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Standards Committee and NERC Generator Ride-through (PRC-029-1)

September 19, 2024

Todd Bennett, Chair of the Standards Committee
Troy Brumfield, Vice Chair of the Standards Committee
Jamie Calderon, NERC Director of Standards Development

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Standards Committee Participants and NERC Staff

	Name
Chair	Todd Bennett
Vice Chair	Troy Brumfield
Members	Patti Metro
	Terri Pyle
	Amy Casuscelli
	Charlie Cook
	Charles Yeung
NERC Staff	Jamie Calderon

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Webinar Agenda

- Background
  - FERC Order 901
  - Ballot Results
  - Technical Conference
- PRC-029-1
- Implementation Plan
- Next Steps
- Questions & Answers

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Background

- FERC Order 901
  - October 2023
  - 4 Milestones through November 2026
  - IBR related performance issues

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Background

- Draft 3 – closed on August 12
  - PRC-029-1 – failed with 52.89%
  - Implementation Plan – failed with 60.04%

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Rule 321

- NERC Board of Trustees invoked Rule 321 on August 15
- Technical Conference Path
- Standards Committee and NERC host technical conference
- Draft Memo to Board based on results
- Revise Draft development
- Re-ballot (need 60%)

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Background – Technical Conference Results

- Remove ambiguity by modifying from “Ride-through”
- i.e. “operate in its entirety”
- Align PRC-029 criteria with current OEM design capabilities as necessary
- Applies to legacy and new
- Leverage submitted testimony to support hardware-based limitations for frequency criteria.
- Industry would like compliance guidance developed

Background – Technical Conference Results

- Standards Committee and NERC debrief on September 6
- Update criteria for legacy equipment. IBR shall either:
  - Meet updated PRC-029 voltage/frequency criteria (aligned with values from current OEM designs)
  - May be eligible of partial exemption if able to demonstrate hardware-based limitations
  - Additional NERC studies may be pursued to verify criteria efficacy

A. Introduction

1. **Title:** **Frequency and Voltage Ride-through Requirements for Inverter-based Resources**

2. **Number:** **PRC-029-1**

3. **Purpose:** To ensure that IBRs Ride-through to support the Bulk Power System (BPS) during and after defined frequency and voltage excursions.

4. **Applicability:**

   4.1 Functional Entities:

   4.1.1. Generator Owner

   4.2 Facilities:

   4.2.1. ~~The Elements associated with (1)~~ Bulk Electric System (BES) IBR~~s; and (2)~~

   ~~**4.2.1.**~~**4.2.2.** Non-BES IBRs that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA, connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage greater than or equal to 60 kV.

Effective Date: See Implementation Plan for Project 2020-02 – PRC-029-1

Standard-only Definition: None

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PRC-029-1 – R1

B. Requirements and Measures

R1. Each Generator Owner shall ensure the design and operation is such that each IBR meets or exceeds Ride-through requirements, in accordance with the "must Ride-through[1] zone" as specified in Attachment 1, except ~~for~~in the following conditions: *[Violation Risk Factor: High] [Time Horizon: Operations Assessment]*

- The IBR needed to electrically disconnect in order to clear a fault;~~ or~~
- The voltage at the high-side of the main power transformer[2] went outside an accepted hardware limitation, in accordance with Requirement R4;~~ or~~
- The instantaneous positive sequence voltage phase angle change is more than 25 electrical degrees at the high-side of the main power transformer and is initiated by a non-fault switching event on the transmission system[3]; or
- The Volts per Hz (V/Hz) at the high-side of the main power transformer exceed 1.1 per unit for longer than 45 seconds or exceed 1.18 per unit for longer than 2 seconds.

