FERC Request for Comment (Docket No. RM25-3-000)

03/24/2025

Federal Energy Regulatory Commission,

Thank you for the opportunity to respond to the Federal Energy Regulatory Commission's (Commission) proposed approval of PRC-029-1 (Frequency and Voltage Ride-through Requirements for Inverter-Based Resources). [1] The organizations listed below agree with the need to develop appropriate reliability standards for inverter-based resources (IBRs).

In this letter we call attention to the fact that PRC-029-1 does not appropriately consider the project-specific study and design process for the HVDC transmission systems that connect existing and future IBRs to the grid. Additionally, it does not adequately account for the reasonable limitations of a technical nature facing IBRs connected by HVDC transmission. These limitations have already been accounted for in IEEE 2800-2022, and they should be incorporated into PRC-029-1.

Understanding the need for the Commission to approve PRC-029-1 in a timely manner, we kindly ask that any Commission approval of PRC-029-1 be coupled with directions to NERC to align PRC-029-1 with IEEE 2800-2022 and to consider our additional recommendations below. Doing so will enable the timely, reasonable, and cost-effective deployment of HVDC-connected IBRs.

Finally, given the unique capabilities of HVDC transmission systems to support grid reliability while also interconnecting badly needed generators for resource adequacy, approving PRC-029-1 without our suggested modifications runs counter to the Commission's (and NERC's) fundamental goal of grid reliability.

Respectfully,

Morgan Putnam, Ph.D.
DNV, HVDC Principal Consultant and Head of DNV's HVDC Standards Joint Industry Project

Organizations Supporting this Letter:

- DNV
- GE Vernova
- Hitachi Energy
- Invenergy
- PPL TransLink WindGrid
- Siemens Energy

[1] *Reliability Standards to Address Inverter-Based Resources,* Order No. 901, 88 FR 74250 (Oct. 30, 2023), 185 FERC ¶ 61,042 (2023)

PRC-029-1 and HVDC-Connected IBRs

The drafting process for PRC-029-1 focused heavily on the impacts to solar and wind inverters. While there are understandable reasons this was the case, important concerns about PRC-029-1's impact on IBRs connected by HVDC transmission were not adequately addressed. As such, those engaged in the development of HVDC-connected IBRs are collectively stepping forward to suggest critical modifications to PRC-029-1.

We believe that further distinction of PRC-029-1's requirements are required to enable the timely, reasonable, and cost-effective deployment of HVDC-connected IBRs and to align PRC-029-1 with IEEE 2800-2022.

As written, PRC-029-1 does not appropriately consider the project-specific study and design process for the HVDC transmission systems that connect IBRs to the grid. The HVDC transmission study and design process is one that carefully considers local, regional, and national grid requirements to cost-effectively tailor the performance of the HVDC system to the specific needs of the local/regional transmission operator.[2] The United States grid is not a one-size-fits-all system. For example, PRC-024-2 gave different Frequency Capability Curves based on the region. Given that HVDC transmission systems are billion-dollar assets moving significant power, in most cases over 1 GW, this optimization process saves millions of dollars in cost per HVDC transmission system while ensuring grid reliability in regions where the draft of PRC-029-1 is more stringent than actual grid characteristics.

By failing to fully consider the existing study and design process undergone by HVDC transmission systems, PRC-029-1 establishes performance criteria that incur costs without clearly benefiting grid reliability (as the performance criteria and their HVDC system design implications will not be appropriate for all projects). To place PRC-029-1 on a more technically sound foundation, the recommendations we present below enable the design of the HVDC transmission systems (the connect IBRs) to be guided by the detailed system studies in the HVDC study and design process, as opposed to performance criteria that may or may not be appropriate for a specific system.

PRC-029-1 and IEEE 2800-2022 should be aligned regarding the technical design requirements of choppers.[3,4] In 7.2.2.4, IEEE 2800-2022 states that: "*The consecutive voltage deviation ride-through capability of an isolated IBR interconnected to the TS via a VSC-HVDC transmission facility may be limited by the energy absorption capability and thermal design of the DC chopper in the VSC-HVDC line, as well as by the ability of fast control of active power production by the isolated IBR. Refer to Annex M. for an explanation.*"[5] If PRC-029-1 is not aligned with IEEE 2800-2022, then HVDC converter manufacturers will need to implement larger chopper designs. This would add cost and require additional engineering labor.

