UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Reliability Standards for Frequency and Voltage Protection Settings and Ride-Through for Inverter-Based Resources	)))	Docket No. RM25-3-000

COMMENTS FROM ELEVATE ENERGY CONSULTING IN RESPONSE TO THE PROPOSED NERC STANDARD PRC-029-1

I. Introduction

Elevate Energy Consulting, Inc. ("Elevate") appreciates the opportunity to submit the following comments to the Federal Energy Regulatory Commission ("Commission") on the Notice of Proposed Rulemaking ("NOPR") issued on December 19, 2024.[1] In this NOPR, the Commission proposes to approve the proposed North American Electric Reliability Corporation (NERC) Reliability Standards PRC-024-4 (Frequency and Voltage Protection Settings for Synchronous Generators, Type 1 and Type 2 Wind Resources, and Synchronous Condensers) and PRC-029-1 (Frequency and Voltage Ride-through Requirements for Inverter-Based Resources), which NERC submitted in response to Commission directives.[2] The Commission seeks comments on all aspects of the proposed approval and additionally is requesting feedback on specific aspects of the proposed NERC PRC-029-1 approval.

Elevate Energy Consulting is dedicated to elevating the electricity sector through the clean energy transition. Elevate brings a wealth of skills, expertise, and experience to support the industry across the entire electricity ecosystem, specializing in renewables integration, advanced power system modeling and

[1] Notice of Proposed Rulemaking re: Reliability Standards for Frequency and Voltage Protection Settings and Ride-Through for Inverter-Based Resources under RM25-3 (*issued* December 19, 2024) RM25-3-000
[2] Final Rule re: Reliability Standards to Address Inverter-Based Resources. RM22-12-000; Order No. 901. Issued October 19, 2023

studies, grid planning and operations, NERC and regulatory compliance, and technical management consulting.

II. Background

Elevate supports the Commission's approach to ensuring that existing and newly connecting inverter-based resources (IBRs) to the Bulk-Power System (BPS) can withstand grid voltage and frequency excursions (i.e., ride through) caused by grid events such as fault, loss of generation or load, or other abnormal operating conditions. Generator ride-through capability and performance are foundational to all other essential reliability services (ERS) and to reliable operation of the BPS.

The Commission is seeking comments on all aspects of the proposed NERC PRC-029-1, and specifically comments on concerns regarding specific topics related to the proposed requirements including:

(1) IBR performance requirement set forth in Requirement R1

(2) Absolute rate of change of frequency (ROCOF) in Requirement R3

(3) Adequacy of NERC's proposed exemption provision in Requirement R4 as it pertains to both projects in service and those under contract, but not yet in-service as of the effective date of Reliability Standard PRC-029-1.

Additionally, the Commission is seeking comments on whether the exemption provision is too broad or too narrow and describing the risks and benefits of expanding or narrowing the exemption provision.[3]

[3] The Commission requested that these comments provide detailed, quantified, and fact-based support for their position.

III. Comments

Technical Concerns with NERC PRC-029-1

Elevate's comments are primarily focused on the proposed NERC PRC-029-1 standard. While Elevate supports the intent of the PRC-029-1 standard to improve ride-through performance of IBRs, there are technical concerns with the proposed standard that we believe warrant additional clarifications and updates to the standard. These technical concerns are detailed below.

A. The proposed PRC-029-1 Reliability Standard had many of its voltage and frequency ride-through requirements adopted from IEEE 2800-2022, "Standard for Interconnection and Interoperability of IBRs Interconnecting with Associated Transmission Electric Power Systems." However, the proposed PRC-029-1 standard is missing many of the technical details, clarifications, and equipment considerations that are captured in the IEEE 2800-2022 standard. With PRC-029-1 lacking the specificity that is captured by IEEE 2800-2022 as developed by hundreds of industry subject matter experts, it is expected that PRC-029-1 could introduce challenges, cost impacts, and inefficiencies on the various IBR resources interconnecting to the system, the entities that own and operate them, the Commission, and NERC for overseeing their performance and reliability impacts on the BPS. These omissions and inconsistencies in the PRC-029-1 standard should be updated to reflect the specific requirements detailed in the IEEE 2800-2022 standard. Below are some of the major inconsistencies and omissions in the proposed PRC-029-1 standard. All inconsistencies and omissions in the proposed PRC-029-1 standard should be reviewed and updated for clarity and completeness.