M1. Each Generator Owner shall have evidence to demonstrate the design of each IBR will adhere to Ride-through requirements, as specified in Requirement R1. Examples of evidence may include, but are not limited to dynamic simulations, studies, plant protection settings, and control settings design evaluation. Each Generator Owner shall retain evidence of actual disturbance monitoring (i.e. ~~S~~sequence of ~~E~~event ~~R~~recorder, ~~D~~dynamic ~~D~~disturbance ~~R~~recorder, and ~~F~~fault ~~R~~recorder) to demonstrate that the operation of each IBR did adhere to Ride-through requirements, as specified in Requirement R1. If the Generator Owner choose to utilize Ride-through exemptions that occur within the "must Ride-through zone" and are caused by non-fault initiated phase jumps of greater than 25 electrical degrees, then each Generator Owner shall also retain evidence of actual disturbance monitoring (i.e. ~~S~~sequence of ~~E~~event ~~R~~recorder, ~~D~~dynamic ~~D~~disturbance ~~R~~recorder, and ~~F~~fault ~~R~~recorder) data to demonstrate that the IBR failed to Ride-through during a phase jump of greater than or equal to 25 electrical degrees, and documentation from their Transmission Planner, Reliability Coordinator, Planning Coordinator, or Transmission Operator that a non-fault initiated switching event occurred.

- Minor revisions grammar
- Lowercase undefined terms – align with PRC-028-1

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PRC-029-1 – R2

- Minor addition to requirement 2.3.1

2.3. While voltage at the high-side of the main power transformer is within the permissive operation region, as specified in Attachment 1, each IBR may operate in current blocking mode if necessary to avoid tripping. Otherwise, each IBR shall follow the requirements for the mandatory operation region in Requirement R2.2.

2.3.1 If an IBR enters current blocking mode, it shall restart current exchange in less than or equal to five cycles of positive sequence voltage returning to a continuous operation region or mandatory operation region.

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PRC-029-1 – R2

- Minor addition to requirement 2.3.1

M2. Each Generator Owner shall have evidence to demonstrate the design of each IBR will adhere to requirements, as specified in Requirement R2. Examples of evidence may include, but are not limited to dynamic simulations, studies, plant protection settings, and control settings design evaluation. Each Generator Owner shall also retain evidence of actual disturbance monitoring (i.e. ~~S~~sequence of ~~E~~event ~~R~~recorder, ~~D~~dynamic ~~D~~disturbance ~~R~~recorder, and ~~F~~fault ~~R~~recorder) data to demonstrate that the operation of each IBR did adhere to performance requirements, as specified in Requirement R2, during each voltage excursion measured at the high-side of the main power transformer. In regard to R2.1.3, R2.2, and R2.5, the Generator Owner shall retain evidence of receiving such performance requirements, (e.g. email exchange, contract information) if the Transmission Planner, Transmission Operator, Reliability Coordinator, or Planning Coordinator has required the Generator Owner through other mechanisms to follow performance requirements other than those in Requirement R2 (e.g. ramp rates, Reactive Power prioritization).

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PRC-029-1 – R3

R3. Each Generator Owner shall ensure the design and operation is such that each IBR meets or exceeds Ride-through requirements during a frequency excursion event whereby the System frequency remains within the "must Ride-through zone" according to Attachment 2 and the absolute rate of change of frequency (RoCoF)[9] magnitude is less than or equal to 5 Hz/second, unless a documented hardware limitation exists in accordance with Requirement R4. *[Violation Risk Factor: High] [Time Horizon: Operations Assessment]*

M3. Each Generator Owner shall have evidence to demonstrate the design of each IBR will adhere to Ride-through requirements, as specified in Requirement R3. Examples of evidence may include, but are not limited to dynamic simulations, studies, plant protection settings, and control settings design evaluation. Each Generator Owner shall also retain evidence of actual disturbance monitoring (i.e. ~~S~~sequence of ~~E~~event ~~R~~recorder, ~~D~~dynamic ~~D~~disturbance ~~R~~recorder, and ~~F~~fault ~~R~~recorder) data to

R4. Each Generator Owner identifying an IBR that is in-service by the effective date of PRC-029-1, has known hardware limitations that prevent the IBR from meeting ~~voltage~~ Ride-through criteria as detailed in Requirements R1 ~~and~~ R3~~2~~, and requires an exemption from specific ~~voltage~~ Ride-through criteria shall:[10] *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

4.1. Document information supporting the identified hardware limitation no later than 12 months following the effective date of PRC-029-1. This documentation shall include:

4.1.1 Identifying information of the IBR (name and facility number~~#~~);

4.1.2 Which aspects of ~~voltage~~ Ride-through requirements that the IBR would be unable to meet and the capability of the hardware due to the limitation;

