NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

March 26, 2020

VIA ELECTRONIC FILING

Kirsten Walli, Board Secretary
Ontario Energy Board
P.O Box 2319
2300 Yonge Street
Toronto, Ontario, Canada
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Re: *North American Electric Reliability Corporation*

Dear Ms. Walli:

The North American Electric Reliability Corporation ("NERC") hereby submits Petition of the North American Electric Reliability Corporation for Approval of Proposed Reliability Standard PRC-024-3. NERC requests, to the extent necessary, a waiver of any applicable filing requirements with respect to this filing.

Please contact the undersigned if you have any questions concerning this filing.

Respectfully submitted,

/s/ Lauren Perotti

Lauren Perotti
Senior Counsel for the North American Electric Reliability Corporation

Enclosure

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ONTARIO ENERGY BOARD
OF THE PROVINCE OF ONTARIO

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION)
)

PETITION OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION FOR APPROVAL OF PROPOSED RELIABILITY STANDARD PRC-024-3

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PETITION OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION FOR APPROVAL OF PROPOSED RELIABILITY STANDARD PRC-024-3

The North American Electric Reliability Corporation ("NERC") hereby submits for approval proposed Reliability Standard PRC-024-3 – Frequency and Voltage Protection Settings for Generating Resources. Proposed Reliability Standard PRC-024-3 improves upon currently effective Reliability Standard PRC-024-2 by clarifying the voltage and frequency protection settings requirements so that generating resources continue to support grid stability during defined system voltage and frequency excursions.

The proposed Reliability Standard, provided in Exhibit A hereto, is just, reasonable, not unduly discriminatory or preferential, and in the public interest. NERC also requests approval of: the associated Implementation Plan (Exhibit B); the associated Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs") (Exhibits A and D); and the retirement of Reliability Standard PRC-024-2.

This petition presents the technical basis and purpose of the proposed Reliability Standard, a summary of the development history (Exhibit E), and a demonstration that the proposed Reliability Standard meets the Reliability Standards criteria (Exhibit C). The NERC Board of Trustees ("Board") adopted the proposed Reliability Standard on February 6, 2020.

This petition is organized as follows: Section I provides a summary of the petition. Section II includes the contacts for any notices and communications related to this filing. Section III

provides background on the development of proposed PRC-024-3. Section IV provides the justification and technical basis for the proposed standard. Section V provides justification for the effective date of the standard. Finally, Section VI includes a conclusion listing the requested approvals.

I. SUMMARY

Protection systems serve an important role in maintaining a reliable Bulk-Power System.[1] By detecting and isolating faulty elements on a system, protection systems help to limit the severity and spread of system disturbances and help to prevent possible damage to protected elements. Some generating resources, such as synchronous generators, for example, have protective relays that respond to frequency and voltage excursions. Other resources, such as nonsynchronous inverter-based resources, have controls that serve a protective function. Regardless of the type of protection on a resource, the protection settings need to strike a balance between protecting the individual resource and supporting system reliability. Proposed Reliability Standard PRC-024-3 helps establish this balance by ensuring that generating resources remain connected during defined frequency and voltage excursions in support of the Bulk-Power System. The standard accomplishes this through requirements for voltage and frequency protection settings on applicable generating resources.

Analysis of recent grid disturbances in the Western Interconnection indicated that some inverter-based resources dropped offline in response to fault events, even when the line faults cleared normally, due to the settings of the protective function controls on those resources. Specifically, the analysis indicated that the settings of the resources calculated frequency incorrectly, resulting in momentary cessation or inverter trips during a transient voltage excursion

[1] Unless otherwise designated, all capitalized terms shall have the meaning set forth in the *Glossary of Terms Used in NERC Reliability Standards*, http://www.nerc.com/files/Glossary_of_Terms.pdf.

associated with typical short circuit faults. Additionally, further analysis identified opportunities to improve currently effective Reliability Standard PRC-024-2 to clarify expectations for inverter-based resources.

Proposed Reliability Standard PRC-024-3 includes modifications based on the recommendations from these analyses. To that end, proposed PRC-024-3 clarifies the types of protection subject to the requirements and incorporates language used by inverter manufacturers and solar development owners. Furthermore, the proposed Reliability Standard enhances reliability by helping to ensure correct protection settings for applicable Bulk Electric System ("BES") generating resources.

II. NOTICES AND COMMUNICATIONS

Notices and communications with respect to this filing may be addressed to the following:

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III. BACKGROUND

The following background information is provided below: (1) a description of the NERC Reliability Standards Development Procedure; (2) ERO Enterprise analysis;[2] and (3) the history of Project 2018-04 Modifications to PRC-024-2.

A. NERC Reliability Standards Development Procedure

The proposed Reliability Standard was developed in an open and fair manner and in accordance with the Reliability Standard development process. NERC develops Reliability Standards in accordance with Section 300 (Reliability Standards Development) of its Rules of Procedure and the NERC Standard Processes Manual.[3] NERC's proposed rules provide for reasonable notice and opportunity for public comment, due process, openness, and a balance of interests in developing Reliability Standards and thus satisfy certain criteria for approving Reliability Standards. The development process is open to any person or entity with a legitimate interest in the reliability of the Bulk-Power System. NERC considers the comments of all stakeholders. Further, a vote of stakeholders and adoption by the Board is required before NERC submits the Reliability Standard to the applicable governmental authorities.

