

**UNITED STATES OF AMERICA  
BEFORE THE  
FEDERAL ENERGY REGULATORY COMMISSION**

**North American Electric Reliability Corporation** )  
 )

**Docket No. RD22-4-000**

**NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION  
AMENDMENT TO INVERTER-BASED RESOURCES WORK PLAN  
AND ERRATA TO WHITEPAPER**

On February 15, 2023, the North American Electric Reliability Corporation (“NERC”), as the Federal Energy Regulatory Commission (“Commission”) certified Electric Reliability Organization, filed the Commission-directed<sup>1</sup> work plan (“Work Plan”) providing NERC’s proposed approach to identify and register owners and operators of inverter-based resources (“IBRs”) connected to the Bulk-Power System (“BPS”) but not registered with NERC (“unregistered IBRs”).<sup>2</sup> In that Work Plan, NERC proposed to coordinate with Regional Entities<sup>3</sup> and stakeholders to develop a new registered entity function within the NERC Rules of Procedure (“ROP”) for unregistered IBRs. This new class of registered entity would be designed to ensure that owners and operators of unregistered IBRs are included in the NERC Compliance Registry.

The Work Plan reflects NERC’s proposed initial parameters for the new class of entity initially entitled “Generator Owner-Inverter-Based Resources” or “GO-IBRs.” On March 3, 2023, the Commission issued a Request for Information directing clarification whether NERC’s proposal intends to include both owners and operators of unregistered IBRs.<sup>4</sup> NERC appreciates this

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<sup>1</sup> *Registration of Inverter-Based Resources*, 181 FERC ¶ 61,124 (2022) [hereinafter *IBR Order*].  
<sup>2</sup> *North Am. Elec. Reliability Corp.*, Docket No. RD22-4-000 (Feb. 15, 2023) [hereinafter *Work Plan Filing*].  
<sup>3</sup> The Regional Entities are (i) Midwest Reliability Organization (“MRO”); (ii) Northeast Power Coordinating Council, Inc. (“NPCC”); (iii) ReliabilityFirst Corporation (“ReliabilityFirst”); (iv) SERC Reliability Corporation (“SERC”); (v) Texas Reliability Entity, Inc. (“Texas RE”); and (vi) Western Electricity Coordinating Council (“WECC”). NERC and the Regional Entities comprise the ERO Enterprise.  
<sup>4</sup> *North Am. Elec. Reliability Corp.*, Docket No. RD22-4-000 (Mar. 3, 2023) (directing an interlocutory request for information seeking clarification regarding the Work Plan) [hereinafter *RFI*].

opportunity to clarify the record, and confirms that its proposed new registered entity function would include both ownership and operational characteristics. As described below, NERC appreciates that its original reliance on existing registry terminology to put forth a “GO-IBR” function obscured this aspect of the proposal. This amendment to the Work Plan seeks to clarify how NERC’s proposal would address unregistered IBR operational functions and how NERC plans to work with stakeholders innovatively to ensure that material unregistered IBRs with aggregate nameplate capacity greater than or equal to 20 MVA are subject to appropriate NERC Reliability Standards.<sup>5</sup>

In addition to this amendment to the Work Plan, NERC has identified a typographical error in the White Paper included as Attachment 2 to the Work Plan Filing and respectfully submits an errata here as a replacement **Attachment 2, White Paper**.<sup>6</sup>

**I. NERC Proposal for an IBR Registered Entity Function Intends to Encompass Ownership and Operational Characteristics.**

The Request for Information asks that NERC, “[p]lease explain whether NERC intends to modify its processes to encompass unregistered IBR generator operators and, if answered in the affirmative, explain NERC’s plan for doing so.”<sup>7</sup>

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<sup>5</sup> NERC is also evaluating an alternative title for the new registered entity function.

<sup>6</sup> The White Paper included a reference at p. 8 to wind resources that are not considered IBR. This reflected associated consideration of dispersed power producing resources generally and has been deleted as a typographical error. The attached Errata deletes this error and includes a footnote to help clarify.

<sup>7</sup> *RFI*, at p. 2 (including a question in the alternative if NERC’s answer had been no).

NERC plans to register owners and operators of unregistered IBRs by working with stakeholders to design ROP registry criteria for two categories of unregistered IBRs:<sup>8</sup>

- IBRs which have aggregate nameplate capacity of less than or equal to 75 MVA and greater than or equal to 20 MVA interconnected at a voltage greater than or equal to 100 kV; or
- IBRs which have aggregate nameplate capacity of greater than or equal to 20 MVA interconnected at a voltage of less than 100 kV.

The Work Plan Filing referred to the new registered entity function as GO-IBRs. This was done to provide a familiar frame of reference for reviewers. However, it is now apparent that relying on this terminology creates confusion. The terminology is grounded in the Functional Model, which is an archived document that presents a useful framework for conventional resources, with less applicability to unregistered IBRs.<sup>9</sup> In the same manner that the unique attributes associated with unregistered IBRs may lend themselves to a subset list of Reliability Standards, these same attributes may reflect overlap between what the Functional Model treats as distinct generator owner and operator tasks.

As stated in the Work Plan filing, ERO Enterprise research and analysis demonstrates that there is a 16% gap of BPS-connected IBRs not subject to Reliability Standards, with that trend expected to continue.<sup>10</sup> The Work Plan's initial parameters would close 14% of that 16% gap and lead 98% of BPS-connected IBRs to become subject to applicable Reliability Standards. While NERC has not fully defined the new registered entity criteria, NERC intends to include operating functions to the extent necessary. While it may prove useful to leverage the existing

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<sup>8</sup> See Work Plan Filing, at Work Plan Transmittal, p. 6; Attachment 1, Work Plan, p. 2; and Attachment 2, White Paper, p. 7 (presenting unregistered IBR parameters).