4.1.3 Identify the specific piece(s) of hardware causing the limitation;

4.1.4 ~~Supporting t~~Technical documentation verifying the limitation is due to hardware that would need~~s~~ to be physically replaced to meet all Ride-through criteria, and ~~or~~ that the limitation cannot be removed by software updates or setting changes, and;

4.1.5 Information regarding any plans to remedy the hardware limitation (such as an estimated date).

4.2. Provide a copy of the information detailed in Requirement R4.1, except for any material considered by the original equipment manufacture to be proprietary information, to the associated Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), Reliability Coordinator(s), and the Compliance Enforcement Authority (CEA) no later than 12 months following the effective date of PRC-029-1.[11]

4.2.1 Provide ~~A~~any response ~~t~~for additional information requested by the associated Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), Reliability Coordinator(s), and the CEA shall be provided back to the requestor within 90 days of the request.

4.2.2 Provide a copy of the acceptance of an hardware limitation by the CEA to the associated Planning Coordinator(s), Transmission

Planner(s), Transmission Operator(s), and Reliability Coordinator(s) within 90 days of receiving the acceptance.[12]

4.3. Each Generator Owner with a previously accepted limitation that replaces the hardware causing the limitation shall document and communicate such a hardware change to the associated Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), and Reliability Coordinator(s) within 90 days of the hardware change.

4.3.1 When existing hardware causing the limitation is replaced, the exemption for that Ride-through criteria no longer applies.

M4. Each Generator Owner submitting for an exemption for an IBR that is in-service by the effective date of PRC-029-1, shall have evidence of submission to the CEA consistent with the information listed in Requirement R4.1. Each Generator Owner shall have evidence of communicated copies of each submission in accordance with Requirement R4.2 and to the associated entities described in Requirement R4.2. Acceptable types of evidence for submittals include but are not limited to, meeting minutes, agreements, copies of procedures or protocols in effect, or email correspondence. Acceptable types of evidence for a hardware limitation may include, but is not limited to damage curves~~documentation that contains study results, experience from an actual event, or~~ provided by the original equipment manufacturer~~'s advice~~. Each Generator Owner that receives a request for additional information under Requirement R4.2.1 shall have evidence of providing that information within 90 ~~calendar~~ days. Each Generator Owner that replaces hardware at an IBR that is directly associated with an accepted exemption and that hardware is the cause for the limitation, shall have evidence of communicating the hardware change to the associated entities described in Requirement R4.3 within 90 ~~calendar~~ days of the hardware replacement.

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PRC-029-1 – Attachment 1

Attachment 1: Voltage Ride-Through Criteria

Table 1: Voltage Ride-through Requirements for AC-Connected Wind IBR [13]

Voltage (per unit)[14]	Operation Region	Minimum Ride-Through Time (sec)
> 1.20	N/A[15]	N/A
≥ 1.10	Mandatory Operation Region	1.0
> 1.05	Continuous Operation Region	1800
≤ 1.05 and ≥ 0.90	Continuous Operation Region	Continuous
< 0.90	Mandatory Operation Region	3.00
< 0.70	Mandatory Operation Region	2.50
< 0.50	Mandatory Operation Region	1.20
< 0.25	Mandatory Operation Region	0.16
< 0.10	Permissive Operation Region	0.16

Table 2: Voltage Ride-through Requirements for All Other IBR

Voltage (per unit)[16]	Operation Region	Minimum Ride-Through Time (sec)
> 1.20	N/A[17]	N/A
> 1.10	Mandatory Operation Region	1.0
> 1.05	Continuous Operation Region	1800
≤ 1.05 and ≥ 0.90	Continuous Operation Region	Continuous
< 0.90	Mandatory Operation Region	6.00
< 0.70	Mandatory Operation Region	3.00
< 0.50	Mandatory Operation Region	1.20
< 0.25	Mandatory Operation Region	0.32
< 0.10	Permissive Operation Region	0.32