B. ERO Enterprise Analysis

Analyses of two grid disturbances in the Western Interconnection uncovered the potential reliability risk of large numbers of inverter-based resources going offline based on protective function controls settings. First, the August 16, 2016 Blue Cut Fire disturbance resulted in

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[2] The "ERO Enterprise" is comprised of NERC and the six Regional Entities: Midwest Reliability Organization, Northeast Power Coordinating Council, ReliabilityFirst, SERC Reliability Corporation, Texas Reliability Entity, and Western Electricity Coordinating Council ("WECC").

[3] The NERC Rules of Procedure are available at http://www.nerc.com/AboutNERC/Pages/Rules-of-Procedure.aspx. The NERC Standard Processes Manual is available at https://www.nerc.com/FilingsOrders/us/RuleOfProcedureDL/SPM_Clean_Mar2019.pdf.

approximately 1,200 MW of solar photovoltaic resources ceasing output in Southern California. Second, the October 9, 2017 Canyon 2 Fire disturbance in Southern California resulted in approximately 900 MW of solar photovoltaic resources ceasing output. A joint NERC and WECC task force analyzed both events, resulting in disturbance reports that included key findings and recommendations for mitigating actions.[4] One such recommendation included issuance of a NERC Alert that provided mitigating actions and requested data.[5]

Concurrently, in 2017, the NERC technical stakeholder committees convened the Inverter-Based Resource Performance Task Force ("IRPTF") to review the causes of inverter-based generation dropping offline during normally cleared Bulk-Power System line faults. The IRPTF supported NERC and WECC staff in the analysis of the two disturbances in Southern California. Based on these analyses, the IRPTF developed recommended performance characteristics for inverter-based resources connected to the Bulk-Power System.[6]

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[4] NERC, *1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report*, Southern California 8/16/2016 Event (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; NERC, *900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report*, Southern California Event: October 9, 2017 Joint NERC and WECC Staff Report (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#search=blue%20cut%20fire.

[5] NERC, Industry Recommendation, *Loss of Solar Resources During Transmission Disturbances due to Inverter Settings – II* (2018), https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_Loss_of_Solar_Resources_during_Transmission_Disturbance-II_2018.pdf.

[6] NERC, Reliability Guideline, *BPS-Connected Inverter-based Resource Performance* (2018) https://www.nerc.com/comm/OC_Reliability_Guidelines_DL/Inverter-Based_Resource_Performance_Guideline.pdf.

In addition, the IRPTF developed a whitepaper that identified opportunities for clarification of Reliability Standard PRC-024-2 (Exhibit F).[7] Specifically, the PRC-024-2 Gaps Whitepaper recommended a standard drafting team address the following issues:

- In Attachments 1 and 2, the region outside the no trip zone of the PRC-024-2 figures could be misinterpreted as a must trip zone.
- In Attachment 1, the table identifies "instantaneous" trip points while the time axis of the graph in the figure starts at 100 ms.
- In Attachment 2, the voltage boundary curve clarifications cause confusion by stating, "the greater of maximum [root mean square] or crest phase-to-phase voltage" because numerically the crest will always be greater than the root mean square.
- In Attachment 2, there is opportunity for clarification for the points in time the cumulative values reset or the starting and ending criteria.
- There is an opportunity to clarify the applicability of the standard to inverter-based resources.

C. Development of the Proposed Reliability Standard

As further described in Exhibit E hereto, NERC initiated a standard development project, Project 2018-04 Modifications to PRC-024-2 ("Project 2018-04"), to address the IRPTF recommendations. The NERC Operating Committee and Planning Committee submitted a Standard Authorization Request ("SAR") developed by the IRPTF that detailed the scope of Project 2018-04. A supplemental SAR was developed to further scope the project to address additional potential reliability issues. The NERC Standards Committee appointed a team with the

[7] NERC, *PRC-024-2 Gaps Whitepaper*, NERC Inverter-based Resource Performance Task Force, https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/NERC_IRPTF_PRC-024-2_Gaps_Whitepaper_FINAL_CLEAN.pdf.

appropriate experience and expertise to address comments on the SAR and develop proposed revisions to PRC-024-2 (Exhibit G).

On April 17, 2019, NERC posted the initial draft of proposed Reliability Standard PRC-024-3 for a 45-day comment period, which included an initial ballot during the last 10 days of the comment period. The initial ballot of PRC-024-3 did not receive the requisite approval, with affirmative votes of 52.28 percent of the ballot pool and 88.37 percent quorum. After considering comments on the initial draft, NERC posted a second draft of PRC-024-3 for an additional 45-day comment period and ballot on September 20, 2019, which included an additional ballot during the last 10 days of the comment period. The second draft of proposed Reliability Standard PRC-024-3 received the requisite approval, with affirmative votes of 86.67 percent of the ballot pool and 81.88 percent quorum. On December 4, 2019, NERC conducted a ten-day final ballot for proposed Reliability Standard PRC-024-3, which received affirmative votes of 82.47 percent of the ballot pool and achieved 89.26 percent quorum. The Board adopted the proposed Reliability Standard on February 6, 2020.