<sup>9</sup> See NERC Functional Model, <https://www.nerc.com/pa/Stand/Pages/FunctionalModel.aspx> (explaining, “[t]he NERC Functional Model and NERC Functional Model Technical Document are historical documents that provided context and guidance to Standards Drafting Teams during Reliability Standards development. As of October 2019, these documents are no longer being actively maintained.”).

<sup>10</sup> See, e.g., Work Plan Filing, at p. 4.

generator owner and operator construct within the Functional Model, NERC seeks to ensure it is not limiting itself to traditional concepts when seeking to address a gap in Reliability Standards coverage that is being created by non-traditional resources. A revised designation for these registered entities may help alleviate the confusion and will be considered as work develops

## **II. CONCLUSION**

Therefore, NERC plans to work with Regional Entities and stakeholders such as (but not limited to) trade associations, the NERC Compliance and Certification Committee, Canadian Governmental Authorities, Commission Staff, and representatives for unregistered IBRs to ensure that unregistered IBRs are registered and subject to applicable Reliability Standards. NERC will consider that new registered entity criteria for IBRs may deviate from the generator owner/operator construct rooted in the Functional Model. As directed in the Registration Order, the Work Plan would continue to be updated every 90 days after Commission approval to reflect continuing refinement of these concepts.

Respectfully submitted,

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Date: March 13, 2023

Errata – Attachment 2

Clean

# Analysis of the Changing Mix of Generating Resources on the BPS

ERO Enterprise BPS Resource Trends Task Force  
White Paper  
February 2023

## Introduction

The landscape of the electric power system across North America is experiencing a substantial transformation. Conventional generation fueled in large part by coal, nuclear, and, in recent years, natural gas turbines are being rapidly replaced by decentralized generation consisting of various forms of inverter-based resources (IBRs). These IBRs are primarily battery energy storage systems (BESS), solar photovoltaic (i.e., solar PV), and wind that are installed on the Bulk Power System<sup>1</sup> (BPS) and distribution systems. As stated in NERC's recent document *Inverter-Based Resource Strategy Ensuring Reliability of the Bulk Power System with Increased Levels of BPS-Connected IBRs*<sup>2</sup> (IBR strategy), "[t]he rapid interconnection of bulk power system (BPS)-connected inverter-based resources (IBR) is the most significant driver of grid transformation and poses a high risk to BPS reliability."

This paper focuses on the analysis and associated recommendations prepared by the ERO Enterprise BPS Resource Trends Task Force (RTTF) in response to potential risks to reliability resulting from grid transformation as seen through BPS resource trends.<sup>3</sup> The RTTF is an ERO Enterprise group comprised of members of the Organization Registration and Certification Group (ORCG) and the Reliability Assessment and Performance Analysis Steering Group (RAPA-SG).

The purpose of the RTTF is to analyze trends in the BPS relative to the changing mix of generating resources and identify any potential reliability risks resulting from these trends. As a result, the RTTF investigated potential modifications to the Bulk Electric System<sup>4</sup> (BES) definition, the NERC Registration Criteria, and related NERC Reliability Standards. Lastly, this paper supports the core tenets of the IBR Strategy.<sup>5</sup>

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<sup>1</sup> The Bulk Power System is defined in the Glossary of Terms Used in NERC Reliability Standards as: (A) facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and (B) electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. (Note that the terms "Bulk-Power System" or "Bulk Power System" shall have the same meaning.)

<sup>2</sup> *Inverter-Based Resource Strategy Ensuring Reliability of the Bulk Power System with Increased Levels of BPS-Connected IBRs*:: [https://www.nerc.com/comm/Documents/NERC\\_IBR\\_Strategy.pdf](https://www.nerc.com/comm/Documents/NERC_IBR_Strategy.pdf)

<sup>3</sup> Earlier presentation of the research included in this White Paper were provided at the *Assessment of Generation Trends Across the BPS*, (Sept. 14, 2022), at 70: [https://www.nerc.com/comm/RSTC/AgendaHighlightsandMinutes/RSTC\\_Meeting\\_September\\_14\\_2022\\_Presentations.pdf](https://www.nerc.com/comm/RSTC/AgendaHighlightsandMinutes/RSTC_Meeting_September_14_2022_Presentations.pdf)

<sup>4</sup> The Bulk Electric System is defined by the Glossary of Terms Used in NERC Reliability Standards, [https://www.nerc.com/files/glossary\\_of\\_terms.pdf](https://www.nerc.com/files/glossary_of_terms.pdf)

<sup>5</sup> IBR Strategy, at p. 4.

## BPS Resource Trends

The analysis in this white paper is based on publicly available Form 860 information reported to the U.S. Energy Information Administration (EIA). This data was analyzed to identify historical BPS resource capacity trends from individual generation units as well as aggregate plant data up to and including year 2021. The generation data in this study included all resources identified as being part of an electric generation utility under the North American Industry Classification System (NAICS), Sector 22, Utilities.<sup>6</sup> Industrial and commercial generation were not considered in the analysis since these resources are typically prime power for industrial sites or backup generation to commercial businesses and are not generally considered a BPS resource. Plants classified as utility including independent power producers, with an aggregate nameplate capacity greater than or equal to 1 MW and connected at a point-of-interconnection (POI) voltage greater than or equal to 40 kV, were included in the population of study data.<sup>7</sup> The data was divided further into the classification of generation units and plants that meet the NERC definition of BES as defined by the Glossary of Terms used in NERC Reliability Standards.