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PRC-029-1 – Attachment 1

1. Table 1 applies to type 3 and type 4 wind IBR or hybrid IBR that include wind, unless connected via a dedicated Voltage Source Converter - High Voltage Direct Current (VSC-HVDC) transmission facility.
2. Table 2 applies to all other IBR types not covered in Table 1; including, but not limited to, the following facilities:
   a. IBR, regardless of their energy resource, interconnecting via a dedicated VSC-HVDC transmission facility.
   b. Other IBR or hybrid IBR consisting of photovoltaic (PV) and BESS.
3. The applicable voltage for VSC-HVDC system with a dedicated connection to an IBR is on the AC side of the transformer(s) that is (are) used to connect the VSC-HVDC system to the interconnected transmission system.
4. The voltage base for per unit calculation is the nominal phase-to-ground or phase-to-phase transmission system voltage unless otherwise defined by the Planning Coordinator, Transmission Planner, or Transmission Owner.
5. The applicable voltage for Tables 1 and 2 is identified as the voltage max/min of phase-to-neutral or phase-to-phase fundamental root mean square (RMS) voltage at the high-side of the main power transformer.
6. Tables 1 and 2 are only applicable when the frequency is within the "must Ride-through zone" as specified in Figure 1 of Attachment 2.
7. At any given voltage value, each IBR shall Ride-through unless the time duration at that voltage has exceeded the specified minimum Ride-through time duration. 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.
8. The specified duration of the mandatory operation regions and the permissive operation regions in Tables 1 and 2 is cumulative over one or more disturbances within any 10 second time period.
9. The IBR may trip for more than four deviations of the applicable voltage at the high-side of the main power transformer outside of the continuous operation region within any 10 second time period.
10. Instantaneous trip settings based on instantaneously calculated voltage measurements with less than filtering lengths of one cycle (16.6 millisecond) are not permissible.
11. The "must Ride-through zone" is the combined area of the mandatory operating regions, the continuous operating regions, and the permissive operating region. All area outside of these operating regions is referred to as the "may Ride-through zone".

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PRC-029-1 – Attachment 2

Attachment 2: Frequency Ride-Through Criteria

Table 3: Frequency Ride-through Capability Requirements

System Frequency (Hz)	Minimum Ride-Through Time (sec)
> 61.8	May trip
> 61.2	299
≤ 61.2 and ≥ 58.8	Continuous
< 58.8	299
< 57.0	May trip
~~System Frequency (Hz)~~	~~Minimum Ride-Through Time (sec)~~
~~> 64.0~~	~~May trip~~
~~≥ 61.8~~	~~6~~
~~≥ 61.5~~	~~299~~
~~> 61.2~~	~~660~~
~~≤ 61.2 and > 58.8~~	~~Continuous~~
~~≤ 58.8~~	~~660~~
~~≤ 58.5~~	~~299~~
~~≤ 57.0~~	~~6~~
~~< 56.0~~	~~May trip~~

1. Frequency measurements are taken at the high-side of the main power transformer.
2. Frequency is measured over a period of time (typically 3-6 cycles) to calculate system frequency at the high-side of the main power transformer.
3. Instantaneous or single points of measurement may not be used in the determination of control settings.
4. At any given frequency value, each IBR shall Ride-through unless the time duration at that frequency has exceeded the specified minimum ride-through time duration.
5. The specified durations of Table 3 are cumulative over one or more disturbances within a 10~~5~~-minute time period.