IV. JUSTIFICATION FOR APPROVAL

As discussed below and in Exhibit C, proposed Reliability Standard PRC-024-3 improves upon PRC-024-2 through modifications that help ensure inverter-based resources respond to grid disturbances in a manner that contributes to the reliable operation of the Bulk-Power System. Proposed PRC-024-3 helps to clarify requirements for generating resources, including inverter-based resources, to balance the needs of equipment protection with grid stability. NERC respectfully requests approval of the standard as just, reasonable, not unduly discriminatory or preferential, and in the public interest. This section discusses the following:

- modifications to applicability (Subsection A);

- modifications to the requirements (Subsection B);
- Quebec Interconnection variance (Subsection C); and
- the enforceability of the proposed Reliability Standard (Subsection D).

A. Modifications to Applicability

Proposed Reliability Standard PRC-024-3 includes modifications that clarify the applicability of the requirements. In PRC-024-2, the applicability of the standard is limited to Generator Owners, with the footnotes to Requirements R1 and R2 clarifying scope and applicability. Proposed PRC-024-3 incorporates these footnotes into one location, the applicability section of the standard. This modification addresses the PRC-024-2 Gaps Whitepaper issue regarding confusion over footnote 1 and its applicability to inverter-based resources. Proposed Reliability Standard PRC-024-3 enhances the clarity of the standard and puts the proper entities on notice of their obligations by placing the items related to applicability in the proper section of the standard.

The revised Applicability section reads as follows:

4. Applicability:
4.1. Functional Entities:
4.1.1 Generator Owners that apply protection listed in Section 4.2.1.
4.1.2 Transmission Owners (in the Quebec Interconnection only) that own a BES generator step-up (GSU) transformer or main power transformer (MPT)[8] and apply protection listed in Section 4.2.1.
4.1.3 Planning Coordinators (in the Quebec Interconnection only)
4.2. Facilities[9]:
4.2.1 Frequency, voltage, and volts per hertz protection (whether provided by relaying or functions within associated control systems) that respond to electrical signals and: (i) directly trip the generating resource(s); or (ii) provide signals to the generating resource(s) to either trip or cease injecting current; and are applied to the following:

[8] PRC-024-3, Footnote 1: For the purpose of this standard, the MPT is the power transformer that steps up voltage from the collection system voltage to the nominal transmission/interconnecting system voltage for dispersed power producing resources.

[9] PRC-024-3, Footnote 2: It is not required to install or activate the protections described in Facilities Section 4.2.

4.2.1.1 BES generating resource(s).
4.2.1.2 BES GSU transformer(s).
4.2.1.3 High side of the generator-connected unit auxiliary transformer[10] (UAT) installed on BES generating resource(s).
4.2.1.4 Individual dispersed power producing resource(s) identified in the BES Definition, Inclusion I4.
4.2.1.5 Elements that are designed primarily for the delivery of capacity from the individual dispersed power producing resources identified in the BES Definition, Inclusion I4, to the point where those resources aggregate to greater than 75 MVA.
4.2.1.6 MPT[11] of resource(s) identified in the BES Definition, Inclusion I4.
4.2.2 Exemptions: Protection on all auxiliary equipment within the generating Facility.

According to proposed Functional Entities section 4.1, the standard applies to Generator Owners that activate or apply the protection listed in Facilities section 4.2. The proposed standard uses the term "protection" to indicate that the standard has a broader application than only protective relays. Protective function controls can cause inverter-based resources to momentarily cease injecting current, creating a similar effect as a synchronous generating resource tripping. Similar to PRC-024-2, entities are not required in PRC-024-3 to install or activate this protection. Due to this broader term, Facilities section 4.2 reinforces that applicable Generator Owners with inverter-based resources, which do not have protective relays, apply the requirements of PRC-024-3 to applicable equipment.

Furthermore, most modern microprocessor-based transformer protection relays are equipped with voltage, frequency, and volts/Hz elements, which could be set separately from those applied on the generator or GSU. These settings could result in a loss of the generating resource during a voltage or frequency excursion if so applied on the high side of the unit auxiliary

[10] PRC-024-3, Footnote 3: These transformers are variably referred to as station power UAT, or station service transformer(s) used to provide overall auxiliary power to the generating resource(s). This UAT is the transformer connected on the generator bus between the low side of the GSU and the generator terminal.

[11] PRC-024-3, Footnote 4: For the purpose of this standard, the MPT is the power transformer that steps up voltage from the collection system voltage to the nominal transmission/interconnecting system voltage for dispersed power producing resources.

transformer.[12] As such, the standard drafting team included 4.2.1.3 "[h]igh side of the generator-connected unit auxiliary transformer (UAT) installed on BES generating resource(s)" in scope of applicability but exempted the rest of protection for auxiliary equipment. The clarity achieved through the more detailed applicability supports reliability by indicating exactly what types of protection (i.e., protection that can trip a generating resource or cause the generating resource to cease injecting current) are subject to the requirements of PRC-024-3.

