning and operations models that represent all generation resources, including registered and unregistered IBRs, as well as aggregate representation of distributed energy resources (both synchronous and IBR).[284] NERC explains that it has a number of projects underway in this area, including Project 2020–06 (Verifications of Models and Data for Generators) and Project 2022–04 (EMT Modeling). NERC states that additional projects may be needed for clarity and model accuracy in the future, including projects to address Commission directives included in a final rule in this proceeding. NERC explains that it is also planning to issue a modeling-focused NERC Alert by the end of 2023 to better understand the extent of condition of modeling issues, which could inform future standards development efforts.[285]

155. CAISO agrees that Bulk-Power System planners and operators need accurate planning and operational information so that their own models, together with the interconnection-wide models, reflect how IBRs operate in real world scenarios.[286] APS asserts, similar to its comments regarding the difficulties of verifying models for IBR–DERs in the aggregate, that there is no feasible method (*i.e.,* comparing actual to simulated events in a systematic way) to validate IBR–DER models system wide.[287] In comparison, CAISO asserts that stakeholders could address the challenge of modeling IBR–DERs in the aggregate.[288]

b. Commission Determination

156. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to submit new or modified Reliability Standards that require Bulk-Power System planners and operators to validate, coordinate, and update in a timely manner the system models by comparing all generator owner, transmission owner, and distribution provider verified IBR models (*i.e.,* models of registered IBRs, unregistered IBRs, and IBR–DERs that in the aggregate have a material impact on the Bulk-Power System) and resulting system models against actual system operational behavior. NERC may implement this directive by modifying Reliability Standards MOD–026 and MOD–027 or by developing new Reliability Standards to establish requirements mandating a process to validate and keep up to date the system models. We find that this directive addresses ACP/SEIA's concerns comments regarding modification to and validation of models that do not reflect

[277] Order No. 2023, 184 FERC ¶ 61,054 at P 1666.

[278] *Id.*

[279] NOPR, 181 FERC ¶ 61,125 at P 40.

[280] *Id.* P 85.

[281] NERC Initial Comments at 10; NYSRC Initial Comments at 1; CAISO Initial Comments at 30; AEP Initial Comments at 3.

[282] NERC Initial Comments at 13 (citing NERC and Texas RE, *March 2022 Panhandle Wind Disturbance Report* (Aug. 2022), *https://www.nerc.com/pa/rrm/ea/Documents/Panhandle_Wind_Disturbance_Report.pdf* (Panhandle Disturbance Report) (covering the Texas Panhandle event (March 22, 2022)); Odessa 2022 Disturbance Report).

[283] ACP/SEIA Initial Comments at 14.

[284] *Id.* at 10.

[285] NERC Initial Comments at 11.

[286] CAISO Initial Comments at 33.

[287] APS Initial Comments at 5.

[288] CAISO Initial Comments at 35–36.

any material electrical performance impact.

157. We believe the development of new or modified Reliability Standards is an important corollary to NERC's ongoing effort to identify and register generator owners and operators of IBRs. Although NERC's registration changes will not at this time address IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, we believe APS's concerns regarding system-wide model validation is addressed in NERC's Reliability Guidelines [289] and through the use of the EPRI DER Settings Database. We recognize that some distribution providers may not be able to provide a precise set of modeling data and parameters that accurately represent IBR–DERs in the aggregate. For these situations, NERC has provided a technical means to estimate in aggregate the needed IBR–DER modeling data and parameters (*i.e.,* for the DER_A model) in the IBR–DER Data Collection Guideline.[290] Further, NERC's 2021 Aggregate DER Model Verification Guideline provides transmission planners and planning coordinators with tools and techniques that can be adapted for their specific systems to verify that aggregate DER models (*i.e.* DER_A models) are a suitable representation of these resources in planning assessments.[291] Furthermore, for those areas with IBR–DERs in the aggregate that materially impact the reliable operation of the Bulk-Power System but do not have an associated registered distribution provider, we modify the NOPR proposal to direct NERC to determine the appropriate registered entity responsible for the data and parameters of IBR–DERs in the aggregate and to establish a process that requires identified registered entities to coordinate, validate, and keep up to date the system models.

4. Need for Coordination When Creating and Updating Planning, Operational, and Interconnection-Wide Data and Models

158. In the NOPR, the Commission preliminarily found that there is a ''coordination gap'' among registered entities that build and verify interconnection-wide models. The Commission noted that the functional entities and designees specified in Reliability Standards MOD–032–1 and MOD–033–2 are not required to work collaboratively to create interconnection-wide models that accurately reflect real-world interconnection-wide IBR performance and behavior. Therefore, the Commission proposed to direct NERC to develop new or modified Reliability Standards that require planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities to validate, coordinate, and keep up to date in a timely manner the verified data and models of registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate by comparing their data and resulting models against actual operational behavior to achieve and maintain necessary modeling accuracy of individual and aggregate (1) registered IBR performance and behaviors and (2) unregistered IBR performance and behaviors, as well as performance and behaviors of IBR–DERs in the aggregate.[292]

a. Comments

159. NERC, CAISO, and AEP support the directives proposed in the NOPR that would require planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities to coordinate when creating and updating planning, operations, and interconnection-wide models.[293] For example, NERC agrees that there is a need for closer ties and coordination for Reliability Standards MOD–032 and MOD–033 activities to require that the models are tested more regularly and any modifications or updates to these models are provided to the relevant entities responsible for planning and operating the Bulk-Power System.[294] Further, NERC states that Reliability Standards MOD–032 and MOD–033 should be updated to require a more comprehensive practice for system model validation requiring models to be rigorously tested for deficiencies and include minimum requirements for benchmarking events, such as by including a requirement that all plant models be validated through Reliability Standard MOD–033 activities.[295]

160. CAISO supports the NOPR proposal and notes that, while there are technical, administrative, and compliance burdens associated with the imposition of additional new or modified IBR Reliability Standards, this initiative will provide a forum to consider ways to achieve an efficient and effective exchange of information among all relevant NERC-registered entities.[296]

b. Commission Determination

161. Pursuant to section 215(d)(5) of the FPA, we modify the NOPR proposal to provide additional specificity to explain coordination and keep up to date in a timely manner the verified data and models of registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate in the system models.[297] Specifically, we direct NERC to develop new or modified Reliability Standards that require planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities to establish for each interconnection a uniform framework with modeling criteria, a registered modeling designee, and necessary data exchange requirements both between themselves and with the generator owners, transmission owners, and distribution providers to coordinate the creation of transmission planning, operations, and interconnection-wide models (*i.e.,* system models) and the validation of each respective system model. Further, we direct NERC to include in the new or modified Reliability Standards a requirement for generator owners, transmission owners, and distribution providers to regularly update and communicate the verified data and models of registered IBRs, unregistered IBRs, and IBR–DERs by comparing their resulting models against actual operational behavior to achieve and maintain necessary modeling accuracy for inclusion of these resources in the system models. For those areas with IBR–DERs in the aggregate that have a material impact on the reliable operation of the Bulk-Power System but do not have an associated registered distribution provider, we modify the NOPR proposal to direct NERC to determine the appropriate registered entity responsible for the models of those IBR–DERs and to determine the registered entities responsible for updating, verifying, and coordinating models for IBR–DERs in the aggregate to meet the system models directives. NERC may implement this directive by modifying Reliability Standards MOD–032–1 and MOD–033–2 or by developing new Reliability Standards to establish requirements mandating an annual [298] process to

[289] *See generally* IBR–DER Data Collection Guideline; Aggregate DER Model Verification Guideline.

[290] *See generally* IBR–DER Data Collection Guideline.

[291] *See generally* Aggregate DER Model Verification Guideline.

[292] NOPR, 181 FERC ¶ 61,125 at PP 84–85.

[293] NERC Initial Comments at 14; CAISO Initial Comments at 33; AEP Initial Comments at 1.

[294] NERC Initial Comments at 14.

[295] *Id.* at 14–15.

[296] CAISO Initial Comments at 31–32.

[297] NOPR, 181 FERC ¶ 61,125 at P 85.

[298] *See* Reliability Standard MOD–032–1 at 15 (explaining that ''presently, the Eastern/Quebec and

coordinate, validate, and keep up-to-date the transmission planning, operations, and interconnection-wide models.