    a. IEEE 2800-2022 recognizes limitations with VSC-HVDC equipment in meeting

consecutive voltage deviation ride-through capabilities, yet the PRC-029 standard does not recognize these limitations. These VSC-HVDC equipment limitations should be added to an updated version of the PRC-029 standard.

b. IEEE 2800-2022 allows for an exception for self-protection when negative-sequence voltage is greater than a specified duration and threshold, which is often required for Type III WTG based plants. This exception is missing in the PRC-029-1 standard and should be added to an updated version of the standard. In addition, inverters in general are sensitive to severe phase voltage imbalance and IEEE 2800-2022 provides exceptions to IBR ride-through requirements during severe and sustained voltage unbalance conditions. These exceptions are missing in the PRC-029-1 standard and should be added to an updated version of the standard.

c. IEEE 2800-2022 recognizes 500kV system voltages are actually operated in the range of 525kV and therefore has equipment rated up to 550kV. This recognition of 500kV operation conditions and their corresponding updated voltage ride-through curves is missing in the PRC-029-1 standard and should be added to an updated version of the standard.

d. IEEE 2800-2022 Section 7.2.2.1 has an exception on IBR post-disturbance current limitations for voltage disturbances that reduce RPA voltage to less than 50% of nominal. This exception is missing in the PRC-029-1 standard and should be added to an updated version of the standard.

e. For voltages greater than 1.05 per unit and less than or equal to 1.10 per unit, a ride-through duration of 1800 seconds is specified in both the IEEE 2800-2022 and proposed PRC-029-1 standards. However, the IEEE 2800-2022 standard specifies that this ride-through

duration is cumulative over a 3600 second time period. This specification is missing in the PRC-029-1 standard and should be added to an updated version of the standard.

f. The IEEE 2800-2022 standard explicitly states that the voltage ride-through curves are to be interpreted as voltage vs time duration to ensure that there is no incorrect interpretation that these curves are "envelope" curves. This explanation is missing from the PRC-029-1 standard and should be added to an updated version of the standard. Similarly, PRC-029-1 Attachment 1 Item #7 states "If the voltage is continuously varying over time, it is necessary to add the duration within each band of Tables 1 and 2 over any 10 second time period." This is an incorrect interpretation of the ride-through curves and must be updated in the PRC-029-1 standard to state the correct interpretation and implementation of the ride-through curves, as failing to do so creates a requirement that could be impossible to meet for most IBRs and could result in many unnecessary exemption requests. In effect, PRC-029-1 as written requires IBRs to withstand an unlimited number of disturbances spaced greater than 10 seconds apart, a requirement that almost every IBR would be unable to meet. The PRC-029-1 standard should be updated to reflect the ride-through curve interpretation and implementation as stated in IEEE 2800-2022 Section 7.2.2, which allows for ride-through exceptions when the number of consecutive voltage deviations exceed a specified threshold over 120-second and 30-minute periods.

g. PRC-029-1 Attachment 1 Item #10 states that "Instantaneous trip settings based on instantaneously calculated voltage measurements with less than filtering lengths of one cycle (16.6 millisecond) are not permissible." As written, this requirement cannot be met by IBR units as their unit-level protections are in the sub-cycle timeframe. IBR unit-level protections cannot and should not have this requirement in PRC-029-1 applied to them.

This requirement in PRC-029-1 should be applied only to protection at the IBR-plant level that has the possibility of disrupting power output of the entire IBR plant. IEEE 2800-2022 has this technical detail defined in clause 9.3, which should be applied to an updated version of the PRC-029-1 standard.

h. The PRC-029-1 standard does not provide any definition for active or reactive power priority modes. This can make evaluation of these modes challenging when examining the power generated by IBRs. IEEE 2800-2022 explains that active current priority mode as allocating the entire current capacity of the inverter to active current and use the remaining capacity for reactive current. The PRC-029-1 standard should be updated to utilize a similar definitions for active current and reactive current priority modes. Similarly, the PRC-029-1 standard utilizes the term real power and reactive power to define the ride-through capability and performance requirements. However, IEEE 2800-2022 and other grid codes around the world, such as the German VDE code, put these requirements in terms of current rather than power, such as active/real current and reactive current. This is an important distinction as most IBR control systems regulate current, not power. The PRC-029-1 standard should be updated to utilize the terms active current and reactive current rather than real power and reactive power.