While the applicable protection described above can cause a resource to trip or cease injecting current, certain protection on auxiliary equipment typically does not cause a generating resource to trip or cease injecting current. As such, proposed PRC-024-3 includes an exemption from applicability for this type of protection. The section 4.2.2 exemption clarifies that protection on auxiliary equipment within the generating Facility is not within scope of PRC-024-3. For both synchronous generating resources and inverter-based resources, protection on auxiliary equipment, such as transformers, typically does not cause the resource itself to trip or cease injecting current. For plants with inverter-based resources, such auxiliary equipment may include air conditioning, the control house, or batteries. Protection used for such auxiliary equipment does not cause a resource to trip or cease injecting current. As a result, it is appropriate to exempt such protection from the settings required in PRC-024-3.

Finally, the standard drafting team expanded the applicability for entities within the Quebec Interconnection by including Transmission Owners with certain equipment and Planning Coordinators. During development, the standard drafting team studied whether Transmission Owners should be included and determined that, outside of Quebec, there were no Transmission

[12] NERC, Project 2018-04 Modifications to PRC-024-2, *PRC-024-3 Draft 1 Summary Comment Responses*, at 10 (2019), https://www.nerc.com/pa/Stand/Project%20201804%20Modifications%20to%20PRC0242/2018-04_PRC-024_Summary_Response_to_Comments_09202019.pdf.

Owners with such equipment that were not also GOs. As a result, these entities were included for the Quebec Interconnection only. This revision enhances reliability through the expansion of applicability in the Quebec Interconnection.

B. Modifications to the Requirements

The revisions to the four requirements in proposed PRC-024-3 support reliability by incorporating language understood by industry to apply to synchronous and nonsynchronous resources, including inverter-based resources. In addition, proposed PRC-024-3 includes updates to the corresponding figures and tables in the attachments (incorporated by reference into the requirements) to clarify the expectations for all applicable generating resources. As a result, applicable entities will understand their obligations to remain connected during a specified transient frequency or voltage excursion. The section below describes the modifications to the requirements in detail.

1. Requirement R1 and Attachment 1

Proposed Requirement R1 includes language applicable to both synchronous and inverter-based resources. The revisions incorporated the term "protection" instead of protective relays; included the term "cease injecting current"; used the term "generating resource" instead of generating unit; and made other minor modifications to make the requirement language consistent with language used by inverter-based manufacturers. NERC proposes to revise Requirement R1 as follows:

R1. Each Generator Owner **shall set its applicable frequency protection**[13] ~~that has generator frequency protective relaying~~[14] ~~activated to trip its applicable generating unit(s) shall set its protective relaying~~ **in accordance with PRC-024 Attachment 1** such that the ~~generator frequency protective relaying does not trip the~~ applicable ~~generating unit(s)~~ **protection does not cause the generating resource to trip or cease injecting current** within the "no trip zone" ~~of PRC-024 Attachment 1, subject to~~ **during a frequency excursion with** the following exceptions:[15] *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- ~~Generating unit(s) may trip if the protective functions (such as out-of-step functions or loss-of-field functions) operate due to an impending or actual loss of synchronism or, for asynchronous generating units, due to instability in power conversion control equipment.~~
- ~~Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).~~
- ~~Generating unit(s)~~ **Applicable frequency protection** may **be set to** trip **or cease injecting current** within a portion of the "no trip zone" ~~of PRC-024 Attachment 1~~ for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

In addition to revisions to the requirement language, proposed PRC-024-3 includes revisions to Attachment 1, which is incorporated by reference into Requirement R1. Attachment 1 displays the no trip boundaries by interconnection for frequency excursions in Figures 1 through 4 and Tables 1 through 4. The revisions to these four sets of figures and tables address two points of clarification identified in the PRC-024-2 Gaps Whitepaper (Exhibit F): (1) inverter-based resources could read the area outside the "no trip zone" as "must trip"; and (2) inverter-based

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[13] PRC-024-3, Footnote 5: **Frequency, voltage, and volts per hertz protection (whether provided by relaying or functions within associated control systems) that respond to electrical signals and: (i) directly trip the generating resource(s); or (ii) provide signals to the generating resource(s) to either trip or cease injecting current.**

[14] PRC-024-2, Footnote 1: ~~Each Generator Owner is not required to have frequency or voltage protective relaying (including but not limited to frequency and voltage protective functions for discrete relays, volts per hertz relays evaluated at nominal frequency, multi-function protective devices or protective functions within control systems that directly trip or provide tripping signals to the generator based on frequency or voltage inputs) installed or activated on its unit.~~