The primary focus was the most recent five-year period from 2017 to 2021. As shown in **Figure 1**, the BPS is undergoing a significant and rapid change in generating resource mix. **Figure 1** includes the aggregate nameplate capacity in Gigawatts (GW) on the BPS for conventional resources and IBRs for each year from 2017 to 2021. Over this short five-year time frame, the total generation supplied by conventional resources on the BPS has decreased by 29 GW and the total generation supplied by IBRs has increased by 73 GW. IBRs accounted for 9% of the total resource capacity in 2017 and now accounts for over 15% of total resource capacity as of 2021 on the BPS.

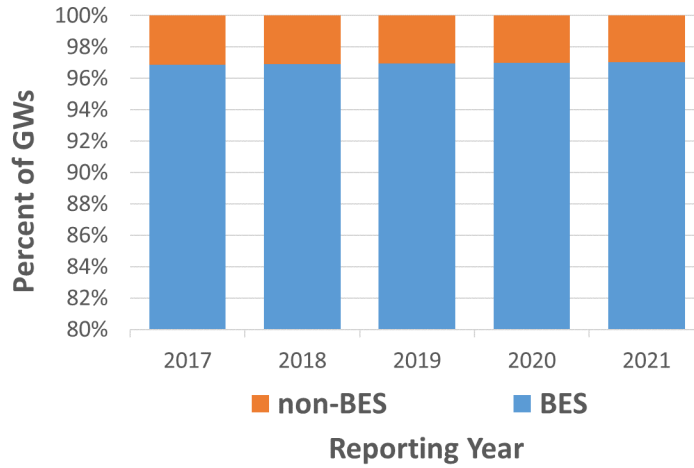


**Figure 1: Total US BPS GWs of Conventional Resources and IBRs**

Breaking down **Figure 1** above into BES and non-BES reveals a significant difference between conventional resources and IBRs. As shown in **Figure 2** below, conventional resources are predominately BES resources with approximately 97% of these resources being classified as BES over the last five years.

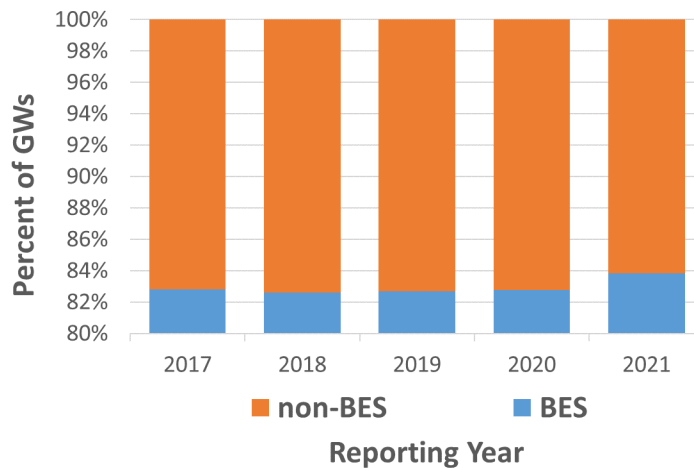
<sup>6</sup> <https://www.naics.com/naics-code-description/?code=22>

<sup>7</sup> Where MW or GW is referenced, it is referring to EIA data.



**Figure 2: Percent Share of BPS Conventional Resources by BES and Non-BES**

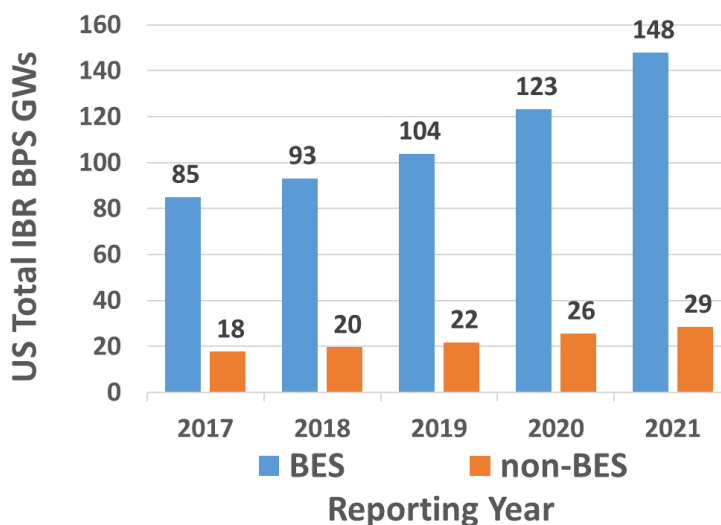
However, as shown in [Figure 3](#), IBRs have a much lower percentage with approximately 84% (2021) of these resources being classified as BES over the same timeframe. This trend is concerning since the number of conventional resources has been gradually declining and the number of IBRs have continued increasing at a significantly lower BES penetration than conventional resources.



**Figure 3: US Percent Share of BPS IBRs by BES and non-BES**

[Figure 4](#) details the BES versus non-BES total aggregate nameplate capacity (in GW) of IBRs. [Figure 4](#) demonstrates that IBRs are steadily increasing at a five-year average rate of 15% for BES resources and 12% for non-BES resources. This rapid change has resulted in a non-BES resource capacity increase of over 60% over this short timeframe to a total capacity of 29 GW in 2021.