D. Planning and Operational Studies

162. In the NOPR, the Commission preliminarily found that the currently effective Reliability Standards do not adequately require planning and operational studies to: (1) assess performance and behavior of both individual and aggregate registered IBRs and unregistered IBRs, as well as IBR–DERs that in the aggregate have a material impact on the Bulk-Power System; (2) have and use validated modeling and operational data for individual registered IBRs and unregistered IBRs, as well as modeling and operational data of IBR–DERs that in the aggregate have a material impact on the Bulk-Power System; and (3) account for the impacts of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, within and across planning and operational boundaries for normal operations and contingency event conditions. The Commission stated that planning and operational studies must use validated IBR modeling and operational data so that studies account for the actual behavior of both registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs that in the aggregate have a material impact on the Bulk-Power System.[299]

163. The Commission preliminarily found that the currently effective Reliability Standards do not result in accurate planning studies of Bulk-Power System performance over a broad spectrum of system conditions and following a wide range of probable contingencies that includes all resources.[300] The Commission observed that inaccurate planning assessments may lead to false expectations that system performance requirements are met and may inadvertently mask potential reliability risks in planning and operations.[301] The Commission proposed to direct NERC to submit for approval one or more new or modified Reliability Standards that would require planning coordinators and transmission planners to include in their planning assessments the study and evaluation of performance and behavior of registered and unregistered IBRs individually and in the aggregate, and IBR–DERs in the aggregate, under normal and contingency system conditions in their planning area. The Commission further proposed that the planning assessments include the study and evaluation of the ride through performance (*e.g.,* tripping and momentary cessation conditions) of such IBRs in their planning area for stability studies on a comparable basis to synchronous generation resources.[302]

164. The Commission stated that the proposed new or modified Reliability Standards should also require planning coordinators and transmission planners to consider the behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, using planning models of their area and using interconnection-wide area planning models. Further, the Commission stated that the proposed new or modified Reliability Standards should also require planning coordinators and transmission planners to consider all IBR behaviors in adjacent and other planning areas that adversely impact a planning coordinator's or transmission planner's area during a disturbance event. The Commission explained that this is needed because registered IBRs, unregistered IBRs, and IBR–DERs tend to act in the aggregate over a wide area during such an event.[303]

165. The Commission preliminarily found that the Reliability Standards also do not require that the various operational studies (including operational planning analyses,[304] real-time monitoring, real-time assessments,[305] and other analysis functions) include all resources to adequately assess the performance of the Bulk-Power System for normal and contingency conditions.[306] The Commission proposed to direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that would require reliability coordinators and transmission operators to include the performance and behavior of registered and unregistered IBRs both individually and in the aggregate, and IBR–DERs in the aggregate, (*e.g.,* IBRs tripping or entering momentary cessation individually or in the aggregate) in their operational planning analysis, real-time monitoring, and real-time assessments, including non-bulk electric system data and external power system network data identified in their data specifications.[307]

166. The Commission further proposed to direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that would require balancing authorities to include the performance and behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, (*e.g.,* resources tripping or entering momentary cessation individually or in the aggregate) in their operational analysis functions and real-time monitoring.[308] The Commission explained that this proposal is consistent with the recommendations in the NERC DER Report, IBR Performance Guideline, IBR–DER Data Collection Guideline, and Loss of Solar Resources Alert II. The Commission stated that these reports indicate that a significant number of IBRs that have been involved in system disturbances were not adequately modeled in interconnection-wide models and tools used to study the performance and behavior of registered and unregistered IBRs individually and

Texas Interconnections build seasonal cases on an annual basis, while the Western Interconnection builds cases on a continuous basis throughout the year'').

[299] NOPR, 181 FERC ¶ 61,125 at P 87.

[300] *Id.* P 88.

[301] *See* NERC Glossary at 23 (defining planning assessment as a ''Documented evaluation of future Transmission System performance and Corrective Action Plans to remedy identified deficiencies.'').

[302] NOPR, 181 FERC ¶ 61,125 at P 88.

[303] *Id.* (citing 2021 Solar PV Disturbances Report at v; Odessa 2021 Disturbance Report at v; NERC, *1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report,* 2 (June 2017), *https://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf* (Blue Cut Fire Event Report) (covering the Blue Cut Fire event (August 16, 2016))); *see also* NOPR, 181 FERC ¶ 61,125 at P 88.

[304] NERC defines operational planning analysis as an ''evaluation of projected system conditions to assess anticipated (pre-Contingency) and potential (post-Contingency) conditions for next-day operations.'' The definition goes on to explain that the evaluation shall reflect ''applicable inputs including, but not limited to, load forecasts; generation output levels; Interchange; known Protection System and Special Protection System status or degradation; Transmission outages; generator outages; Facility Ratings; and identified phase angle and equipment limitations. (Operational Planning Analysis may be provided through internal systems or through third-party services).'' NERC Glossary at 22.

[305] NERC defines real-time assessment as an ''evaluation of system conditions using Real-time data to assess existing (pre-Contingency) and potential (post-Contingency) operating conditions.'' The definition goes on to explain that the assessment shall reflect ''applicable inputs including, but not limited to: load, generation output levels, known Protection System and Special Protection System status or degradation, Transmission outages, generator outages, Interchange, Facility Ratings, and identified phase angle and equipment limitations. (Real-time Assessment may be provided through internal systems or through third-party services).'' *Id.* at 25.

[306] NOPR, 181 FERC ¶ 61,125 at P 89.

[307] *Id.* (citing Reliability Standard IRO–010–4, Requirement R1, pt. 1.1 and Reliability Standard TOP–003–5, Requirement R1, pt. 1.1.).

[308] *Id.* (citing Reliability Standard TOP–003–5, Requirement R2, pt. 2.1.).

in the aggregate, as well as IBR–DERs in the aggregate. Thus, the Commission found that neighboring operators may be unaware that faults in one operator's area can trigger controls actions and trip IBRs in another operator's area.[309]

1. Comments

167. Commenters generally support a directive to require planning authorities to include data within their planning assessments to reflect expected actions of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, under normal and contingency system conditions.[310] NERC also supports the proposed Commission directive to require transmission planners and planning coordinators to coordinate their studies with neighboring entities so that accurate models of registered and unregistered IBRs, as well as IBR–DERs in the aggregate, are represented appropriately for the operating conditions under study.[311]

168. NERC expects that any standard development project to address such a directive would need to include a wider set of operating conditions than simply ''peak'' and ''off-peak'' conditions. NERC explains that using production cost models or other simulation methods to identify operating conditions that could result in extreme stress on the grid could help inform planning assessments.[312]

169. NERC highlights that there may be gaps in the currently effective Reliability Standard TPL–001–5.1 planning assessments if they are performed without accurate IBR models and studies. NERC also points to its Project 2022–02 (Modifications to TPL–001–5.1 and MOD–032–1) as addressing some issues regarding appropriate inclusion of IBRs and DERs (IBR–DERs and synchronous DERs) in planning assessments but notes that additional modifications may be required to adequately address the issues presented in the NOPR. NERC also suggests enhancing the directive by identifying a wider set of operating conditions that would result in the most extreme expected grid stress conditions, both during on-peak load conditions but also off-peak, high renewables conditions (*e.g.,* low inertia).[313]

170. Indicated Trade Associations note that NERC has several ongoing projects to improve the assessments of IBR performance as examples of the ongoing work to address IBR-related reliability concerns that should inform the NERC standard drafting teams that will work to address the directives in the final rule, once issued, including Project 2021–04 (Modifications to Reliability Standard PRC–002) and Project 2022–02 (Modifications to Reliability Standards TPL–001–5.1 and MOD–032–1). Indicated Trade Associations state that Project 2021–04 would modify disturbance monitoring and reporting requirements to better assess resource performance of IBRs during disturbances, and Project 2022–02 is intended to clarify how IBRs are modeled and studied in planning assessments and to include distribution system IBR–DER data and models in steady state and stability contingency analysis.[314]

171. LADWP generally supports including registered and unregistered IBRs in planning assessments, as well as assessments of IBR performance under normal and contingency system conditions, as critical to ensuring the reliable operation of the Bulk-Power System because during disturbance events IBRs tend to act in the aggregate over a widespread area. LADWP also supports including the study and evaluation of ride through performance for stability studies on a comparable basis to synchronous generation resources.[315] LADWP offers that NERC could create a standardized method and criteria for performing additional performance and behavior analysis.[316]

172. IRC supports directives for planning and operational studies, asserting that the current standards do not grant them authority to require relevant entities to provide IBR-related data sufficient for accurate planning or operational studies.[317] SPP encourages the Commission to ensure that registered IBRs provide evidence that they are included in planning coordinator and transmission planner planning assessments.[318]

173. Commenters also support the Commission's proposed directive to require operational authorities to include data within their operational studies to reflect expected actions of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, under normal and contingency system conditions.[319] NERC supports coordinating models used by balancing authorities, transmission operators, and reliability coordinators across their footprints so that faults in one area do not result in unexpected tripping issues in another area.[320]

2. Commission Determination

174. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop and submit to the Commission for approval new or modified Reliability Standards that require planning coordinators and transmission planners to include in their planning assessments the study and evaluation of performance and behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, under normal and contingency system conditions in their planning area. These Reliability Standards should require planning coordinators and transmission planners to include in their planning assessments the study and evaluation of the ride through performance (*e.g.,* tripping and momentary cessation conditions) of IBRs in their planning area for stability studies on a comparable basis to synchronous generation resources. The new or modified Reliability Standards should also require planning coordinators and transmission planners to study the Bulk-Power System reliability impacts of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, in their planning models of their area and in their interconnection-wide area planning models. Further, the new or modified Reliability Standards should also require planning coordinators and transmission planners to study the Bulk-Power System reliability impacts of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, in adjacent and other planning areas that adversely impacts a planning coordinator's or transmission planner's area during a disturbance event.

175. Regarding NERC's recommendations to clarify the types of steady-state and dynamic grid conditions to include in planning studies, we agree that it is important to ensure performance during periods of grid stress. Accordingly, we direct

[309] *Id.* P 89.

[310] *See, e.g.,* NERC Initial Comments at 18–20; AEP Initial Comments at 3; LADWP Reply Comments at 4; NYSRC Initial Comments at 2; infiniRel Initial Comments at 2; CAISO initial Comments at 36; IRC initial Comments at 4; ISO–NE Initial Comments at 3–4.

[311] NERC Initial Comments at 19.

[312] *Id.* at 18.

[313] *Id.* at 18–19.

[314] Indicated Trade Associations Initial Comments at 7.

[315] LADWP Reply Comments at 4.