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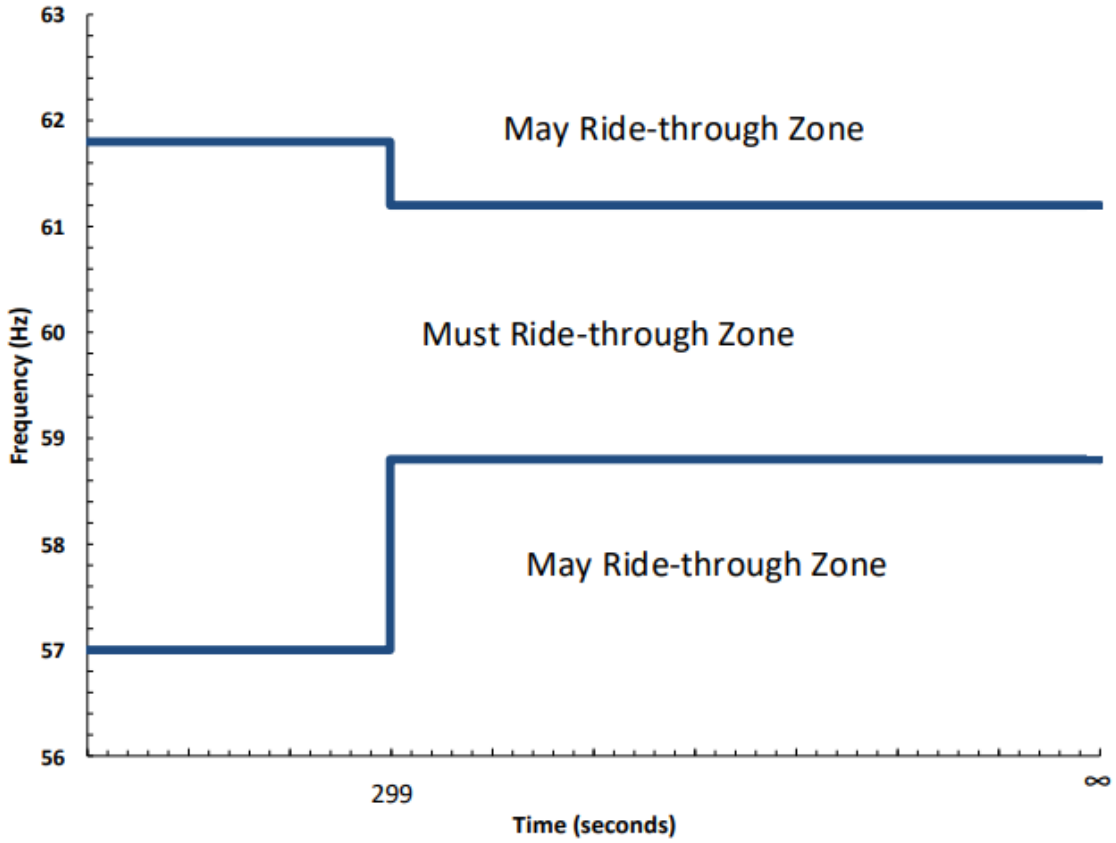
PRC-029-1 – Attachment 2



