

Utilizing the Excess Capability of BPS- Connected Inverter-Based Resources for Frequency Support

NERC Inverter-Based Resource Performance Working Group (IRPWG)

White Paper

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The Federal Energy Regulatory Commission (FERC) issued Order No. 842 in 2018, amending the pro forma Large Generator Interconnection Agreement (LGIA) and Small Generator Interconnection Agreement (SGIA) to require all “newly interconnecting large and small generating facilities, both synchronous and non-synchronous, to install, maintain, and operate equipment capable of providing primary frequency response (PFR) as a condition of interconnection.”¹ On the same subject, NERC recently published a white paper, *Fast Frequency Response Concepts and Bulk Power System Reliability Needs*,² in March 2020 describing the interrelationships between primary frequency response (PFR) and fast frequency response (FFR). This work extends on the FERC Order NO. 842 and the NERC white paper and recommends leveraging PFR and FFR capabilities from inverter-based resources to the extent possible to support BPS frequency as an essential reliability service.

Specifically, inverter-based resources operating at their maximum contractual agreement, also referred to as the steady-state interconnection limit (SSIL), may be able to support the grid during underfrequency events beyond their SSIL. This situation is most likely to occur in ac-coupled³ hybrid plants (i.e., the combination of battery energy storage and wind or solar PV) or in standalone wind, solar PV, and battery energy storage plants where additional capacity is available but not presently utilized due to the SSIL constraints imposed by interconnection agreements. It should be noted that this paper only focuses on the excess capability of inverter-based resources that is limited by the SSIL; it does not consider the short-term overload capability of individual inverters.

By establishing a short-term interconnection limit (STIL)⁴ in interconnection agreements, inverter-based resources with excess active power capability beyond SSIL can use this capability to better support the grid frequency. However, once the system frequency recovers to nominal, the MW output of the plant should

¹ https://www.nerc.com/FilingsOrders/us/FERCOrdersRules/E-2_Order%20on%20Primary%20Frequency%20Response.pdf

² “White Paper: Fast Frequency Response Concepts and Bulk Power System Reliability Needs,” March 2020:

https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/Fast_Frequency_Response_Concepts_and_BPS_Reliability_Needs_White_Paper.pdf

³ Dc-coupled hybrid plants can be deemed similar to the standalone IBR facilities for the topic of this paper.

⁴ A similar concept is also introduced in IEEE P2800 standard. However, there are some differences. A prudent reader is encouraged to refer to the IEEE P2800 standard to fully understand the similarities and differences:

<https://standards.ieee.org/project/2800.html#:~:text=IEEE%20P2800%20%2D%20IEEE%20Draft%20Standard,Associated%20Transmission%20Electric%20Power%20Systems>

return to a value equal to or below SSIL. Moreover, if the equipment can only withstand operation between SSIL and STIL temporarily due to thermal or any other constraints, then it can return to SSIL prior to the recovery of the system frequency.

Currently, exceedance of SSIL to provide PFR or FFR is either not permitted in interconnection agreements or not well-defined. Provided all equipment ratings and stability limits are properly studied and respected, the excess capability of an inverter-based resource can be leveraged to enhance BPS reliability. This can be accomplished by establishing an STIL in the interconnection agreement of the inverter-based resource with excess capability. This will afford additional PFR and FFR during underfrequency events to the Balancing Authority and thus enhance BPS reliability.

In an effort to advance this concept, the NERC IRPWG has developed a set of recommendations and identified the applicable entities within the industry that would need to act upon these recommendations to enable this capability.

Recommendations for Utilizing the Excess Capability of BPS-Connected Inverter-Based Resources for PFR and FFR Support	
Recommendation	Applicability
The <i>pro forma</i> LGIA and SGIA should be amended to specify conditions under which the SSIL and STIL of the facility established in the interconnection agreement would complement each other to enable the facility to respond to underfrequency events and provide PFR or FFR to the BPS for the duration until the frequency is restored.	Federal Energy Regulatory Commission (FERC)
Transmission Owners (TOs), in coordination with their Transmission Planner (TP) and Planning Coordinator (PC), should update local interconnection requirements per NERC FAC-001 to permit operation of all newly interconnecting inverter-based resources to provide PFR and FFR while operating at their SSIL up to their STIL. PFR and FFR requirements should focus on the required performance—droops, dead-bands, response times, and reaction times. ⁵	TOs, TPs, PCs
TPs and PCs should evaluate and enhance their interconnection study processes per NERC FAC-002 to ensure the added provision of FFR and PFR from inverter-based resources does not adversely affect BPS reliability or stability. Adequate simulations are needed to ensure all system operating limits are met with these capabilities enabled. TPs and PCs should review, amend, and file their <i>pro forma</i> interconnection agreements and procedures to clarify SSIL and STIL to support PFR or FFR whenever excess capability is available. TPs and PCs should also ensure any transmission planning studies including PFR or FFR from these types of resources are appropriately modeled in underfrequency load shedding (UFLS) studies per the latest effective version of NERC PRC-006.	TPs, PCs

⁵ Refer to NERC *Reliability Guideline: Improvements to Interconnection Requirements for BPS-Connected Inverter-Based Resources*: https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability_Guideline_IBR_Interconnection_Requirements_Improvements.pdf

Recommendations for Utilizing the Excess Capability of BPS-Connected Inverter-Based Resources for PFR and FFR Support

Recommendation	Applicability
<p>Equipment manufacturers, developers, Generator Owners (GOs), and Generator Operators (GOPs) of BPS-connected inverter-based resources that have excess capabilities and able to provide additional active power (above SSIL) to support frequency response should utilize the STIL established by interconnection agreements or requirements. If the agreements and requirements are amenable to this functionality being enabled, it should be functionally available per FERC Order No. 842. Any provision of additional active power should not hinder or limit the capability to provide reactive power to the BPS and take into account the facilities’ required power factor limits relative to the SSIL established in the interconnection agreement as well as active or reactive current priority control settings.</p>	<p>Inverter and plant-level controller manufacturers, inverter-based resource developers, GOs, GOPs</p>
<p>Reliability Coordinators (RCs) and Transmission Operators (TOPs) should ensure the additional active power generated by resources exceeding their SSIL up to their STIL to provide PFR or FFR would not cause any adverse impacts to reliability and stability of the BPS during real-time operations. This includes ensuring that no system operating limits are exceeded and operational planning assessments and real-time assessments are reflective of these additional capacities from inverter-based resources.</p> <p>Balancing Authorities (BAs) should ensure awareness of the on-line FFR and PFR capabilities to ensure sufficient reserves to support BPS frequency immediately following sudden loss of generation or sudden increase in load events.</p>	<p>RCs, TOPs, BAs</p>

Upon approval of this white paper, the NERC IRPWG will hold an informational webinar to comprehensively discuss various plant design scenarios under which STIL (above SSIL) is possible.