[316] *Id.* at 4.

[317] IRC Initial Comments at 5.

[318] SPP Initial Comments at 5.

[319] NERC Initial Comments at 7; AEP Initial Comments at 3; NYSRC Initial Comments at 2; infiniRel Initial Comments at 2; CAISO Initial Comments at 37; IRC Initial Comments at 4; ISO–NE Reply Comments at 3.

[320] NERC Initial Comments at 20.

NERC to consider in its standards development process whether to include in new or modified Reliability Standards a requirement that planning coordinators and transmission planners include a wide set of grid stress performance conditions (*i.e.,* both typical and extreme conditions) in planning assessments.[321] Likewise, with regards to NERC's comments related to on-peak and off-peak studies, we direct NERC to consider in the standards development process whether to require planning coordinators and transmission planners to account in planning assessments for both on-peak and off-peak conditions, normal and abnormal (contingency) conditions with high penetration levels of IBRs (*i.e.,* registered IBRs, unregistered IBRs, and IBR–DERs that in the aggregate have a material impact on the Bulk-Power System), and normal and abnormal conditions with low inertia. While we agree with NERC that the above suggestions have merit, we believe that vetting in the standards development process is preferable to determine whether such provisions are beneficial and the scope and language of such provisions. Accordingly, we simply direct NERC to consider these matters without directing a specific outcome.

176. We adopt the NOPR proposal and direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that require reliability coordinators and transmission operators to include the performance and behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs in the aggregate, (*e.g.,* IBRs tripping or entering momentary cessation individually or in the aggregate) in their operational planning analyses, real-time monitoring, and real-time assessments, including non-bulk electric system data and external power system network data identified in their data specifications.[322] Further, we agree with commenters and direct NERC to submit to the Commission for approval new or modified Reliability Standards requiring reliability coordinators and transmission operators, when performing operational studies, as well as operational planning analyses, real-time monitoring, real-time assessments, and other analyses, to include in these studies all generation resources (*i.e.,* all generation resources including all IBRs) necessary to adequately assess the performance of the Bulk-Power System for normal and contingency conditions.[323]

177. We adopt the NOPR proposal and direct NERC to submit to the Commission for approval one or more new or modified Reliability Standards that require balancing authorities to include the performance and behavior of registered and unregistered IBRs individually and in the aggregate, as well as IBR–DERs that in the aggregate have a material impact on the Bulk-Power System, (*e.g.,* resources tripping or entering momentary cessation individually or in the aggregate) in their operational analysis functions and real-time monitoring to support the reliable operation of the Bulk-Power System during normal and contingency conditions.[324]

E. Performance Requirements

1. Registered IBR Frequency and Voltage Ride Through Requirements

178. In the NOPR, the Commission preliminarily found that the Reliability Standards should require registered IBRs to ride through system disturbances to support essential reliability services.[325] Without the availability of essential reliability services, the Commission explained that the system would experience instability, voltage collapse, or uncontrolled separation. Therefore, the Commission proposed to direct NERC to develop new or modified Reliability Standards that would require registered IBR facilities to ride through system frequency and voltage disturbances where technologically feasible. The Commission stated that ride through performance during system disturbances is necessary for registered IBRs to support essential reliability services.

179. The Commission proposed that the new or modified Reliability Standards should require registered IBRs to continue to produce power and perform frequency support during system disturbances. The Commission proposed to direct NERC to develop new or modified Reliability Standards that would require IBR generator owners and operators to use appropriate settings (*i.e.,* inverter, plant controller, and protection) that: (1) will assure frequency ride through during system disturbances and that would permit IBR tripping only to protect the IBR equipment; and (2) allow for voltage ride through during system disturbances and would permit IBR tripping only when necessary to protect the IBR equipment.[326] In the NOPR, the Commission also explained that any new or modified Reliability Standards should require generator owners of IBR facilities to prohibit momentary cessation in the no-trip zone during disturbances by using appropriate and coordinated protection and controls settings.[327]

180. The Commission proposed to direct NERC to develop new or modified Reliability Standards that clearly address and document the technical capabilities of, and differences between, registered IBRs and synchronous generation resources so that registered IBRs will support these essential reliability services.[328]

a. Comments

181. Commenters generally support the Commission's proposed directives to require IBRs to use appropriate settings that will assure ride through during system disturbances.[329] NERC supports the development of a comprehensive, performance-based ride through standard to assure future grid reliability.[330] Indicated Trade Associations and APS agree that the current Reliability Standards do not have IBR-specific performance requirements necessary to ensure the reliable operation of the Bulk-Power System.[331] IRC asserts that there should be requirements for all IBRs to act to support Bulk-Power System reliability during disturbances.[332] AEU highlights the ability of IBRs to deliver ancillary services such as frequency control.[333] CAISO encourages the Commission to move forward in directing NERC to

[321] NOPR, 181 FERC ¶ 61,125 at P 88 & n.164 (citing several NERC disturbance reports that identifies the potential adverse impact of registered IBRs, unregistered IBRs, and IBR–DERs acting in the aggregate in various system conditions over a wide area).

[322] *See, e.g.,* Reliability Standard IRO–010–4, Requirement R1, pt. 1.1 (stating ''[a] list of data and information needed by the Reliability Coordinator to support its Operational Planning Analyses, Real-time monitoring, and Real-time Assessments. . .'') and Reliability Standard TOP–003–5, Requirement R1, pt. 1.1 (stating ''[a] list of data and information needed by the Transmission Operator to support its Operational Planning Analyses, Real-time monitoring, and Real-time Assessments . . . '').

[323] NOPR, 181 FERC ¶ 61,125 at P 52.

[324] *See, e.g.,* Reliability Standard TOP–003–5, Requirement R2, part 2.1 (stating ''[a] list of data and information needed by the Balancing Authority to support its analysis functions and Real-time monitoring'').

[325] NOPR, 181 FERC ¶ 61,125 at P 90.

[326] *Id.* PP 93–95.

[327] *Id.* P 94.

[328] *Id.* P 90.

[329] NERC, AEU, ACP/SEIA, AEP, CAISO, Indicated Trade Associations, ISO–NE, IRC, NYSRC, Ohio FEA, SCE/PG&E, and SPP all indicated support for Reliability Standards for IBR performance requirements.

[330] NERC Initial Comments at 21.

[331] Indicated Trade Associations Initial Comments at 4–5; APS Initial Comments at 2 (indicating it largely supports Indicated Trade Associations Initial Comments but providing additional comments on specific topics).

[332] IRC Initial Comments at 5.

[333] AEU Initial Comments at 2.

establish a minimum standard to require all IBRs to ride through frequency disturbances [334] and states that, in its experience, modern inverters can meet these standards without substantial costs or hardships.[335]

182. NERC, ACP/SEIA, Indicated Trade Associations, SCE/PG&E, and SPP all point to NERC Project 2020–02 (Modifications to PRC–024 (Generator Ride-through)) as the best means to address ride through performance of IBRs. NERC explains that it has already updated the scope of its existing Project 2020–02 to require ride through performance for all generation resources (not just IBRs).[336] ACP/SEIA, SPP, and Indicated Trade Associations note that this project is addressing performance standards for all resource types, including IBRs.[337] SCE/PG&E explain that Project 2020–02 aims to reduce the type of abnormal performance reliability impacts to the Bulk-Power System that NERC has described in its disturbance reports.[338]

183. ACP/SEIA agree with the Commission's prioritization to require NERC to develop IBR ride through Reliability Standards proposed in the NOPR, although they caution that, depending on local factors, different transmission operators may require different ride through performance of generators.[339] ACP/SEIA recommend that NERC continue with Project 2020–02 to modify Reliability Standard PRC–024–3 so that it becomes a ride through performance standard for both IBR and synchronous resources, which would both save time and provide a technology-neutral solution in addressing the full scope of the ride through risk facing the Bulk-Power System.[340] ACP/SEIA also ask the Commission to clarify in the final rule that the new or modified Reliability Standards on ride through should not require generators to maintain real power output at pre-disturbance levels, noting that it is neither feasible nor desirable for generators to maintain real power output at pre-disturbance levels in many instances. ACP/SEIA suggest that the directive instead require registered IBRs to continue to inject current during system disturbances.[341]

184. EPRI notes that maintaining current at the pre-disturbance level during a disturbance may not be practical, needed, or aligned with IEEE 2800–2022 or other international requirements.[342] EPRI explains that Commission directives to NERC to develop Reliability Standards for IBR ride-through capability and performance requirements could refer to IEEE 2800–2022 standards in accordance with good utility practice as examples of technical minimum requirements.[343]

185. NERC supports the Commission's proposed directive to require frequency and voltage ride through during system disturbances.[344] NERC explains that its updated scope for Project 2020–02 will require ride through performance for all generation resources and will include: (1) no momentary cessation in the no trip zone specified, (2) no tripping on instantaneous frequency and voltage deviations, (3) no tripping due to phase lock loop loss within acceptable bounds, (4) no tripping due to DC bus protection and overcurrent protection, and (5) no tripping for unbalanced faults.[345] AEU states that IBRs are not only capable of delivering voltage regulation but, in some cases, can provide ancillary services ''more quickly and accurately than conventional technologies.'' [346]

186. Indicated Trade Associations point to NERC Project 2021–02 Modifications to VAR–002–4.1 (Generator Operation for Maintaining Network Voltage Schedules) as an existing standards project that is working to modify the currently effective Reliability Standard to specify and ensure the reactive support and voltage control obligations of IBRs in accordance with their capability.[347] ISO–NE notes that if the Commission restricts its directive to only registered IBR generator owners and operators, it will leave out the majority of IBRs within New England.[348]