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PRC-029-1 – Attachment 2

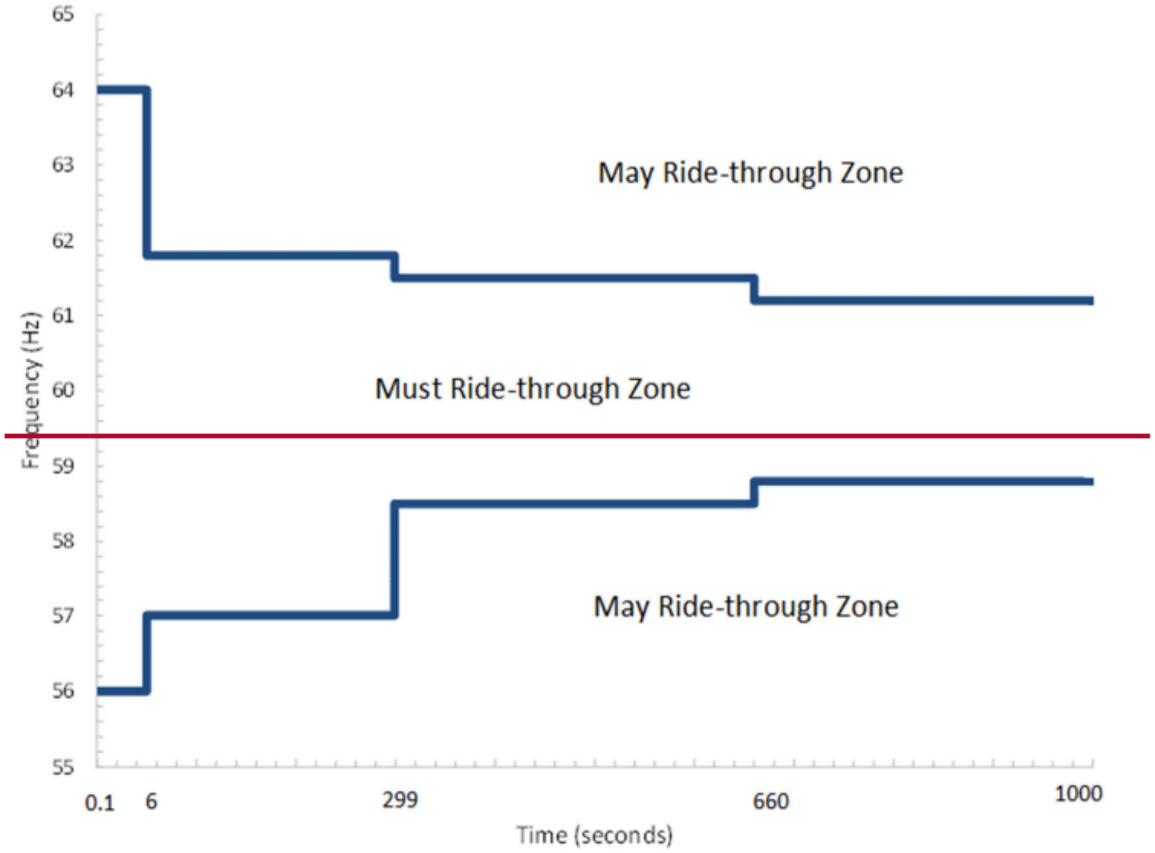

Figure 1: PRC-029 Frequency Ride-through Requirements

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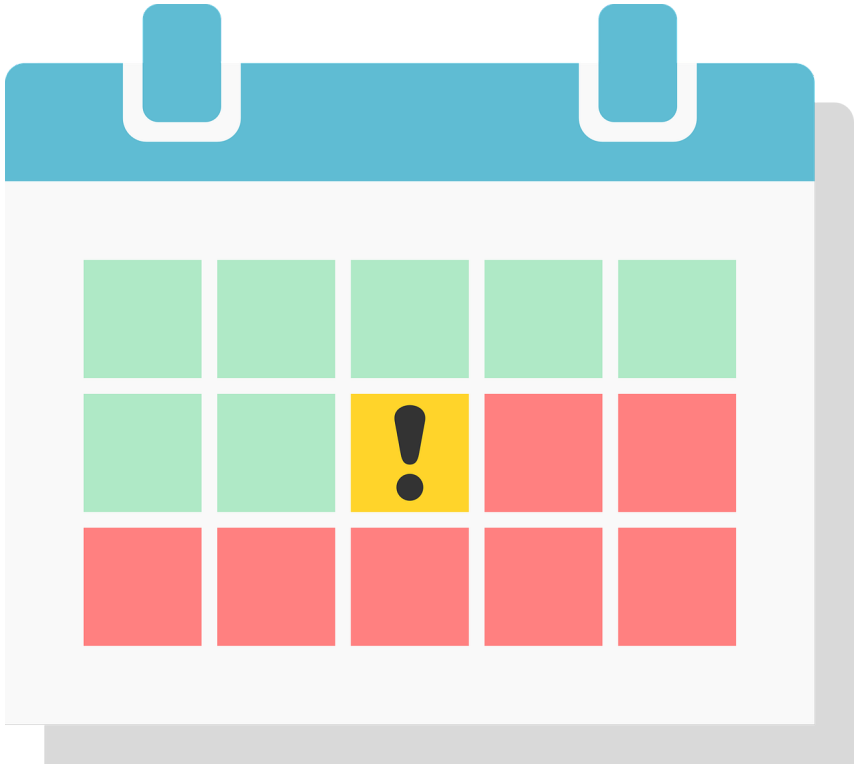
Next Steps

- Draft Memo to Board (SC and NERC)
- File Milestone 2 projects with FERC on Nov 4, 2024

- Point of Contact
  - Jamie Calderon, Director of Standards Development
    - Jamie.Calderon@nerc.net or call 404-960-0568



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Questions and Answers

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References

- Project Page
- Technical Conference
- SAR
- PRC-029-1 Clean
- PRC-029-1 Redline
- PRC-029-1 Implementation Plan