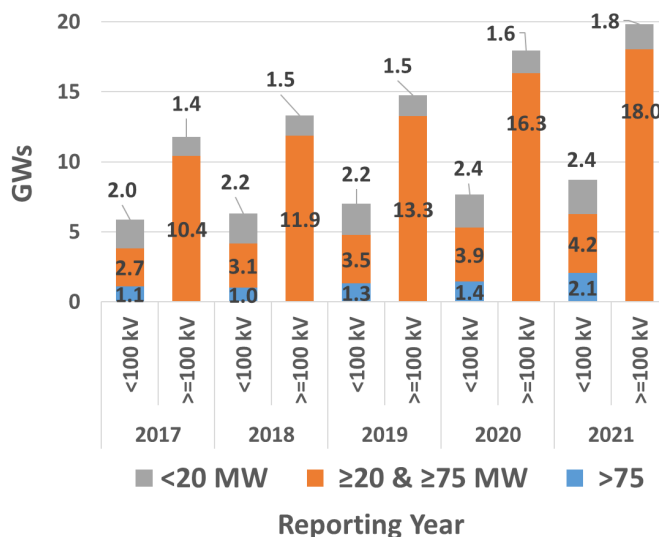




**Figure 4: BPS IBRs GWs by BES and Non-BES**

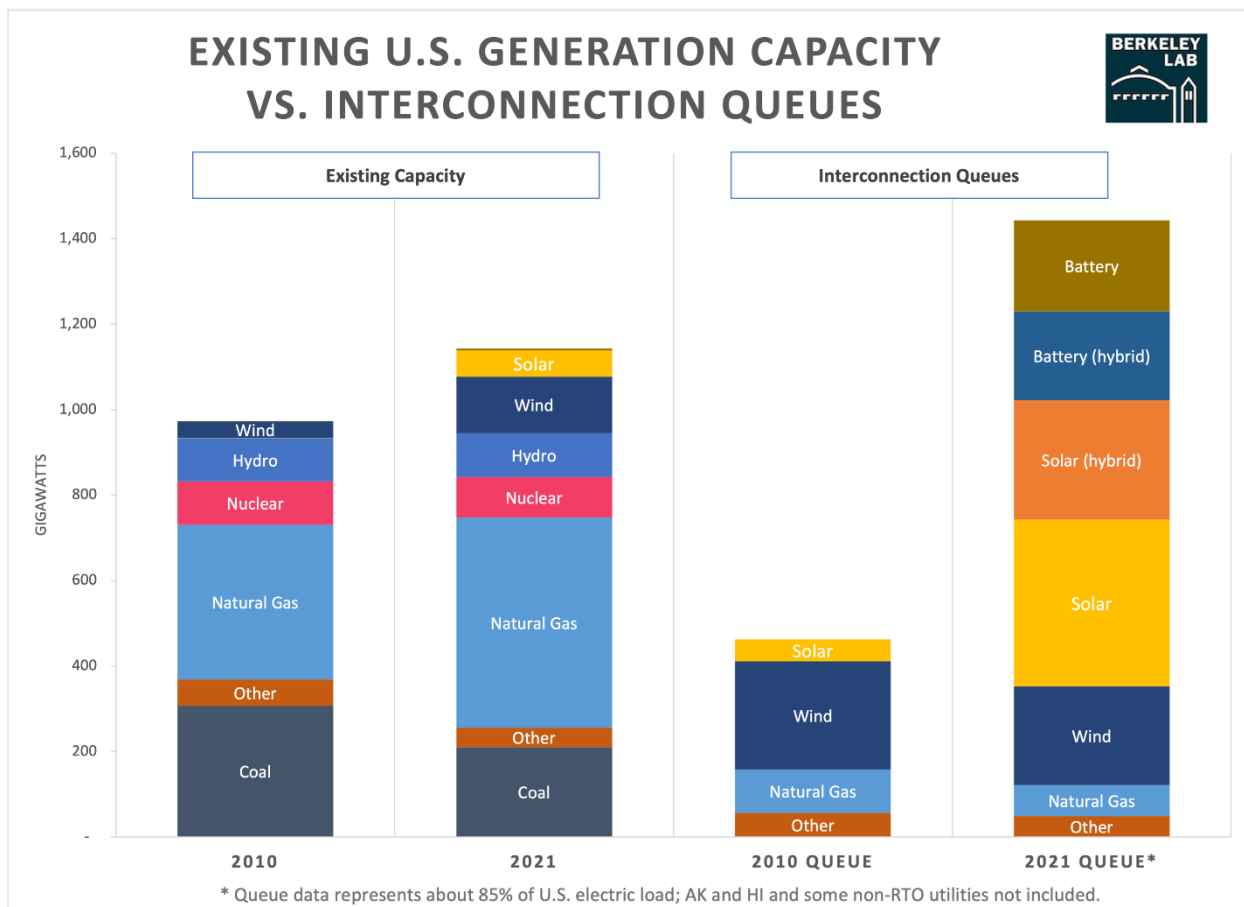
To further understand the characteristics of the non-BES IBRs, the RTTF analyzed the data by individual plant size and interconnection voltage.

**Figure 5** provides refinement of the total non-BES IBR aggregate nameplate capacity to distinguish between plants at an interconnection voltage greater than or equal to 100 kV and less than 100 kV. In 2021, IBRs with an aggregate capacity of greater than or equal to 20 MW, at an interconnected voltage greater than or equal to 100 kV and less than 100 kV, accounted for 24.3 GW (sum of orange and grey bars) of the total 29 GW (see **Figure 4**) of non-BES IBR capacity.



**Figure 5: US Total Non-BES IBRs GWs by Voltage Class and Plant Class (<20 MW, ≥20 to ≤75 MW, and >75 MW)**

The following chart was developed by Lawrence Berkeley National Laboratory, shown in [Figure 6](#), labeled “Existing U.S. Generation Capacity vs. Interconnection Queues.” The key takeaway from this chart is the bar graph on the far right which shows the aggregate total of proposed generation projects contained in the interconnection queues of various organizations across the United States in 2021. The “2021 Queue” bar graph shows over 1,300 GW of IBR capacity which is a substantial increase above the current level of IBR capacity, and exceeds the current total capacity of all BPS generating resources currently in service.