187. UNIFI notes that newer technologies such as grid-forming IBRs have different behavioral responses to disturbances on the grid and offers an initial set of specifications for grid-forming IBRs that could be used as uniform technical requirements for the interconnection, integration, and interoperability of grid-forming IBRs.[349]

188. ACP/SEIA recommend that the Commission direct NERC to either exempt existing equipment that cannot meet the new or modified Reliability Standards or specify that the new or modified Reliability Standards should require compliance only to the extent it is possible with the equipment's current capabilities. ACP/SEIA suggest that any exemption should cover generators that cannot meet the ride-through requirements with updates to their inverter and control settings, and thus would require replacement of that equipment. ACP/SEIA point to Reliability Standard PRC–024–3 as an example of an exemption that is already included.[350]

189. CAISO recommends that the Commission support NERC in identifying technical changes or equipment modifications that could be made to existing IBRs incapable of disabling momentary cessation, such as eliminating plant-level controller interactions.[351] NYSRC disagrees that there should be an exception for existing IBRs and recommends that the Commission delineate an amount of time for IBR facilities to either demonstrate compliance or institute their own mitigation measures.[352] NYSRC and ISO–NE ask the Commission to clarify that the performance requirements directed as part of the final rule would apply to both new and existing IBRs.[353]

b. Commission Determination

190. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop new or modified Reliability Standards that require registered IBR generator owners and operators to use appropriate settings (*i.e.,* inverter, plant controller, and protection) to ride through frequency and voltage system disturbances and that permit IBR tripping only to protect the IBR equipment in scenarios similar to when synchronous generation resources use tripping as protection from internal faults. The new or modified Reliability Standards must require registered IBRs to continue to inject current and perform frequency

[334] CAISO Initial Comments at 11.

[335] *Id.* at 7 (citing *Cal. Indep. Sys. Operator Corp.,* 168 FERC ¶ 61,003, at P 18 n.23 (2019) (noting that, based on input from developers and manufacturers of IBRs, ''CAISO believes that the cost of meeting these requirements will be *de minimis*'').

[336] *See, e.g.,* NERC Initial Comments at 22.

[337] ACP/SEIA Initial Comments at 7–8; SPP Initial Comments at 6; Indicated Trade Associations Initial Comments at 8.

[338] SCE/PG&E Initial Comments at 5.

[339] ACP/SEIA Initial Comments at 1–2.

[340] *Id.* at 10–11.

[341] *Id.* at 7.

[342] EPRI Initial Comments at 25.

[343] *Id.* at 5.

[344] NERC Initial Comments at 22.

[345] *Id.*

[346] AEU Initial Comments at 3.

[347] Indicated Trade Associations Initial Comments at 8.

[348] ISO–NE Initial Comments at 5.

[349] UNIFI Initial Comments at 1.

[350] ACP/SEIA Initial Comments at 9. *See also id.* at 8 (Reliability Standard PRC–024–3, Requirement R3 requires generator owners to document each known regulatory or equipment limitation that prevents the resource from meeting protection settings criteria).

[351] CAISO Initial Comments at 17 (quoting 2021 Solar PV Disturbances Report at 14).

[352] NYSRC Initial Comments at 4.

[353] *Id.;* ISO–NE Initial Comments at 6.

support during a Bulk-Power System disturbance. Any new or modified Reliability Standard must also require registered IBR generator owners and operators to prohibit momentary cessation in the no-trip zone during disturbances. NERC must submit new or modified Reliability Standards that establish IBR performance requirements, including requirements addressing frequency and voltage ride through, post-disturbance ramp rates, phase lock loop synchronization, and other known causes of IBR tripping or momentary cessation.[354] This directive is supported by the comments, as well as the recommendations from multiple event reports, including the Blue Cut Fire Event Report,[355] the Odessa 2021 Disturbance Report,[356] and the 2021 Solar PV Disturbances Report.[357] The directive is also consistent with NERC's comments and the March 2023 Alert language.[358] Additionally, in response to requests by ISO–NE and NYSRC for the Commission to clarify that the performance requirements directed as part of the final rule would apply to both new and existing IBRs, we further clarify that all performance requirement directives apply to new and existing registered IBRs.

191. In response to ACP/SEIA's comments, we clarify that we are not directing NERC to modify the currently effective Reliability Standards to require registered IBRs to maintain real power output during system disturbances. Rather, the new or modified Reliability Standards must require registered IBRs to continue to inject current during system disturbances. We note that Order No. 2023 requires non-synchronous resources to ensure that, within any physical limitations of the generating facility, its control and protection settings are configured or set to ''continue active power production during disturbance and post disturbance periods at pre-disturbance levels unless providing primary frequency response or fast frequency response'' [359] The ride through directive in this final action differs from the ride-through requirements established in Order No. 2023 because the Reliability Standards apply more comprehensively and are enforced differently. While ride through requirements set forth in Reliability Standards will apply to both existing IBRs and newly interconnecting IBRs, the ride through requirements of the *pro forma* LGIA and *pro forma* SGIA established in Order No. 2023 apply only to newly interconnecting IBRs. Moreover, any ride through requirements established through the Reliability Standards would be enforceable by NERC, its Registered Entities, and the Commission through the Reliability Standard enforcement process.

192. We believe that, through its standard development process, NERC is best positioned, with input from stakeholders to determine specific IBRs performance requirements during ride through conditions, such as type (*e.g.,* real current and/or reactive current) and magnitude of current. NERC should use its discretion to determine the appropriate technical requirements needed to ensure frequency and voltage ride through by registered IBRs during its standards development process. In response to comments regarding NERC Project 2020–02 Modifications to PRC–024 (Generator Ride-through) and its updated scope to address IBR ride through performance,[360] we discuss this suggestion further in section IV.F, which requires that NERC's informational filing discuss how it is considering standard development projects already underway that may satisfy the directives in this final action.

193. Regarding ACP/SEIA's request for an explicit exemption for existing IBRs with equipment limitations, we agree that a subset of existing registered IBRs—typically older IBR technology with hardware that needs to be physically replaced and whose settings and configurations cannot be modified using software updates—may be unable to implement the voltage ride though performance requirements directed herein. Therefore, we direct NERC through its standard development process to determine whether the new or modified Reliability Standards should provide for a limited and documented exemption for certain registered IBRs from voltage ride through performance requirements. Any such exemption should be only for voltage ride-through performance for those existing IBRs that are unable to modify their coordinated protection and control settings to meet the requirements without physical modification of the IBRs' equipment. Further, we direct NERC to ensure that any such exemption would be applicable for only existing equipment that is unable to meet voltage ride-through performance. When such existing equipment is replaced, the exemption would no longer apply, and the new equipment must comply with the appropriate IBR performance requirements specified in the Reliability Standards (*e.g.,* voltage and frequency ride through, phase lock loop, ramp rates, etc.). The concern that there are existing registered IBRs unable to meet voltage ride through requirements should diminish over time as legacy IBRs are replaced with or upgraded to newer IBR technology that does not require such accommodation.[361] We encourage NERC's standard drafting team to consider currently effective Reliability Standard PRC–024–3, Requirement R3 as an example for establishing registered IBR technology exemptions.[362] Finally, we direct NERC, through its standard development process, to require the limited and documented exemption list (*i.e.,* IBR generator owner and operator exemptions) to be communicated with their respective Bulk-Power System planners and operators (*e.g.,* the IBR generator owner's or operator's planning coordinator, transmission planner, reliability coordinator, transmission operator, and balancing authority). The Bulk-Power System planners and operators' mitigation activity directives are discussed below in section IV.E.2.

194. In response to ISO–NE's concern that applying ride through performance requirements only to registered IBRs means that the requirements would not apply to the vast majority of IBR capacity in New England, the Commission has already directed NERC to register IBRs that materially impact reliability and believes that NERC's workplan approved in the Order Approving Workplan will be a step towards mitigating ISO–NE's concern about unregistered IBRs.[363]

195. Although EPRI asserts that IEEE standards specify technical minimum

[354] *See infra* P 209.

[355] Blue Cut Fire Event Report at 11–13.

[356] Odessa 2021 Disturbance Report at vii, 12–13.

[357] 2021 Solar PV Disturbances Report at vii, 15, 31.

[358] March 2023 Alert at 4–5 (recommending that industry set fault ride through parameters ''to maximize active current delivery during the fault and post-fault periods'' and to ''not artificially limit dynamic reactive power capability delivered to the point of interconnection during normal operations and [Bulk-Power System] disturbances.'').

[359] Order No. 2023, 184 FERC ¶ 61,054 at P 1715.

[360] *See, e.g.,* NERC Initial Comments at 22; Indicated Trades Associations Initial Comments at 8.

[361] *See generally* 2021 Solar PV Disturbances Report at 14 (discussing momentary cessation from legacy facilities that cannot eliminate its use).

[362] Reliability Standard PRC–024–3, Requirement R3 (explaining that ''each Generator Owner shall document each known regulatory or equipment limitation that prevents an applicable generating resource(s) with frequency or voltage protection from meeting the protection setting criteria in Requirements R1 or R2, including (but not limited to) study results, experience from an actual event, or manufacturer's advice.'').