Without incorporation of the following recommended changes, it is our belief that the ultimate effect of PRC-029-1 will be to unreasonably increase the cost of HVDC-connected IBRs.

[2] For example, one can review Southwest Power Pool's HVDC Planning Manual, which was approved by their Transmission Working Group in 2024.

[3] A chopper is a specific type of dynamic braking system (DBS). However, here we are using the term 'chopper' to cover all DBS, as was done in IEEE 2800-2022.

[4] For clarity, IEEE 2800 addressed DC choppers specifically given their use in offshore wind interconnection; however, AC choppers are used for the same purpose for HVDC interconnection of onshore IBR and have similar thermal limitations.

[5] A section with additional information on DC choppers is provided at the end of this letter.

Recommended changes to PRC-029-1

We suggest the following changes to PRC-029-1 to provide flexibility in designing reasonable and cost-efficient solutions when developing IBRs connected by HVDC transmission systems:

1. **Please clarify that new and existing IBRs connected by HVDC transmission must comply with PRC-029-1's ride-through requirements up to the point where they must trip to avoid violating the thermal limits of the HVDC transmission system's chopper.** We recommend inserting the phrase 'for HVDC-connected IBRs, this is subject to chopper capability' into Points 7 and 8, as well as other relevant sections, to ensure alignment with IEEE 2800-2022's provisions for HVDC-connected IBRs. This change will bring PRC-029-1 into closer alignment with IEEE 2800-2022.

   Please also add a note underneath Table 2 of Attachment 1 that sustained undervoltages are subject to chopper capability and depend on the prioritization of real power vs. reactive power.

   These chopper-related clauses should apply to HVDC-connected IBRs, regardless of whether they are "in service" by the effective date of PRC-029-1. Again, these clauses align with IEEE 2800-2022, which saw fit to accommodate chopper limitations for HVDC-connected IBRs for the foreseeable future.[6]

Additional changes to PRC-029-1 for consideration

2. **Please note in R2.1.3 that active power generation from HVDC-connected IBRs could be ramped down to avoid reaching the thermal limits of the chopper:** it is possible to envision scenarios where the active power transmission must be limited to avoid the thermal overload of the chopper (i.e. a persistent undervoltage of <0.95 pu causes the system operator to prioritize reactive power injection).

3. **Please clarify Points 7, 8, and 9 in Attachment 1:** Please clarify whether or not Points 7, 8, and 9 would collectively mean that an HVDC-connected IBR was responsible for consecutively riding through up to 0.32 seconds with voltage per unit below 0.25, up to 1.20 seconds with voltage per unit below 0.50, up to 3.00 seconds with voltage per unit below 0.70, and up to 6.00 seconds with voltage per unit below 0.90.

Thank you for your careful consideration of our recommended changes to PRC-029-1.

Additional information on choppers:
For those unfamiliar with choppers, it is worth noting that choppers support the reliable recovery of HVDC-connected IBRs after a fault on the AC grid. Further, while current DC chopper designs have limitations, there is a decade of operational experience proving that they offer very fast and reliable power recovery after clearance of the fault on the AC grid.

The reasonableness and technical merit for incorporating exemption for the design limits of current DC chopper designs is revealed in Annex M of IEEE 2800-2022. Annex M refers to the German VDE standard as a reference and

[6] These thermal limitations are being further considered in the IEEE 2800.2, which defines the verification principles for IEEE 2800-2022.

mentions that: "*Typically, the DC chopper is designed to absorb the IBR continuous rating (ICR) for two seconds and needs a cool down time before it is capable to absorb energy again. This may limit the isolated IBRs interconnected via VSC-HVDC from riding through consecutive voltage deviations requirements specified in 7.2.2.4. … The existing grid codes, such as the European Connection Conditions (ECC) and the German Technical Connection Rule (TCR) VDE-AR-N 413, allows a limit on consecutive voltage deviations ride-through capability considering the energy absorption capability and thermal design of the DC chopper*".

In summary, IEEE 2800-2022 and European grid codes create specific language for HVDC-connected IBRs that consider the technical limitations of current DC chopper designs (and the broader capabilities that they would like HVDC transmission systems to have when considering their unique role in the larger system). That language would also be applicable to onshore HVDC-connected IBRs that use AC choppers for the same purpose while facing similar thermal limitations during abnormal voltage conditions.