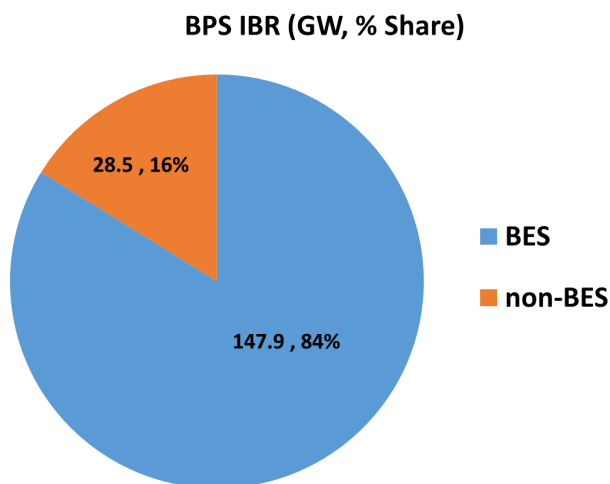
**Figure 6: Interconnection Queues (All fuel types)**

### RTTF Conclusion

The RTTF has observed that the changing resource mix has resulted in a significant shift in generating resources on the BPS from conventional resources to IBRs and that the percentage of IBR capacity (84%) that are classified as BES resources is significantly lower compared to conventional resources (97%).

[Figure 7](#) shows a pie chart of the aggregate nameplate capacity in GW of IBRs in 2021. The blue portion includes the existing BES resources totaling approximately 147.9 GW, or 84% of the total IBRs. The orange portion includes non-BES resources representing approximately 28.5 GW or 16% of the BPS IBRs. Within this smaller piece there are three discrete groupings of IBRs, which include:

- plants with an aggregate capacity of less than or equal to 75 MVA and greater than or equal to 20 MVA and interconnected at a voltage greater than or equal to 100 kV, totaling approximately 18 GW, or 10% of the total,
- plants with an aggregate capacity greater than or equal to 20 MVA and interconnected at a voltage less than 100 kV, totaling approximately 6.3 GW, or 4% of the total, and
- plants with an aggregate capacity of less than 20 MVA and interconnected at any voltage, totaling approximately 4.2 GW, or 2% of the total.



**Figure 7: BPS IBRs in GWs by Percent Share (2021)**

The first two bullets above represent approximately 24.3 GW of IBR capacity from plants of substantial size (i.e.,  $\geq 20$  MW) that is not subject to performance requirements in accordance with NERC Reliability Standards. Furthermore, the rate of increase of IBR capacity over the last five years has been steadily increasing, and is expected to continue based on the amount of IBRs currently identified in the interconnection queues shown in [Figure 6](#).

An additional concern associated with the increase in IBRs is that the available capacity exhibited by these resources during peak load periods is significantly lower than their nameplate capacity. As described in the *NERC 2022 Summer Reliability Assessment*,<sup>8</sup> “Because the electrical output of variable energy resources (e.g., wind, solar) depends on weather conditions, on-peak capacity contributions are less than nameplate capacity.” The assessment shows “Expected Share of Nameplate (%)” for the three Interconnections (i.e., Eastern, ERCOT, and Western) combined to be 19% for wind and 70% for solar PV.

<sup>8</sup> See page 45, NERC 2022 Summer Reliability Assessment:  
[https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC\\_SRA\\_2022.pdf](https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2022.pdf)

Also, as detailed in the NERC report *Multiple Solar PV Disturbances in CAISO, Disturbances between June and August 2021, Joint NERC and WECC Staff Report*, April 2022,<sup>9</sup> many non-BES solar PV facilities had active power reductions of more than 10 MW during these events. As shown in Appendix B: Detailed Review of Affected Facilities, there were a total of 12 plants across the events listed that were impacted (out of 30 total plants, or approximately 40% of the impacted plants) that are non-BES resources and whose capacity is between 20 MW and 75 MW. Also, the NERC report *Odessa Disturbance, Texas Events: May 9, 2021 and June 26, 2021, Joint NERC and Texas RE Staff Report*, September 2021<sup>10</sup> showed that two non-BES solar PV plants and one non-BES wind plant whose capacity is between 20 MW and 75 MW were impacted.

The RTTF has concluded that the changing resource mix, as described above, with large amounts of non-BES IBRs being added to the BPS that have no NERC Reliability Standards obligations, has resulted in a current and increasing gap in reliability of the BPS that must be addressed. This gap is exacerbated when considering reduced nameplate capacity availability due to the weather dependency of these resources. Further, the events as described in the referenced disturbance reports showed numerous non-BES plants that were impacted during these events, which is an indication that future events may continue to see increasing non-BES IBR impacts.

## **RTTF Recommendation**

The RTTF is proposing the following recommendation to address the potential risk to the reliability of the BPS driven by the significant increase of unregistered IBR capacity connecting to the BPS that do not meet the criteria established by Inclusion I4 of the BES definition and therefore the owners of these resources are not subject to adherence with the NERC Reliability Standards. These facilities are connected to the BPS and can impact the reliability of the BES. The RTTF recommends the following:

Creation of a new Functional Registration under Section 500 and Appendices 5A and 5B of the NERC Rules of Procedure (ROP) identified as Generator Owner – Inverter-Based Resource (GO-IBR) to include the owners of the following:<sup>11</sup>

- an IBR whose aggregate total capacity (i.e., gross nameplate rating) is less than or equal to 75 MVA and greater than or equal to 20 MVA and interconnected at a voltage of greater than or equal to 100 kV, and
- an IBR whose aggregate total capacity (i.e., gross nameplate rating) is greater than or equal to 20 MVA and interconnected at a voltage less than 100 kV.

This proposal will require expanding the ‘applicability’ of certain NERC Reliability Standards to include the new GO-IBR functional entity, where needed to reduce risk to the BPS.