i. The PRC-029-1 standard does not provide any consideration for the types of transmission events and conditions that the IBR ride-through requirements are required or exempted from. There will be certain extreme transmission contingencies and disturbances that no IBR, or synchronous generator, would be capable of or expected to ride through, as they would go far beyond the design basis of the IBR facilities. IEEE 2800-2022 provides for this type of design basis by stating that “the TS owner/TS operator, in coordinator with the

IBR owner, should specify reasonable TS operating and network conditions for which the requirements of this standard shall apply at the time of interconnection and, as practical, over the foreseeable future considering anticipated system changes." The PRC-029-1 standard should be updated with similar language allowing for reasonable transmission operating conditions and contingencies to be considered for applicability of the PRC-029-1 standard.

B. The proposed PRC-029-1 standard has the following additional technical concerns or omissions that should be considered and addressed.

   a. PRC-029-1 makes no mention or specification for grid strength (e.g., short circuit strength), often a necessary component that must be considered for IBR stability and control capabilities. Having PRC-029-1 updated in a future version to add some specification for grid strength or allow the transmission provider to allow specification of grid strength would be helpful in the design aspects of IBRs and lead to a more reliable implementation of the standard. Inclusion of short circuit strength requirements or allowances would also then open up the possibility of expanding into Grid Forming (GFM) requirements for IBRs. GFM-capable IBRs are going to be required on our electric systems as the penetration of IBRs across out networks continues to grow in order to ensure stable and reliable grid operations under both normal and emergency conditions. With a reduction in synchronous generators that are connected to the grid, GFM IBRs will be critical to ensuring stable operations of the system in general while also ensuring non-GFM IBRs, called Grid Following (GFL) IBRs, remain stable and connected to the system as well. While PRC-029-1 opens up the door to ensuring IBRs remain connected to the system under grid

disturbances, this standard as written only considers the near-term grid conditions. Future updates of the PRC-029-1 standard to consider grid strength and GFM requirements would enable the standard to better prepare our IBRs for the rapidly changing generation resources of our electric system.

b. PRC-029-1 Requirement 2.1.1 states that the IBR shall "continue to deliver pre-disturbance Real Power." However, this is not possible for IBRs to achieve, as any step change in voltage will cause short variations of Real Power that will quickly return to pre-disturbance conditions. These short transient variations in Real Power are expected and should not cause any compliance concerns with the PRC-029-1 standard; however, as written there could be various interpretations of this requirement 2.1.1 and therefore this requirement should be modified to allow for reasonable short-duration, minor power variations of an IBR following abrupt voltage changes.

c. PRC-029-1 Requirement R2.1.1 is mandating IBRs return to an exact value of active power equal to the pre-disturbance active power following a disturbance. However, PRC-029-1 Requirement R2.1.3 requires that the IBR should prioritize active or reactive power if the certain capability limits are hit. If reactive power prioritization in prioritized following R2.1.3, the injected active power has to be reduced to free up room for reactive power generation. This can result in injection of an active power smaller than the pre-disturbance value, thereby violating Requirement R2.1.1. In other words, the only conditions that both Requirements R2.1.1 and R2.1.3 can be met when active power is prioritized, or the IBR current limit/reactive power limit has not reached. Therefore, meeting R2.1.1 can potentially result in violation of R2.1.3 and vice versa in certain cases. These conflicting requirements should be investigated and addressed in an updated version of the PRC-029-

1 standard.

d. The PRC-029-1 Requirement R2.4 uses the terms “high voltage thresholds” and “time durations.” The terms are ambiguous and have not been defined. In addition, this requirement is in general difficult to understand and follow. The PRC-029-1 standard should be updated to better explain this requirement further, including providing adequate definitions of the terms used in the requirement, while also providing an example on how to evaluate this requirement for an IBR facility, potentially in the technical rationale document or a new attachment to the standard.

e. In Requirement R2.5 of PRC-029-1, it is not clear if the term “restore” is referring to the settling of active power to the pre-disturbance value or only its rise to the pre-disturbance value within one second. If the latter is true, active power would be allowed to oscillate and settle at the pre-disturbance value in a time window longer than one second. Such oscillatory behavior may have system-wide impacts, especially on voltage and frequency stabilities. This term in R2.5 of the PRC-029-1 should be further defined in a future update to the PRC-029-1 standard.