[15] PRC-024-2, Footnote 2: ~~For frequency protective relays associated with dispersed power producing resources identified through Inclusion I4 of the Bulk Electric System definition, this requirement applies to frequency protective relays applied on the individual generating unit of the dispersed power producing resources, as well as frequency protective relays applied on equipment from the individual generating unit of the dispersed power producing resource up to the point of interconnection.~~

resources would calculate frequency instantaneously rather than over a window of time, leading to incorrect frequency measurements. On each of the interconnection figures and tables, the standard drafting team inserted an asterisk statement that clarified the area outside the no trip zone is not a must trip zone. Furthermore, the standard drafting team added footnote 9 next to "instantaneous" in each of the tables. For example, the table for the Eastern Interconnection is displayed below to demonstrate the placement of the footnote:

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (sec)
≥61.8	Instantaneous[9]	≤57.8	Instantaneous[9]
≥60.5	$10^{(90.935-1.45713*f)}$	≤59.5	$10^{(1.7373*f-100.116)}$
<60.5	Continuous operation	> 59.5	Continuous operation

Footnote 9 clarifies that calculating frequency instantaneously to trip instantaneously is not permissible and reads as follows:

> "Frequency is calculated over a window of time. While the frequency boundaries include the option to trip instantaneously for frequencies outside the specified range, this calculation should occur over a time window. Typical window/filtering lengths are three to six cycles (50 – 100 milliseconds). Instantaneous trip settings based on instantaneously calculated frequency measurement is not permissible."[16]

This is consistent with the options for proper operation of frequency protections as described in the Inverter-based Resource Performance Guideline[17] and the PRC-024-2 Gaps Whitepaper (Exhibit F).

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16 PRC-024-3, Footnote 9.

17 *Supra* note 19, at 17.

Furthermore, the standard drafting team clarified in footnote 8 that the figures in Attachment 1 do not visually represent the entire "no trip zone" but rather the Attachment 1 tables clarify the entirety of the boundaries. Footnote 8 states:

> "The figures do not visually represent the "no trip zone" boundaries before 0.1 seconds and after 10,000 seconds. The Frequency Boundary Data Points Table defines the entirety of the 'no trip zone' boundaries."[18]

This was another point of clarification recommended by the PRC-024-2 Gaps Whitepaper (Exhibit F).

2. Requirement R2 and Attachment 2

Similar to the revisions in Requirement R1, proposed Requirement R2 includes clarifying modifications. NERC proposes to revise Requirement R2 as follows:

> **R2**. Each Generator Owner **shall set its applicable voltage protection[19] in accordance with PRC-024 Attachment 2,** ~~that has generator voltage protective relaying[14] activated to trip its applicable generating unit(s) shall set its protective relaying~~ such that ~~the generator voltage protective relaying does not trip~~ the applicable **protection does not cause the generating resource to trip or cease injecting current within the "no trip zone" during a voltage excursion at the high side of the GSU or MPT,** ~~generating unit(s) as a result of a voltage excursion (at the point of interconnection[20]) caused by an event on the transmission system external to the generating plant that remains within the "no trip zone" of PRC-024 Attachment 2.[21] If the Transmission Planner allows less stringent voltage relay settings than those required to meet PRC-024 Attachment 2, then the Generator Owner shall set its protective relaying within the voltage recovery characteristics of a location-specific Transmission Planner's study.~~

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[18] PRC-024-3, Footnote 8.

[19] PRC-024-3, Footnote 5: **Frequency, voltage, and volts per hertz protection (whether provided by relaying or functions within associated control systems) that respond to electrical signals and: (i) directly trip the generating resource(s); or (ii) provide signals to the generating resource(s) to either trip or cease injecting current.**

[20] PRC-024-2, Footnote 3: ~~For the purposes of this standard, point of interconnection means the transmission (high voltage) side of the generator step-up or collector transformer.~~

[21] PRC-024-2, Footnote 4: ~~For voltage protective relays associated with dispersed power producing resources identified through Inclusion I4 of the Bulk Electric System definition, this requirement applies to voltage protective relays applied on the individual generating unit of the dispersed power producing resources, as well as voltage protective relays applied on equipment from the individual generating unit of the dispersed power producing resource up to the point of interconnection.~~

~~Requirement R2 is~~ subject to the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- **If the Transmission Planner allows less stringent voltage protection settings than those required to meet PRC-024 Attachment 2, then the Generator Owner may set its protection within the voltage recovery characteristics of a location-specific Transmission Planner's study.**
- ~~Generating unit(s) may trip in accordance with a Special Protection System (SPS) or Remedial Action Scheme (RAS).~~
- ~~Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).~~
- ~~Generating unit(s) may trip by action of protective functions (such as out-of-step functions or loss-of-field functions) that operate due to an impending or actual loss of synchronism or, for asynchronous generating units, due to instability in power conversion control equipment.~~
- ~~Generating unit(s)~~ **Applicable voltage protection** may **be set to** trip **or cease injecting current during a voltage excursion** within a portion of the "no trip zone" ~~of PRC-024 Attachment 2~~ for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

Proposed Requirement R2 supports reliability by clearly identifying which resources must stay online and continue injecting current during voltage excursions. Specifically, proposed Requirement R2 includes language that replaces "point of interconnection" to more clearly identify the protection within scope of PRC-024-3. Proposed Requirement R2 applies "during a voltage excursion at the high side of the [generator step-up transformer] GSU or [main power transformer] MPT." This language clearly indicates at what location the voltage is to be either measured or calculated when determining the voltage for a voltage excursion.