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<sup>9</sup> [https://www.nerc.com/pa/rrm/ea/Documents/NERC\\_2021\\_California\\_Solar\\_PV\\_Disturbances\\_Report.pdf](https://www.nerc.com/pa/rrm/ea/Documents/NERC_2021_California_Solar_PV_Disturbances_Report.pdf)

<sup>10</sup> [https://www.nerc.com/pa/rrm/ea/Documents/Odessa\\_Disturbance\\_Report.pdf](https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf)

<sup>11</sup> In accordance the NERC Rules of Procedure (ROP), Section 501.1, “NERC shall establish and maintain the NCR of the Bulk Power System owners, operators, and users that are subject to approved Reliability Standards.” GO-IBR is used for purposes of this White Paper, although another name may be considered in the future.

The applicable group of Reliability Standards would include those focused on the key parameters for BPS reliability – facility interconnection analysis, data for modeling and verification, and protection coordination and resource performance. The standards include, but are not limited to, FAC-002 (facility interconnection), IRO-010 and TOP-003 (Data), MOD-025, -026, -027, and -032 (modeling), and PRC-019 and -024 (protection and performance).

The RTTF recommendation for the creation of the new GO-IBR function and inclusion into the needed NERC Reliability Standards will address the risks presented by the analysis outlined above. It will address the potential reliability gap of unregistered IBRs not meeting BPS interconnection, data, modeling, protection, and performance criteria which can materially impact the reliability of the BPS.<sup>12</sup> This recommendation can be implemented in the most expeditious manner. The focus is on IBRs and will include BESS, solar PV, and wind.<sup>13</sup>

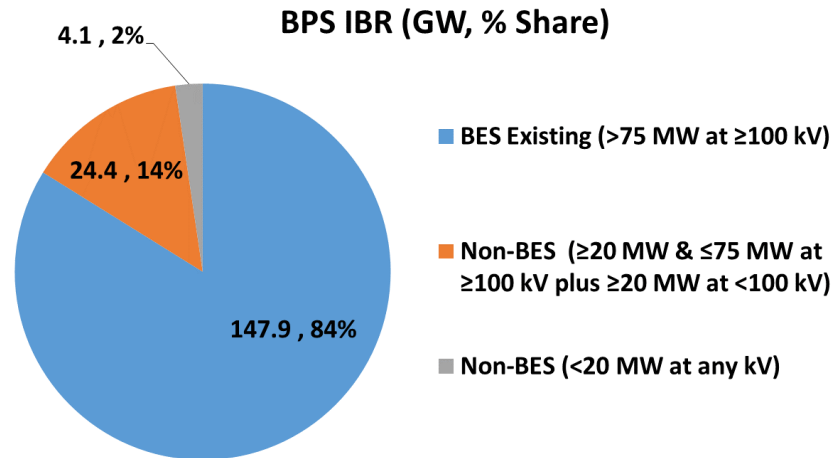
Given the above referenced events, historical data, and the urgent need to ensure IBRs do not exacerbate events, revising the NERC Registry Criteria will provide the timeliest way to close the potential reliability gap. **Figure 8** highlights this first step to specifically register IBRs that are less than or equal to 75 MVA and greater than or equal to 20 MVA at an interconnection voltage greater than or equal to 100 kV and IBRs that are greater than or equal to 20 MVA at an interconnection voltage less than 100 kV will close the reliability gap.

Registering IBR entities (e.g., GO-IBR function) will allow specific performance and risk related standards such as FAC-002 (facility interconnection), IRO-010 and TOP-003 (Data), MOD-025, -026, -027, and -032 (modeling standards), and PRC-019 and -024 (protection and performance) to be modified by adding the new function to the applicability of these NERC Reliability Standards. This approach is estimated to increase awareness and visibility of existing IBRs by approximately 16% bringing the total IBRs subject to the necessary NERC Reliability Standards to 98%, commensurate with conventional resources.

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<sup>12</sup> In accordance with ROP, Appendix 5B, Statement of Compliance Registry Criteria (Revision 7), Statement of Issue, “As the ERO, NERC intends to comprehensively and thoroughly protect the reliability of the grid. To support this goal NERC will include in its Compliance Registry each entity that NERC concludes can materially impact the reliability of the BPS.” Furthermore, as stated in Limitation of responsibilities to a sub-set of Reliability Standards, “NERC may limit the compliance obligations of... a similarly situated class of entities, as warranted based on the particular facts and circumstances, to a sub-set list of Reliability Standards (which may specify Requirements/sub-Requirements).”

<sup>13</sup> “... inverter-based resources are Type 3 and 4 wind turbine generators (WTGs), solar photovoltaic (PV) resources, and battery energy storage systems.” See page ix, NERC Reliability Guideline Power Plant Model Verification for Inverter-Based Resources, September 2018, [https://www.nerc.com/comm/RSTC\\_Reliability\\_Guidelines/PPMV\\_for\\_Inverter-Based\\_Resources.pdf](https://www.nerc.com/comm/RSTC_Reliability_Guidelines/PPMV_for_Inverter-Based_Resources.pdf)



**Figure 8: Recommended BPS IBRs in GWs by Percent Share (2021)**

Errata – Attachment 2

Redline

# Analysis of the Changing Mix of Generating Resources on the BPS

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## Introduction

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<sup>1</sup> The Bulk Power System is defined in the Glossary of Terms Used in NERC Reliability Standards as: (A) facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and (B) electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. (Note that the terms "Bulk-Power System" or "Bulk Power System" shall have the same meaning.)

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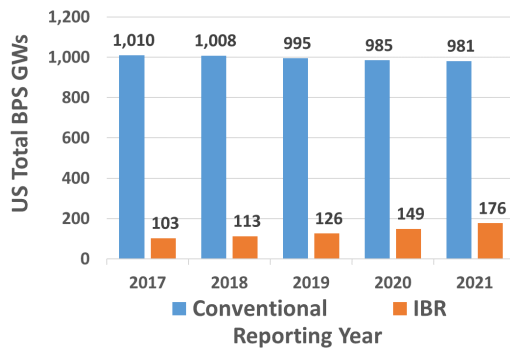
<sup>5</sup> IBR Strategy, at p. 4.