f. PRC-029-1 Requirement R4 allows for IBRs that are in-service by the effective date of the PRC-029-1 standard to have exemptions from requirements R1-3 for documented hardware limitations. However, this requirement should be expanded to IBRs that are not yet in service but have already made irreversible investment decisions, such as procurements and contracts for long lead time equipment (e.g., transformers, circuit breakers, inverters, and turbines). IBRs that have made these expensive, irreversible investments are in the same category as existing IBRs with hardware limitations. Once this equipment has been purchased, even if not yet installed, and there are documented

hardware limitations, these IBRs should be allowed the same type of exemptions as defined in Requirement R4. The PRC-029-1 standard should be updated to allow IBRs that have ordered equipment as of the effective date of the PRC-029-1, with documented hardware limitations, to be included in the Requirement R4 exemptions.

g. PRC-029-1 Measure M4 defines the potential evidence documentation for the hardware limitation exemptions in Requirement R4. This evidence list in this measure should match the language using in the PRC-024 standard for consistency in the documentation of these hardware limitations and exemptions.

h. In the proposed NERC PRC-029-1 Reliability Standard, Requirement R6 defines that entities with documented equipment limitations for legacy IBRs shall communicate these limitations to their associated PC, TP, and RC. Requirement R6.1 and its sub-requirements then go into the specific documentation that must be included in the communication. This list of sub-requirements could more clearly define the details of this communication between the entity seeking the hardware limitation and its PC, TP, and RC. Additional details that would better support evaluation of the exception request could include timeframes for communications, file formats, an explanation of the reason(s) the equipment cannot meet the requirements, and other general information to ensure a thoroughly adequate transfer of information for the equipment limitation requests. As the industry has seen with similar processes on-going in other regions, having detailed and thorough process steps well defined will ensure that these exemption requests can be handled efficiently, accurately, and consistently by all parties. Failing to provide more structure around these equipment limitation requests may result in inefficient steps and inconsistent implementation of the equipment limitation process.

FERC Order 827 and Considerations of IBR Technology Capabilities

FERC Order 827 defines the reactive power requirements for non-synchronous generation, which includes IBRs.[4] In this Order, IBRs must provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging, unless the transmission provider has established a different power factor range that applies to all non-synchronous generations in the transmission provider's control area on a comparable basis (the transmission provider is limited to establishing a different power factor range only, and not any other reactive power requirements). This in essence creates a reactive power capability curve that is triangle in shape. This triangle shape of reactive power capability is limited compared to the built-in capabilities of IBR technology today which can go much further beyond this power factor range defined in Order 827. Reference IEEI 2800-2022 Clause 5 which has a much wider reactive power capability curve to reflect the IBR technology available today. While some transmission providers are adopting the IBR capability requirements in IEEE 2800-2022 Clause 5, there is concern with adopting the utilization of these reactive power requirements as there is potential conflict with the specific wording of the reactive power requirements defined in Order 827.[5] This is beginning to result in IBRs with installed capabilities that will sit latent and unused purposefully due to the requirements in place for reactive power requirements. We recommend that the reactive power capability curve defined in Order 827 should be updated to a full rectangular curve over the current triangle curve created by the currently defined power factor range, while allowing for appropriate compensation of reactive power support beyond established limits.

[4] https://www.ferc.gov/sites/default/files/2020-06/RM16-1-000.pdf
[5] https://www.energy.gov/sites/default/files/2024-12/i2X%20FIRST%20Meeting%2012.17%20Slides.pdf, page 57

IV. Conclusion

Elevate appreciates the Commission's proactive approach to ensuring system reliability in the United States and appreciates the opportunity to provide these comments on the proposed NERC PRC-029-1 standard. We believe that as written the current proposed NERC PRC-029-1 standard has some ambiguous or technically impossible requirements included that could lead to unnecessary exemptions, inefficiencies, and added costs for the industry. Elevate recommends that the Commission provide a conditional approval of the proposed PRC-029-1 with the condition that NERC address the technical concerns we have raised in our comments in a revised version of the standard. Elevate also recommends that the reactive power requirements defined in FERC Order 827 be investigated and updated to consider the available IBR technology today and the capability and performance requirements of IBRs defined in proposed PRC-029-1 and IEEE 2800-2022.

(Signature Block on the Following Pages)

Dated: March 24, 2025

Fredericksburg, Virginia

Respectfully Submitted,

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CERTIFICATE OF SERVICE

I hereby certify that on this day I have served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Fredericksburg, VA this 24th day of March, 2025.

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