Additionally, proposed Requirement R2 includes "cease injecting current" to clarify the settings required for inverter-based resources. This term, which often is used by manufacturers of inverter-based resources, provides clarity that the controls for inverter-based resources should not be set to drop current output to zero within the defined boundaries. While system conditions may not permit current to flow, the requirements dictate that the equipment voltage and frequency

protection settings should not stop injecting current. The requirement does not prescribe the levels at which the resources should inject current. Rather, the requirement mandates the inverter-based resource remain responsive to system conditions and support reliability of the BES accordingly. Finally, the standard drafting team modified the exceptions within Requirement R2 by eliminating exceptions not relevant to voltage protection settings.

Proposed Attachment 2, incorporated by reference into proposed Requirement R2, provides the voltage no trip boundary data points in Table 1 for the Eastern, Western, and ERCOT Interconnections. Additionally, Attachment 2 includes a visual representation in Figure 1, with a note clarifying that areas outside the no trip zone boundary are not to be interpreted as a must trip zone. In doing so, the revisions in Figure 1 in Attachment 2 help to clarify for all resources, including inverter-based resources, that the resources are not required to trip outside of the boundary. Rather, the resource may trip outside of the boundary if, for instance, doing so is required to protect the equipment. As such, the proposed revisions support reliability by clarifying areas that previously had been subject to possible misinterpretation.

Additionally, proposed Attachment 2 includes modifications to the voltage boundary clarifications and evaluating protection settings sections. The voltage boundary clarifications modifications serve to interpret the voltage boundary with respect to the nominal voltage that should be assumed, the nature of the specified time durations, the assumed system frequency for volts per hertz protection settings, the nature of the per unit voltage in the boundaries, and the end time for the "no trip zone". The evaluating protection settings modifications serve to reinforce that the requirements pertain to voltage excursions at the high side of the GSU or MPT. Specifically, the evaluating protection settings specify where to measure the voltage for voltage excursions and how to properly evaluate voltage drop within the plant.

3. Requirements R3 and R4

Proposed Requirement R3 incorporates minor conforming changes to clarify the types of resources and protection subject to the requirement. In PRC-024-1, NERC developed Requirement R3 to permit entities to comply with certain Nuclear Regulatory Commission ("NRC") requirements through use of the regulatory limitation exemption. This was based on the Federal Energy Regulatory Commission ("FERC") guidance that "NRC requirements should be used when implementing the Reliability Standards."[22] In addition, Requirement R3 provides notice of regulatory or equipment limitations so Transmission Planners can simulate the performance of generating resources that must set protection to trip or cease injecting current within the no trip zone.

NERC performed analysis on the potential number of inverter-based resources that could be eligible for the Requirement R3 exemption. Based on data received in response to a NERC Alert, NERC determined that 2,566 BES inverter-based resources on 27 distinct plants, totaling 4395 MW, could not eliminate the control to momentarily cease injecting current during voltage and frequency excursions. As such, NERC determined this is the maximum number of inverter-based resources that could qualify for the equipment limitation exemption in Requirement R3. Of those resources, only 1,821 MW are not able to reduce the voltage control setting that causes the resource to cease injecting current. Moreover, entities can mitigate the risk of this finite number of resources dropping off during frequency and voltage excursions by factoring that into their planning. Going forward, entities are expected to ensure any newly installed equipment can meet the setting requirements in proposed PRC-024-3 without invoking Requirement R3. In addition, input from two inverter manufacturers during development indicated that present design

[22] *Mandatory Reliability Standards for the Bulk-Power System,* Order No. 693, FERC Stats. & Regs. ¶ 31,242 at P 1787, *order on reh'g*, Order No. 693-A, 120 FERC ¶ 61,053 (2007).

requirements for inverter technology and control no longer need inverters to cease injecting current within the "no trip zone." As a result, NERC does not consider these resources a significant risk.

The proposed revisions to Requirement R3 read as follows:

R3. Each Generator Owner shall document each known regulatory or equipment limitation[23] that prevents an applicable generating **resource(s)** ~~unit~~ with ~~generator~~ frequency or voltage protecti~~ve~~**on** ~~relays~~ from meeting the ~~relay~~ **protection** setting criteria in Requirements R1 or R2**,** including (but not limited to) study results, experience from an actual event, or manufacturer's advice. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

3.1 The Generator Owner shall communicate the documented regulatory or equipment limitation, or the removal of a previously documented regulatory or equipment limitation, to its Planning Coordinator and Transmission Planner within 30 calendar days of any of the following:

- Identification of a regulatory or equipment limitation.
- Repair of the equipment causing the limitation that removes the limitation.
- Replacement of the equipment causing the limitation with equipment that removes the limitation.
- Creation or adjustment of an equipment limitation caused by consumption of the cumulative turbine life-time frequency excursion allowance.