## BPS Resource Trends

The analysis in this white paper is based on publicly available Form 860 information reported to the U.S. Energy Information Administration (EIA). This data was analyzed to identify historical BPS resource capacity trends from individual generation units as well as aggregate plant data up to and including year 2021. The generation data in this study included all resources identified as being part of an electric generation utility under the North American Industry Classification System (NAICS), Sector 22, Utilities.<sup>6</sup> Industrial and commercial generation were not considered in the analysis since these resources are typically prime power for industrial sites or backup generation to commercial businesses and are not generally considered a BPS resource. Plants classified as utility including independent power producers, with an aggregate nameplate capacity greater than or equal to 1 MW and connected at a point-of-interconnection (POI) voltage greater than or equal to 40 kV, were included in the population of study data.<sup>7</sup> The data was divided further into the classification of generation units and plants that meet the NERC definition of BES as defined by the Glossary of Terms used in NERC Reliability Standards.

The primary focus was the most recent five-year period from 2017 to 2021. As shown in **Figure 1**, the BPS is undergoing a significant and rapid change in generating resource mix. **Figure 1** includes the aggregate nameplate capacity in Gigawatts (GW) on the BPS for conventional resources and IBRs for each year from 2017 to 2021. Over this short five-year time frame, the total generation supplied by conventional resources on the BPS has decreased by 29 GW and the total generation supplied by IBRs has increased by 73 GW. IBRs accounted for 9% of the total resource capacity in 2017 and now accounts for over 15% of total resource capacity as of 2021 on the BPS.

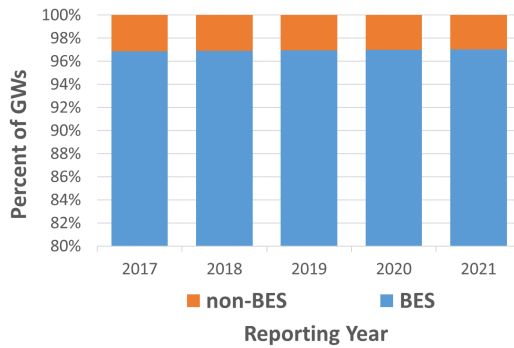


**Figure 1: Total US BPS GWs of Conventional Resources and IBRs**

Breaking down **Figure 1** above into BES and non-BES reveals a significant difference between conventional resources and IBRs. As shown in **Figure 2** below, conventional resources are predominately BES resources with approximately 97% of these resources being classified as BES over the last five years.

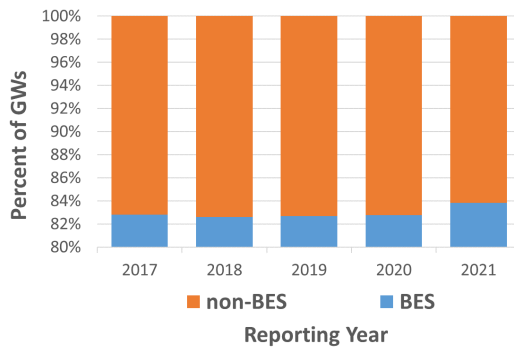
<sup>6</sup> <https://www.naics.com/naics-code-description/?code=22>

<sup>7</sup> Where MW or GW is referenced, it is referring to EIA data.



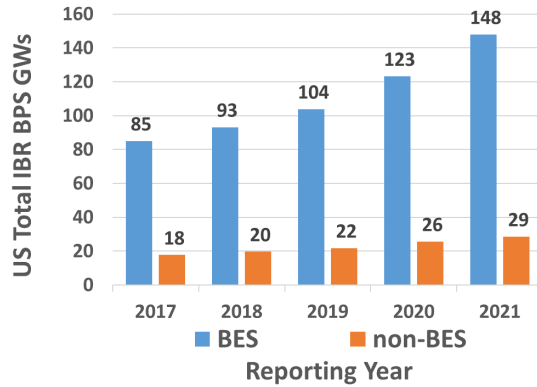
**Figure 2: Percent Share of BPS Conventional Resources by BES and Non-BES**

However, as shown in [Figure 3](#), IBRs have a much lower percentage with approximately 84% (2021) of these resources being classified as BES over the same timeframe. This trend is concerning since the number of conventional resources has been gradually declining and the number of IBRs have continued increasing at a significantly lower BES penetration than conventional resources.



**Figure 3: US Percent Share of BPS IBRs by BES and non-BES**

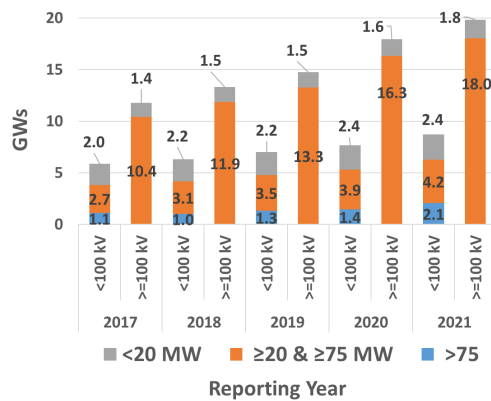
[Figure 4](#) details the BES versus non-BES total aggregate nameplate capacity (in GW) of IBRs. [Figure 4](#) demonstrates that IBRs are steadily increasing at a five-year average rate of 15% for BES resources and 12% for non-BES resources. This rapid change has resulted in a non-BES resource capacity increase of over 60% over this short timeframe to a total capacity of 29 GW in 2021.