[363] *See* Order Approving Workplan, 183 FERC ¶ 61,116 at P 32 (explaining that NERC asserts that its work plan would result in approximately 98 percent of Bulk-Power System-connected IBRs being subject to applicable Reliability Standards).

capability and performance requirements that could be referenced as examples of good utility practice,[364] NERC's comments indicate that currently effective Reliability Standard PRC–024–3, as well as the re-scoped Project 2020–02 (Modifications to PRC–024 (Generator Ride-through)), differ from IEEE standards in that both the currently effective Reliability Standard and re-scoped PRC–024 project disallow momentary cessation within the no trip zone, while IEEE–2800–2022 would allow momentary cessation under certain conditions.[365] As the record in this proceeding provides no basis to conclude that the performance requirements of IEEE 2800–2022 are preferable to NERC's or would adequately address the reliability concerns discussed in this final action, we decline to direct NERC to specifically reference IEEE standards in its new or modified Reliability Standards. Rather, NERC has the discretion to consider during its standards development process whether and how to reference IEEE standards in the new or modified Reliability Standards.

2. Bulk-Power System Planners and Operators Voltage Ride Through Mitigation Activities

196. In the NOPR, the Commission acknowledged that some registered generator owners and operators of IBRs currently in operation may be unable to prohibit momentary cessation in the no-trip zone during disturbances by using appropriate and coordinated protection and controls settings.[366] For such scenarios, the Commission proposed to direct NERC to require Bulk-Power System planners and operators to implement mitigation activities that may be needed to address any reliability impact to the Bulk-Power System posed by these existing facilities.[367]

a. Comments

197. NYSRC raises concerns with the Commission's proposal because allowing an exception for legacy registered IBRs would mean that transmission owners and operators would be responsible for mitigating an event consisting of an unknown number of IBRs disconnecting from the system at any time in the future, in an unanticipated manner.[368] NYSRC asserts that requiring transmission planners and operators to ensure there are mitigation strategies for scenarios where existing IBRs are unable to meet performance requirements would be infeasible, as they would need to plan for and address an event consisting of an unknown number of IBRs disconnecting at any time.[369]

198. Indicated Trade Associations disagree with the Commission's proposal to require transmission planners and operators to mitigate instances in which IBRs are incapable of prohibiting momentary cessation in the no-trip zone during disturbances, asserting that such a requirement should be solely the responsibility of registered generator owners.[370] Indicated Trade Associations also ask the Commission to clarify what it means by an ''operator'' being responsible for mitigating events.

b. Commission Determination

199. Pursuant to section 215(d)(5) of the FPA, we modify the NOPR proposal. To the extent NERC determines that a limited and documented exemption for those registered IBRs currently in operation and unable to meet voltage ride-through requirements is appropriate due to their inability to modify their coordinated protection and control settings,[371] we direct NERC to develop new or modified Reliability Standards to mitigate the reliability impacts to the Bulk-Power System of such an exemption. As NERC will consider the reliability impacts to the Bulk-Power System caused by an such exemption, we believe that the concerns raised by NYSRC and Indicated Trade Associations on the appropriate registered entity responsible for implementing the mitigation activities, and the nature of such mitigation, should be addressed in the NERC standards development process.

3. Post-Disturbance IBR Ramp Rate Interactions and Phase Lock Loop Synchronization

200. In the NOPR, the Commission proposed to direct NERC to develop new or modified Reliability Standards to address other registered IBR performance and operational characteristics that can affect the reliable operation of the Bulk-Power System, namely, ramp rate interactions and phase lock loop synchronization.[372] The Commission stated that the proposed directives would improve the reliable operation of the Bulk-Power System by helping to avoid instability, voltage collapse, uncontrolled separation, or islanding.[373]

201. The Commission proposed to direct NERC to ensure that post-disturbance ramp rates for registered IBRs are not restricted or do not artificially interfere with the IBR returning to a pre-disturbance output level in a quick and stable manner after a Bulk-Power System fault event.[374] Furthermore, the Commission proposed to direct NERC to require that IBRs ride through any conditions not addressed by the proposed new or modified Reliability Standards covering frequency or voltage ride through, including phase lock loop loss of synchronism.[375]

202. Further, the Commission proposed to direct that the Reliability Standards obligate generator owners to communicate to the relevant planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities the actual post-disturbance ramp rates and the ramp rates set to meet expected dispatch levels (*i.e.,* generation-load balance). The Commission explained that the proposed new or modified Reliability Standards should account for the technical differences between IBRs and synchronous generation resources, such as IBRs' faster control capability to

[364] *See, e.g.,* EPRI Initial Comments at 5; *see also id.* at 8 (proposing generally that the Reliability Standards should consider using the precise language and definitions as published in the industry standards and aligning requirements with leading international practice and grid codes).

[365] *See* NERC Initial Comments at 22 n.39 (explaining that ''[a] notable caveat is that IEEE 2800 allows momentary cessation (referred to as current blocking) at very low voltages (*i.e.,* <0.1 pu voltage). This nuance could be addressed by the standard drafting team and should be considered by regulatory bodies to ensure alignment.'').

[366] *See, e.g.,* 2021 Solar PV Disturbances Report at 14 (discussing technical limitations of legacy IBRs related to voltage control and momentary cessation).

[367] NOPR, 181 FERC ¶ 61,125 at PP 94–95.

[368] NYSRC Initial Comments at 4.

[369] *Id.*

[370] Indicated Trade Associations Initial Comments at 8.

[371] *See supra* section IV.E.1.

[372] NOPR, 181 FERC ¶ 61,125 at P 91.

[373] *Id.* P 92.

[374] *Id.* P 96. *See* Canyon 2 Fire Event Report at 11 (stating that ''[e]xisting inverters where momentary cessation cannot be effectively eliminated should not be impeded from restoring current injection following momentary cessation. Active current injection should not be restricted by a plant-level controller or other slow ramp rate limits. Resources with this interaction should remediate the issue in close coordination with their [balancing authority] and inverter manufacturers to ensure that ramp rates are still enabled appropriately to control gen-load balance but not applied to restoring output following momentary cessation.'').

[375] *Id.* P 97. *See* Canyon 2 Fire Event Report at vi (explaining that inverters should ride through momentary loss of synchronism during Bulk-Power System events, such as faults. Inverters riding through these disturbances should ''continue to inject current into the grid and, at a minimum, lock the [phase lock loop] to the last synchronized point and continue injecting current to the [Bulk-Power System] at that calculated phase until the [phase lock loop] can regain synchronism upon fault clearing'').

ramp power output down or up when capacity is available.[376]

203. The Commission also explained that the currently effective Reliability Standards do not require that all generation resources maintain voltage phase angle synchronization with the Bulk-Power System grid voltage during a system disturbance.[377] The Commission proposed that any new or modified Reliability Standards should require IBRs to ride through momentary loss of synchronism during Bulk-Power System disturbances and require IBRs to continue to inject current into the Bulk-Power System at pre-disturbance levels during a disturbance.[378]

a. Comments

204. NERC, AEP, CAISO, IRC, and NYSRC support the proposed directive to address post-disturbance IBR ramp rate interactions and phase lock loop synchronization.[379] NERC explains that it is considering requirements amending the project scope for Project 2020–02 Modifications to PRC–024 (Generator Ride-through) to include consideration of post-fault recovery times, ramp rate interactions, or the injection of certain levels of currents (and powers) during grid disturbances, and to include requirements that disallow phase lock loop loss of synchronism and other phase angle-based tripping within acceptable bounds.[380]

205. ACP/SEIA do not believe that IBRs can inject current accurately when synchronism is lost and assert that in those cases IBRs would blindly provide pre-fault current, which would not be desirable for grid stability.[381] ACP/SEIA recommend revising the language of the directive to require generators to maintain synchronism where possible and continue to inject current to support system stability.[382]

206. Although SPP agrees with proposed directives related to ramp rate interactions and phase lock loop synchronization, SPP requests that the Commission include in the final rule a consideration of the IEEE 2800–2022 standard. SPP recommends that the Commission direct an analysis of the interrelationship or overlap between the IEEE standards and any new or modified Reliability Standards.[383]

207. EPRI suggests that the Commission direct NERC to develop new or modified Reliability Standards using comprehensive and holistic ride through capability and performance requirements instead of explicitly mentioning causes of trip (*i.e.,* loss of phase lock loop synchronism in this case) or causes of slow recovery (*i.e.,* slow ramp rate), which may leave out other causes.[384]

b. Commission Determination

208. Pursuant to section 215(d)(5) of the FPA, we adopt the NOPR proposal and direct NERC to develop and submit to the Commission for approval new or modified Reliability Standards that require post-disturbance ramp rates for registered IBRs to be unrestricted and not programmed to artificially interfere with the resource returning to a pre-disturbance output level in a quick and stable manner after a Bulk-Power System disturbance event. The proposed Reliability Standards must account for the technical differences between registered IBRs and synchronous generation resources, such as registered IBRs' faster control capability to ramp power output down or up when capacity is available.[385] Further, the Reliability Standards must require generator owners to communicate to the relevant planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities the actual post-disturbance ramp rates and the ramp rates to meet expected dispatch levels (*i.e.,* generation-load balance).