Finally, proposed Requirement R4 includes revised language that clarifies the requirement is applicable to synchronous and nonsynchronous resources. The proposed revisions to Requirement R4 read as follows:

R4. Each Generator Owner shall provide its applicable ~~generator~~ protection ~~trip~~ settings associated with Requirements R1 and R2 to the Planning Coordinator or Transmission Planner that models the associated ~~unit~~ **generating resource(s)** within 60 calendar days of receipt of a written request for the data and within 60 calendar days of any change to those previously requested ~~trip~~ settings unless directed by the requesting Planning Coordinator or Transmission Planner that the reporting of ~~relay~~ **protection** setting changes is not required. *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

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[23] PRC-024-3, Footnote 6: Excludes limitations ~~that are~~ caused by the setting capability of the ~~generator~~ frequency**,** ~~and~~ voltage**, and volts per hertz** protective relays ~~themselves~~ **for the generating resource(s). This** ~~but~~ does not exclude limitations originating in the equipment ~~that they~~ protect**ed by the relay**. **This also does not exclude limitations of frequency, voltage, and volts per hertz protection embedded in control systems.**

C. Quebec Variance

Proposed PRC-024-3 includes an interconnection-wide variance for Requirement R2 and Attachment 2 for applicable entities in the Quebec Interconnection. The variance is necessary based on the topology of the Quebec Interconnection.

The Quebec Interconnection is largely composed of transmission systems designed to move power from large hydroelectric complexes located north of the Quebec province to the main consumption load centers in the south. In addition, this main transmission system uses static and dynamic var compensation devices in order to maintain stability and control its voltage during system disturbances.

The particular topology of this transmission system makes it at risk of incurring over and under voltage conditions. Severe voltage surges can be attributed to the following characteristics: (1) the use of long transmission lines at 230 kV, 315 kV, and 735 kV between the power plants and the load; (2) massive utilisation of series compensation; (3) radial feeding of remote loads; and (4) AC-DC interconnection facilities with high rated filters. In contrast, under voltage conditions can be attributed to the following: (1) system behavior combined with the remoteness of generation complexes; (2) the poorly meshing of some parts of the system; and (3) low short circuit ratios. The design of the transmission system must account for these various conditions and phenomena that impose a larger envelope of the voltage boundary.

Consequently, the unique design of the transmission system justifies the Requirement R2 variance to maintain reliability. The variance for Requirement R2, located in Section D and Attachment 2a of the standard, accommodates the unique topology of the Quebec Interconnection. For example, the requirement permits inverter-based resources to cease injecting current during specific overvoltage conditions. While this exception is not permitted in the continent-wide

requirements, the variance has a narrower voltage no trip boundary. As a result, the variance is more stringent than the continent-wide standard despite permitting some cessation of current.

D. Enforceability of Proposed Reliability Standard

The proposed Reliability Standard also includes measures that support the requirements by clearly identifying what is required and how the ERO will enforce the requirements. The measures help ensure that the requirement will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party. Additionally, the proposed Reliability Standard includes VRFs and VSLs, which provide guidance on the way that NERC will enforce the requirements. The VRFs and VSLs for the proposed Reliability Standard comport with NERC and FERC guidelines related to their assignment. Exhibit D provides the NERC and FERC guidelines and notes that the VRFs in proposed PRC-024-3 did not change from the VRFs in PRC-024-2 and only conforming changes were made to the VSLs in PRC-024-2.

V. EFFECTIVE DATE

NERC respectfully requests approval of the proposed Reliability Standard to become effective as set forth in the proposed Implementation Plan, provided in Exhibit B hereto. The proposed Implementation Plan provides that, where approval by an applicable governmental authority is required, the standard shall become effective on the first day of the first calendar quarter that is twenty-four (24) months after the effective date of the applicable governmental authority's order approving the standard, or as otherwise provided for by the applicable governmental authority. Where approval by an applicable governmental authority is not required, the standard shall become effective on the first day of the first calendar quarter that is twenty-four (24) months after the date the standard is adopted by the NERC Board of Trustees, or as otherwise provided for in that jurisdiction.

The implementation period is designed to afford registered entities sufficient time to ensure entities can be fully compliant with the proposed PRC-024-3 by the effective date. The proposed implementation period reflects considerations provided by subject matter experts that twenty-four months is needed to provide registered entities time to review, and reset as necessary, any settings that may need to change to become compliant with the revised requirements. The proposed implementation period also reflects consideration that registered entities may need to perform additional coordination or modeling as a result of the revisions.

VI. CONCLUSION

For the reasons set forth above, NERC respectfully requests approval of:

- proposed Reliability Standard PRC-024-3, and associated elements included in Exhibit A, effective as proposed herein;
- the proposed Implementation Plan included in Exhibit B; and
- the retirement of Reliability Standard PRC-024-2, effective as proposed herein.

Respectfully submitted,

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Date: March 26, 2020

EXHIBITS A-B and D-G

EXHIBIT C

Reliability Standards Criteria

The discussion below explains how the proposed Reliability Standard meets or exceeds the Reliability Standards criteria.

1. **Proposed Reliability Standards must be designed to achieve a specified reliability goal and must contain a technically sound means to achieve that goal.**

The proposed Reliability Standard improves upon the voltage and frequency protection settings requirements so that applicable protection does not cause a generating resource to trip or cease injecting current within a certain time period during a frequency or voltage excursion. Specifically, proposed Reliability Standard PRC-024-3 improves reliability by clarifying the generating resources subject to the requirements and revising the requirement language to incorporate terms used by industry for all applicable generating resources. The Project 2018-04 standard drafting team, comprised of industry experts, incorporated findings and recommendations from task forces assessing inverter-based resources to provide a technically sound basis for the proposed revisions.

2. **Proposed Reliability Standards must be applicable only to users, owners and operators of the bulk power system, and must be clear and unambiguous as to what is required and who is required to comply.**

The proposed Reliability Standard is clear and unambiguous as to what is required and who is required to comply. The proposed Reliability Standard applies to certain Generator Owners and, in the Quebec Interconnection, certain Transmission Owners and Planning Coordinators. The proposed Reliability Standard clearly articulates the actions that such entities must take to comply with the standard.

3. **A proposed Reliability Standard must include clear and understandable consequences and a range of penalties (monetary and/or non-monetary) for a violation.**

The Violation Risk Factors and Violation Severity Levels ("VSLs") for the proposed Reliability Standard comport with NERC and FERC guidelines related to their assignment, as discussed further in Exhibit D. The assignment of the severity level for each VSL is consistent with the corresponding requirement. The VSLs do not use any ambiguous terminology, thereby supporting uniformity and consistency in the determination of similar penalties for similar violations. For these reasons, the proposed Reliability Standard includes clear and understandable consequences.

4. **A proposed Reliability Standard must identify clear and objective criterion or measure for compliance, so that it can be enforced in a consistent and non-preferential manner.**

The proposed Reliability Standard contains measures that support the requirements by clearly identifying what is required to demonstrate compliance. These measures help provide clarity regarding the manner in which the requirements will be enforced and help ensure that the requirements will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party. The measures are substantively unchanged from the currently effective version of the standard.

5. **Proposed Reliability Standards should achieve a reliability goal effectively and efficiently — but do not necessarily have to reflect "best practices" without regard to implementation cost or historical regional infrastructure design.**

The proposed Reliability Standard achieves the reliability goals effectively and efficiently. The proposed Reliability Standard clearly articulates the reliability objective that applicable entities must meet and balances protecting individual resources with supporting system reliability. The variance is necessary due to the unique attributes of the Quebec Interconnection.

6. **Proposed Reliability Standards cannot be "lowest common denominator," *i.e.*, cannot reflect a compromise that does not adequately protect Bulk-Power System reliability. Proposed Reliability Standards can consider costs to implement for smaller entities, but not at consequences of less than excellence in operating system reliability.**

The proposed Reliability Standard does not reflect a "lowest common denominator" approach. The proposed Reliability Standard helps to ensure all applicable generating resources contribute to system reliability.

7. **Proposed Reliability Standards must be designed to apply throughout North America to the maximum extent achievable with a single Reliability Standard while not favoring one geographic area or regional model. It should take into account regional variations in the organization and corporate structures of transmission owners and operators, variations in generation fuel type and ownership patterns, and regional variations in market design if these affect the proposed Reliability Standard.**

The proposed Reliability Standard applies throughout North America, except for Requirement R2 in the Quebec Interconnection. The variance is more stringent than the continent-wide Reliability Standard and is necessitated due to different characteristics of the Quebec Interconnection.

8. **Proposed Reliability Standards should cause no undue negative effect on competition or restriction of the grid beyond any restriction necessary for reliability.**

The proposed Reliability Standard has no undue negative impact on competition. The proposed Reliability Standard requires the same performance by each of the applicable Functional Entities. The proposed Reliability Standard does not unreasonably restrict the available transmission capability or limit use of the Bulk-Power System in a preferential manner.

9. **The implementation time for the proposed Reliability Standard is reasonable.**

The proposed 24-month implementation period for the proposed Reliability Standard is just and reasonable and appropriately balances the urgency in the need to implement the standard

against the reasonableness of the time allowed for those who must comply to review, and reset as necessary, any settings that may need to change.

10. The Reliability Standard was developed in an open and fair manner and in accordance with the Reliability Standard development process.

The proposed Reliability Standard was developed in accordance with NERC's ANSI-accredited processes for developing and approving Reliability Standards. Exhibit E includes a summary of the development proceedings and details the processes followed to develop the proposed Reliability Standard. These processes included, among other things, comment and ballot periods. Additionally, all meetings of the drafting team were properly noticed and open to the public. The initial and additional ballot achieved a quorum, and the additional ballot and final ballot exceeded the required ballot pool approval levels.

11. NERC must explain any balancing of vital public interests in the development of proposed Reliability Standards.

NERC has identified no competing public interests regarding the request for approval of the proposed Reliability Standard. No comments were received that indicated the proposed Reliability Standard conflicts with other vital public interests.

12. Proposed Reliability Standards must consider any other appropriate factors.

No other negative factors relevant to whether the proposed Reliability Standard is just and reasonable were identified.