209. We direct NERC to submit to the Commission for approval new or modified Reliability Standards that would require registered IBRs to ride through any conditions not addressed by the proposed new or modified Reliability Standards that address frequency or voltage ride through, including phase lock loop loss of synchronism. The proposed new or modified Reliability Standards must require registered IBRs to ride through momentary loss of synchronism during Bulk-Power System disturbances and require registered IBRs to continue to inject current into the Bulk-Power System at pre-disturbance levels during a disturbance, consistent with the IBR Interconnection Requirements Guideline and Canyon 2 Fire Event Report recommendations.[386] Related to ACP/SEIA's comment recommending to revise the directive to require generators to maintain synchronism where possible and continue to inject current to support system stability, we direct NERC, through its standard development process, to consider whether there are conditions that may limit generators to maintain synchronism.

210. Regarding NERC's comment informing that NERC is considering whether to amend the Project 2020–02 Modifications to PRC–024 (Generator Ride-through) scope, while NERC did not request any particular Commission action, we support such project modification as consistent with our above directive that registered IBRs ride through any conditions, including phase lock loop loss of synchronism. Similarly, we believe that EPRI's suggestion to use comprehensive and holistic ride through capability and performance requirements instead of a piecemeal approach to addressing performance concerns that may exclude other ride through capability and performance requirements aligns with our above directive.

211. Related to SPP's comment to include in the final rule consideration of IEEE 2800–2022 to address ramp rate interactions and phase lock loop synchronization of registered IBRs, we decline to direct NERC to specifically reference IEEE standards in its new or modified Reliability Standards for similar reasons as discussed above in section IV.E.1. Rather, NERC has the discretion to consider during its standards development process whether and how to reference IEEE standards in the new or modified Reliability Standards. As discussed in section IV.F below, NERC's informational filing should discuss how it is considering standard development projects already underway to meet the directives in this final action.

F. Informational Filing and Reliability Standard Development Timeline

212. In the NOPR, the Commission proposed to direct NERC to submit a compliance filing within 90 days of the effective date of the final rule in this proceeding. The proposed compliance filing would include a detailed, comprehensive standards development and implementation plan explaining how NERC will prioritize the development and implementation of

[376] NOPR, 181 FERC ¶ 61,125 at P 96.

[377] *Id.* P 97.

[378] *Id.*

[379] NERC Initial Comments at 5; AEP Initial Comments at 5; CAISO Initial Comments at 1; IRC Initial Comments at 5; NYSRC Initial Comments at 1.

[380] NERC Initial Comments at 22.

[381] ACP/SEIA Initial Comments at 8.

[382] *Id.*

[383] SPP Initial Comments at 4.

[384] EPRI Initial Comments at 25.

[385] NOPR, 181 FERC ¶ 61,125 at P 96.

[386] *Id.* P 97; *see also* Canyon 2 Fire Event Report at 20 (recommending that ''[i]nverters should not trip for momentary [phase lock loop] loss of synchronism caused by phase jumps, distortion, etc., during [Bulk-Power System] grid events (*e.g.,* faults). Inverters should continue to inject current into the grid and, at a minimum, lock the [phase lock loop] to the last synchronized point and continue injecting current to the [Bulk-Power System] at that calculated phase until the [phase lock loop] can regain synchronism upon fault clearing.'').

new or modified Reliability Standards. The Commission proposed requiring NERC to explain in its compliance filing how it is prioritizing its IBR Reliability Standard projects to meet the directives in the final rule, taking into account the risks posed to the reliability of the Bulk-Power System, standard development projects already underway, resource constraints, and other factors as necessary.[387]

213. The Commission proposed to direct NERC to use a staggered approach that would result in NERC submitting new or modified Reliability Standards in three stages: (1) new or modified Reliability Standards including directives related to registered IBR failures to ride through frequency and voltage variations during normally cleared Bulk-Power System faults filed with the Commission within 12 months of Commission approval of the plan; (2) new or modified Reliability Standards addressing the interconnected directives related to registered IBR, unregistered IBR, and IBR–DER data sharing; registered IBR disturbance monitoring data sharing; registered IBR, unregistered IBR, and IBR–DER data and model validation; and registered IBR, unregistered IBR, and IBR–DER planning and operational studies filed with the Commission within 24 months of Commission approval of the plan; and (3) new or modified Reliability Standards including the remaining directives for post-disturbance ramp rates and phase lock loop synchronization filed with the Commission within 36 months of Commission approval of the plan.[388]

1. Comments

214. NERC supports a directive to require a compliance filing within 90 days.[389] NERC generally supports the Commission's proposal for a compliance filing, including a standards development plan.[390] Nevertheless, NERC seeks clarification of the Commission's use of ''implementation plan'' and whether that phrase refers to the timeline for developing responsive new or modified Reliability Standards or the timeline for entity implementation of the approved new or modified Reliability Standards. NERC cautions that if implementation plan means ''the time for an entity to implement a new or revised Reliability Standard,'' then it would be unable to provide meaningful information for Reliability Standards still in development because reasonable implementation periods are still under consideration through NERC's Commission-approved Reliability Standard development process.[391]

215. Indicated Trade Associations suggest directing NERC to include in its work plan a comparison to its ongoing IBR-related standards projects' scopes and how each relates to the directives in the final rule.[392] Indicated Trade Associations caution against losing the work already completed.[393] Indicated Trade Associations and IRC point to existing NERC projects addressing reliability gaps pertaining to IBR data sharing that could be leveraged to address the proposed directives, including Project 2020–06 (Verifications of Models and Data for Generators), Project 2022–02 (Modifications to Reliability Standards TPL–001–5.1 and MOD–032–1), and Project 2021–04 (Modifications to Reliability Standard PRC–002–2).[394]

216. SCE/PG&E, while broadly supportive of the Commission's goals, recommend initiating a pilot program as a first step before progressing to directives for new or modified Reliability Standards. SCE/PG&E recommend that the pilot program should study: (1) changes by the CAISO to address IBRs and consider whether they translate to national standards; (2) interconnection tariff revisions under review at the California Public Utilities Commission under California Electric Rule 21; and (3) systems with high-IBR penetrations and what information is available to distribution providers, generator owners, generator operators, transmission owners, and transmission operators within these footprints.[395] SCE/PG&E assert that NERC could take advantage of ongoing state actions to ensure reliable operation and to coordinate with the states so there are no conflicting obligations.[396]

217. NERC, AEP, Bonneville, CAISO, and Ohio FEA generally support the idea of a staggered standard development plan but provide some recommendations to adjust the schedule to take advantage of NERC's ongoing standard development projects. NERC proposes an alternate timeline whereby it would submit proposed new or modified Reliability Standards addressing: (1) comprehensive ride through requirements (including frequency, voltage, post-disturbance ramp rates, and phase lock loop synchronization), post-event performance validation, and disturbance monitoring data within 12 months of Commission approval of the plan; (2) data sharing issues, other than disturbance monitoring data, and data and model validation for registered and unregistered IBRs and IBR–DERs in the aggregate within 24 months of Commission approval of the plan; and (3) planning and operational studies for registered and unregistered IBRs and IBR–DERs in the aggregate within 36 months of Commission approval of the plan.[397] NERC explains that its alternate timeline would leverage existing and planned activities more efficiently and address higher priority risks more expeditiously, while allowing sufficient time to develop consensus approaches on other issues.[398]

218. AEP and CAISO support the Commission's proposed staggered approach but suggest modifying the proposal to include all aspects of ride through performance (*i.e.,* phase lock loop synchronization and post-disturbance ramp rates) in the first stage.[399] Further, as NERC is working on addressing currently unregistered IBR generator owners and operators, AEP recommends addressing the interconnected issues related to registered and unregistered IBR and IBR–DER data sharing, validation, and studies after the remaining directives in the three-year time frame.[400]

219. Bonneville believes that the three-year proposed timeline should be extended to five years.[401] Bonneville explains that the proposed directives for data sharing, model validation, and studies will ''require extensive industry collaboration'' and that a five-year timeline will ensure that NERC and industry have adequate time to develop the standards, especially as Bonneville notes there will be an increase in generation interconnection requests and corresponding need for additional model validation.[402]

220. Ohio FEA anticipates that using a staggered standards development timeline will provide additional opportunities for stakeholders to participate in the development of the new or modified Reliability Standards and recommends robust comment

[387] *Id.* P 72.

[388] *Id.* P 73.

[389] NERC Initial Comments at 23.

[390] *Id.*

[391] *Id.* at 23–24.

[392] Indicated Trade Associations Initial Comments at 2.

[393] *Id.* at 5.

[394] *Id.* at 6; IRC Initial Comments at 3.

[395] SCE/PG&E Initial Comments at 9–11.

[396] *Id.* at 10.

[397] NERC Initial Comments at 26–30.

[398] *Id.* at 24.

[399] AEP Initial Comments at 5; CAISO Initial Comments at 5.

[400] AEP Initial Comments at 6.

[401] Bonneville Initial Comments at 1.

[402] *Id.* at 3.

periods at each stage in the staggered approach.[403]

221. ACP/SEIA caution that, although supportive of ride through requirements, one year to develop such standards is a short time when compared with how long it typically takes to develop Reliability Standards and may be infeasible if NERC does not use its existing standards development projects to comply with the rule.[404]

2. Commission Determination

222. Pursuant to § 39.2(d) of the Commission's regulations,[405] we modify the NOPR proposal and direct NERC to submit an informational filing within 90 days of the issuance of the final rule in this proceeding. Further, pursuant to section 215(d)(5)(g) of the FPA, we direct NERC to submit new or modified Reliability Standards addressing the reliability concerns outlined herein by certain deadlines, detailed further below.

223. NERC's informational filing should include a detailed, comprehensive standards development plan and explanation of how NERC will prioritize the development of new or modified Reliability Standards directed in this rule. We agree with NERC and Indicated Trade Associations, among others, that there are existing projects that can be leveraged to address our directives in a timely manner.[406] Therefore, NERC should take into account the risk posed to the reliability of the Bulk-Power System, standard development projects already underway, resource constraints, its ongoing registration of Bulk-Power System-connected IBR generator owners and operators, and other factors as necessary.[407] As we recognized in the NOPR, data models and validation build and rely upon the data sharing directives. Similarly, the planning and operational study directives require the use of validated models and data sharing.[408]

224. In its comments, NERC provides an alternate timeline it explains would leverage its existing and planned activities more efficiently. It references initiatives already underway and highlights several ongoing standards development projects that could be adjusted to address the directives in this final action.[409] As NERC explains in its comments, a standards development plan provides visibility to both the Commission and stakeholders on how NERC will address the important reliability issues identified in this final action. In the interest of time, however, and as NERC appears to have already extended considerable effort in thinking through how it would address IBR-related gaps through its Reliability Standard projects, we do not find it necessary to approve NERC's final work plan.

225. As requested by NERC, we clarify that the Commission's reference to ''implementation'' in the NOPR means the date on which the new or modified Reliability Standards would become mandatory and enforceable for relevant registered entities. But we find persuasive NERC's assertion that that the implementation plan is better developed standard-by-standard through NERC's Commission approved Reliability Standard development process. Therefore, we decline to direct NERC to include in its informational filing the dates by which all of the new or modified Reliability Standards would be mandatory and effective.

226. Although we are not directing NERC to include implementation dates in its informational filing and are leaving determination of the proposed effective dates to the standards development process, we are concerned that the lack of a time limit for implementation could allow identified issues to remain unresolved for a significant and indefinite period. Therefore, we emphasize that industry has been aware of and alerted to the need to address the impacts of IBRs on the Bulk-Power System since at least 2016. The number of events, NERC Alerts, reports, whitepapers, guidelines, and ongoing standards projects more than demonstrate the need for the expeditious implementation of new or modified Reliability Standards addressing IBR data sharing, data and model validation, planning and operational studies, and performance requirements. Thus, in that light, the Commission will consider the justness and reasonableness of each new or modified Reliability Standard's implementation plan when it is submitted for Commission approval.[410] Further, we believe that there is a need to have all of the directed Reliability Standards effective and enforceable well in advance of 2030 and direct NERC to ensure that the associated implementation plans sequentially stagger the effective and enforceable dates to ensure an orderly industry transition for complying with the IBR directives in this final action prior to that date.

227. We decline to direct NERC to implement a pilot program to better analyze the impact of IBRs on the Bulk-Power System as requested by SCE/PG&E. While there may be merit in conducting a pilot program for systems with high-IBR penetrations to better understand what information is available to distribution providers, generator owners, generator operators, transmission owners, and transmission operators within these footprints, we leave to NERC's discretion the value of such a study; and in any case such a pilot program must not impact the prioritization or timely completion of the directed Reliability Standards.

228. We agree with NERC, CAISO, and AEP that the stages should be modified from the NOPR proposal to group the ride through directives and the development of new or modified Reliability Standards for data sharing and model validation to inform the standard development for planning and operational studies.

229. Therefore, as we are persuaded by commenters' suggestions regarding the proposed staggered groupings for new or modified Reliability Standards, we modify the NOPR proposal to adopt NERC's proposed staggered grouping that would result in NERC submitting new or modified Reliability Standards in three stages. NERC's standards development plan submitted as a part of its informational filing must ensure that NERC submits new or modified Reliability Standards by the following deadlines. First, by November 4, 2024, NERC must submit new or modified Reliability Standards that establish IBR performance requirements, including requirements addressing frequency and voltage ride through, post-disturbance ramp rates, phase lock loop synchronization, and other known causes of IBR tripping or momentary cessation (section IV.E.). NERC must also submit, by November 4, 2024, new or modified Reliability Standards that require disturbance monitoring data sharing and post-event performance validation for registered IBRs (section IV.B.2.). Second, by November 4, 2025,

[403] Ohio FEA Initial Comments at 7.

[404] ACP/SEIA Initial Comments at 4.

[405] 18 CFR 39.2(d).

[406] *See, e.g.,* NERC Initial Comments at 22; Indicated Trades Associations Initial Comments at 8 (discussing NERC Project 2020–02 Modifications to PRC–024 (Generator Ride-through) and its updated scope to address IBR ride through performance).

[407] *See* IBR Registration Order, 181 FERC ¶ 61,124.

[408] NOPR, 181 FERC ¶ 61,125 at P 74.

[409] NERC Initial Comments at 21–22.

[410] *See* Order No. 672, 114 FERC ¶ 61,104 at P 333 (''In considering whether a proposed Reliability Standard is just and reasonable, the Commission will consider also the timetable for implementation of the new requirements, including how the proposal balances any urgency in the need to implement it against the reasonableness of the time allowed for those who must comply.'').

NERC must submit new or modified Reliability Standards addressing the interrelated directives concerning: (1) data sharing for registered IBRs (section IV.B.1), unregistered IBRs (section IV.B.3.), and IBR–DERs in the aggregate (section IV.B.3.); and (2) data and model validation for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate (section IV.C.). Finally, by November 4, 2026, NERC must submit new or modified Reliability Standards addressing planning and operational studies for registered IBRs, unregistered IBRs, and IBR–DERs in the aggregate (section IV.D.). We continue to believe this staggered approach to standard development is necessary based on the scope of work anticipated and that specific target dates will provide a valuable tool and incentive to NERC to timely address the directives in this final action.

230. NERC may expedite its standards development plan and submit new or modified Reliability Standards prior to the deadlines. We decline to extend the three-year staggered approach to a five-year staggered approach as requested by Bonneville due to the pressing nature of the Commission's concerns discussed above, such as IBR momentary cessation occurring in the aggregate today that can lead to instability, system-wide uncontrolled separation, and voltage collapse.

V. Information Collection Statement

231. The information collection requirements contained in this order are subject to review by the Office of Management and Budget (OMB) under section 3507(d) of the Paperwork Reduction Act of 1995.[411] OMB's regulations require approval of certain information collection requirements imposed by agency rules.[412] Upon approval of a collection of information, OMB will assign an OMB control number and expiration date. Respondents subject to the filing requirements of this rule will not be penalized for failing to respond to this collection of information unless the collection of information displays a valid OMB control number. Comments are solicited on the Commission's need for the information proposed to be reported, whether the information will have practical utility, ways to enhance the quality, utility, and clarity of the information to be collected, and any suggested methods for minimizing the respondent's burden, including the use of automated information techniques.

232. The directives to NERC to submit new or modified Reliability Standards that address specific matters pertaining to the impacts of IBRs on the reliable operation of the Bulk-Power System are covered by, and already included in, the existing OMB-approved information collection FERC–725 (Certification of Electric Reliability Organization; Procedures for Electric Reliability Standards; OMB Control No. 1902–0225), under Reliability Standards Development.[413] In this final action, we direct NERC to develop new or modify the currently effective Reliability Standards to address these issues and, when these Reliability Standards are submitted to the Commission for approval, to explain in the accompanying petition how the issues are addressed in the proposed new or modified Reliability Standards. NERC may propose to develop new or modified Reliability Standards that address our concerns in an equally efficient and effective manner; however, NERC's proposal should explain how the new or modified Reliability Standards address the Commission's concerns discussed in this final action.

233. Necessity of Information. Direct NERC to develop new or modified Reliability Standards addressing reliability gaps pertaining to IBRs in four areas: (1) data sharing; (2) model validation; (3) planning and operational studies; and (4) performance requirements.

VI. Environmental Analysis

234. The Commission is required to prepare an Environmental Assessment or an Environmental Impact Statement for any action that may have a significant adverse effect on the human environment.[414] The Commission has categorically excluded certain actions from this requirement as not having a significant effect on the human environment. Included in the exclusion are rules that are clarifying, corrective, or procedural or that do not substantially change the effect of the regulations being amended.[415] The actions directed herein fall within this categorical exclusion in the Commission's regulations.

VII. Regulatory Flexibility Act

235. The Regulatory Flexibility Act of 1980 (RFA)[416] generally requires a description and analysis of final rules that will have significant economic impact on a substantial number of small entities. This final action directs NERC, the Commission-certified ERO, to develop new or modified Reliability Standards for IBRs on the Bulk-Power System. Therefore, this final action will not have a significant or substantial impact on entities other than NERC.[417] Consequently, the Commission certifies that this final action will not have a significant economic impact on a substantial number of small entities.

236. Any new or modified Reliability Standards proposed by NERC in compliance with this rulemaking will be considered by the Commission in future proceedings. As part of any future proceedings, the Commission will make determinations pertaining to the RFA based on the content of the Reliability Standards proposed by NERC.

VIII. Document Availability

237. In addition to publishing the full text of this document in the **Federal Register**, the Commission provides all interested persons an opportunity to view and/or print the contents of this document via the internet through the Commission's Home Page (*http://www.ferc.gov*).

238. From FERC's Home Page on the internet, this information is available on eLibrary. The full text of this document is available on eLibrary in PDF and Microsoft Word format for viewing, printing, and/or downloading. To access this document in eLibrary, type the docket number excluding the last three digits of this document in the docket number field.

239. User assistance is available for eLibrary and the FERC's website during normal business hours from FERC Online Support at (202) 502–6652 (toll free at 1–866–208–3676) or email at *ferconlinesupport@ferc.gov,* or the Public Reference Room at (202) 502–8371, TTY (202) 502–8659. Email the Public Reference Room at *public.referenceroom@ferc.gov.*

[411] 44 U.S.C. 3507(d).

[412] 5 CFR 1320.11.

[413] Reliability Standards Development as described in FERC–725 covers standards development initiated by NERC, the Regional Entities, and industry, as well as Reliability Standards the Commission may direct NERC to develop or modify. The information collection associated with this final action ordinarily would be a non-material addition to FERC–725. However, an information collection request unrelated to this final action is pending review under FERC–725 at the Office of Management and Budget. To submit this final action timely to OMB, we will submit this to OMB as a temporary placeholder under FERC–725(1A), OMB Control No. 1902–0289.

[414] *Reguls. Implementing the Nat'l Env't Pol'y Act,* Order No. 486, 52 FR 47897 (Dec. 17, 1987), FERC Stats. & Regs. ¶ 30,783 (1987) (cross-referenced at 41 FERC ¶ 61,284).

[415] 18 CFR 380.4(a)(2)(ii).

[416] 5 U.S.C. 601–612.

[417] *See, e.g., Transmission Sys. Plan. Performance Requirements for Extreme Weather,* Order No. 896, 88 FR 41262 (June 23, 2023), 183 FERC ¶ 61,191, at P 198 (2023).

IX. Effective Date and Congressional Notification

240. This final action is effective December 29, 2023. The Commission has determined, with the concurrence of the Administrator of the Office of Information and Regulatory Affairs of OMB, that this rule is not a ''major rule'' as defined in section 351 of the Small Business Regulatory Enforcement Fairness Act of 1996.

By the Commission. Commissioner Danly is concurring with a separate statement attached.

Issued October 19, 2023

Kimberly D. Bose,

Secretary.

Appendix A: Commenter Names

Acronyms	Commenter name
AEU	Advanced Energy United.
ACP/SEIA	American Clean Power Association and Solar Energy Industries Association.
AEP	American Electric Power Service Corporation.
APS	Arizona Public Service Company.
Bonneville	Bonneville Power Administration.
CAISO	California Independent System Operator Corporation.
EPRI	Electric Power Research Institute.
Indicated Trade Associations	Edison Electric Institute, American Public Power Association, Large Public Power Council, National Rural Electric Cooperative Association, and Transmission Access Policy Study Group.
infiniRel	infiniRel Corporation.
ISO–NE	ISO New England Inc.
IRC	ISO/RTO Council.
NYSRC	New York State Reliability Council.
LADWP	Los Angeles Department of Water and Power.
Ohio FEA	Public Utilities Commission of Ohio's Office of the Federal Energy Advocate.
Mr. Plankey	Sean P. Plankey.
SCE/PG&E	Southern California Edison Company and Pacific Gas and Electric Company.
SPP	Southwest Power Pool, Inc.
UNIFI	Universal Interoperability for Grid-forming Inverters Consortium.

Appendix B: NERC IBR Resources Cited in the Final Action

NERC Guidelines

NERC Guidelines referenced in this NOPR are available here: *https://www.nerc.com/comm/Pages/Reliability-and-Security-Guidelines.aspx.*

NERC, *Reliability Guideline: Modeling Distributed Energy Resources in Dynamic Load Models* (Dec. 2016), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_-_Modeling_DER_in_Dynamic_Load_Models_-_FINAL.pdf* (retired).

NERC, *Reliability Guideline: Distributed Energy Resources Modeling,* (Sept. 2017), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_-_DER_Modeling_Parameters_-_2017-08-18_-_FINAL.pdf* (retired).

NERC, *Reliability Guideline: BPS-Connected Inverter-Based Resource Performance* (Sept. 2018), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Inverter-Based_Resource_Performance_Guideline.pdf* (IBR Performance Guideline).

NERC, *Reliability Guideline: Parameterization of the DER_A Model* (Sept. 2019), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_A_Parameterization.pdf* (2019 DER_A Model Guideline) (retired).

NERC, *Reliability Guideline: DER Data Collection for Modeling in Transmission Planning Studies* (Sept. 2020), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_Data_Collection_for_Modeling.pdf* (IBR–DER Data Collection Guideline).

NERC, *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies* (Mar. 2021), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline%20_DER_Model_Verification_of_Aggregate_DER_Models_used_in_Planning_Studies.pdf* (Aggregate DER Model Verification Guideline).

NERC, *Reliability Guideline: Parameterization of the DER_A Model for Aggregate DER* (Feb. 2023), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_ModelingMerge_Responses_clean.pdf* (2023 DER_A Model Guideline).

NERC, *Reliability Guideline: Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources—Recommended Model Requirements and Verification Practices* (Mar. 2023), *https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline-EMT_Modeling_and_Simulations.pdf.*

NERC White Papers

IRPTF white papers referenced in this NOPR are available here: *https://nerc.com/comm/PC/Pages/Inverter-Based-Resource-Performance-Task-Force.aspx.*

NERC, *A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability* (Oct. 2014), *https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Concept%20Paper.pdf* (Essential Reliability Services Concept Paper).

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United States of America

Federal Energy Regulatory Commission

Reliability Standards to Address Inverter-Based Resources
Docket No. RM22–12–000

DANLY, Commissioner, *concurring:*

1. I concur in today's order [1] in which we direct NERC to develop new or modified mandatory and enforceable Reliability Standards prior to 2030 in order to address a set of reliability risks we have known about, and been actively discussing, since at least 2016 and about which I have long warned. Is today's order important and necessary? Yes. Is it timely? No. Six of the thirteen documented events occurred in 2021.[2] The Commission and NERC could have, and should have, acted sooner, particularly since 2030 marks the time at which inverter-based resources (IBRs) ''are projected to account for a significant share of the electric energy generated in the United States.'' [3]

2. The reliability risks at issue arise from the rapid, widespread (one might say reckless) addition of IBRs (*e.g.,* wind and solar) to the Bulk-Power System (BPS).[4] According to NERC, ''[t]he rapid interconnection of [BPS]-connected [IBRs] is the most significant driver of grid transformation and poses a high risk to BPS reliability.'' [5] As NERC has explained, ''[e]ach event analyzed has identified new performance issues, such as momentary cessation, unwarranted inverter or plant-level tripping issues, controller interactions and instabilities, and other critical performance risks that must be mitigated.'' [6] ''Simulations conducted by the NERC Resource Subcommittee demonstrate that the risks to the [BPS] reliability posted by momentary cessation are greater than any of the actual IBR disturbances that NERC has documented since 2016 . . . These simulation results indicate that IBR momentary cessation occurring in the aggregate can lead to instability, system-wide uncontrolled separation, and voltage collapse.'' [7]

3. NERC has also observed ''[m]ultiple recent disturbances that involve the

[1] *Reliability Standards to Address Inverter-Based Resources,* 185 FERC ¶ 61,042 (2023).

[2] *Id.* P 26 & n.53 (''The 12 events report an average of approximately 1,000 MW of IBRs entering into momentary cessation or tripping in the aggregate. The 12 Bulk-Power System events are: (1) the Blue Cut Fire (August 16, 2016); (2) the Canyon 2 Fire (October 9, 2017); (3) Angeles Forest (April 20, 2018); (4) Palmdale Roost (May 11, 2018); (5) San Fernando (July 7, 2020); (6) the first Odessa, Texas event (May 9, 2021); (7) the second Odessa, Texas event (June 26, 2021); (8) Victorville (June 24, 2021); (9) Tumbleweed (July 4, 2021); (10) Windhub (July 28, 2021); (11) Lytle Creek (August 26, 2021); and (12) Panhandle Wind Disturbance (March 22, 2022).''). On June 4, 2022, an IBR-related disturbance near Odessa, Texas (the third in this location) occurred. *Id.* P 27.

[3] *Id.* P 58 (footnote omitted).

[4] *Id.* P 2.

[5] NERC, *Inverter-Based Resource Strategy: Ensuring Reliability of the Bulk Power System with Increased Levels of BPS-Connected IBRs,* at 1 (June 2022) (footnote omitted), *https://www.nerc.com/comm/Documents/NERC_IBR_Strategy.pdf.*

[6] *Id.* at 4.

[7] *Reliability Standards to Address Inverter-Based Resources,* 185 FERC ¶ 61,042 at P 14 (citations omitted).

widespread reduction of solar photovoltaic (PV) resources have occurred in California, Utah, and Texas.'' [8] The ''first major events involving [battery energy storage system facilities'' occurred just last year in March and April, 2022.[9] The reliable operation of the Bulk-Power System remains imperiled until these issues are addressed. Time is of the essence.

4. Our oversight role requires us to remain vigilant in ensuring that NERC Reliability Standards are timely, efficient, and effective. Up to nearly fourteen years to establish mandatory and enforceable NERC Reliability Standards to address a known, and potentially catastrophic, risk to the reliability of the BPS is simply too long a time to wait. And we will have to wait yet longer to learn whether the standards we do ultimately implement end up proving effective. Who knows what will happen in the meantime.

5. Better late than never, I suppose.

For these reasons, I respectfully concur.

James P. Danly,

Commissioner.

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[8] *2022 California Battery Energy Storage Sys. Disturbances, California Events: March 9 and April 6, 2022, Joint NERC and WECC Staff Report,* at iv (Sept. 2023), *https://www.nerc.com/comm/RSTC/Documents/NERC_BESS_Disturbance_Report_2023.pdf.*

[9] *Id.*