**Figure 4: BPS IBRs GWs by BES and Non-BES**

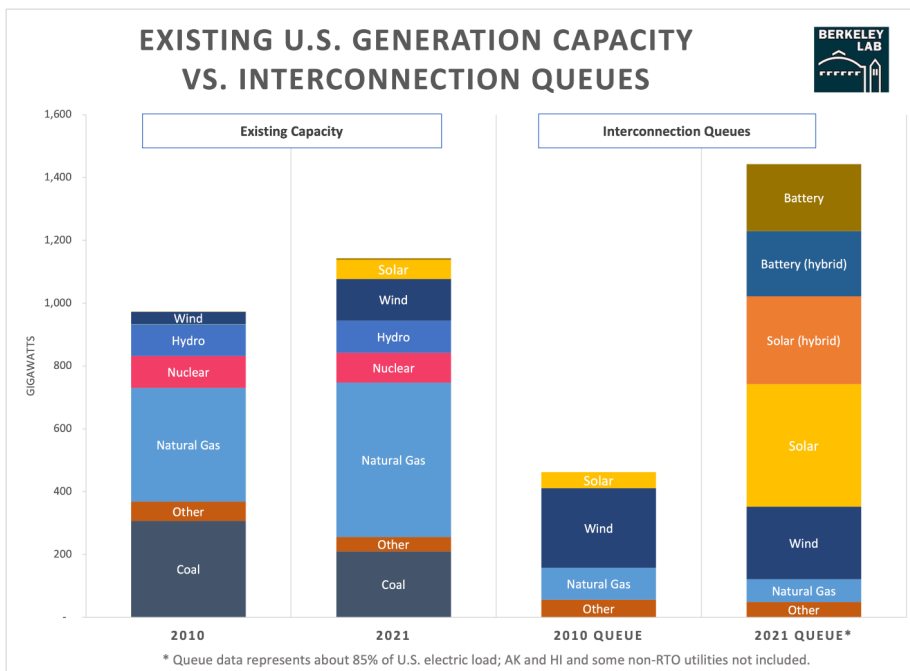
To further understand the characteristics of the non-BES IBRs, the RTTF analyzed the data by individual plant size and interconnection voltage.

Figure 5 provides refinement of the total non-BES IBR aggregate nameplate capacity to distinguish between plants at an interconnection voltage greater than or equal to 100 kV and less than 100 kV. In 2021, IBRs with an aggregate capacity of greater than or equal to 20 MW, at an interconnected voltage greater than or equal to 100 kV and less than 100 kV, accounted for 24.3 GW (sum of orange and grey bars) of the total 29 GW (see Figure 4) of non-BES IBR capacity.



**Figure 5: US Total Non-BES IBRs GWs by Voltage Class and Plant Class (<20 MW, ≥20 to ≤75 MW, and >75 MW)**

The following chart was developed by Lawrence Berkeley National Laboratory, shown in [Figure 6](#), labeled “Existing U.S. Generation Capacity vs. Interconnection Queues.” The key takeaway from this chart is the bar graph on the far right which shows the aggregate total of proposed generation projects contained in the interconnection queues of various organizations across the United States in 2021. The “2021 Queue” bar graph shows over 1,300 GW of IBR capacity which is a substantial increase above the current level of IBR capacity, and exceeds the current total capacity of all BPS generating resources currently in service.



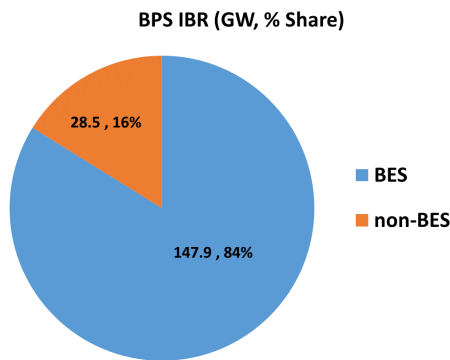
**Figure 6: Interconnection Queues (All fuel types)**

**RTTF Conclusion**

The RTTF has observed that the changing resource mix has resulted in a significant shift in generating resources on the BPS from conventional resources to IBRs and that the percentage of IBR capacity (84%) that are classified as BES resources is significantly lower compared to conventional resources (97%).

[Figure 7](#) shows a pie chart of the aggregate nameplate capacity in GW of IBRs in 2021. The blue portion includes the existing BES resources totaling approximately 147.9 GW, or 84% of the total IBRs. The orange portion includes non-BES resources representing approximately 28.5 GW or 16% of the BPS IBRs. Within this smaller piece there are three discrete groupings of IBRs, which include:

- plants with an aggregate capacity of less than or equal to 75 MVA and greater than or equal to 20 MVA and interconnected at a voltage greater than or equal to 100 kV, totaling approximately 18 GW, or 10% of the total,
- plants with an aggregate capacity greater than or equal to 20 MVA and interconnected at a voltage less than 100 kV, totaling approximately 6.3 GW, or 4% of the total, and
- plants with an aggregate capacity of less than 20 MVA and interconnected at any voltage, totaling approximately 4.2 GW, or 2% of the total.



**Figure 7: BPS IBRs in GWs by Percent Share (2021)**

The first two bullets above represent approximately 24.3 GW of IBR capacity from plants of substantial size (i.e.,  $\geq 20$  MW) that is not subject to performance requirements in accordance with NERC Reliability Standards. Furthermore, the rate of increase of IBR capacity over the last five years has been steadily increasing, and is expected to continue based on the amount of IBRs currently identified in the interconnection queues shown in [Figure 6](#).

An additional concern associated with the increase in IBRs is that the available capacity exhibited by these resources during peak load periods is significantly lower than their nameplate capacity. As described in the *NERC 2022 Summer Reliability Assessment*,<sup>8</sup> “Because the electrical output of variable energy resources (e.g., wind, solar) depends on weather conditions, on-peak capacity contributions are less than nameplate capacity.” The assessment shows “Expected Share of Nameplate (%)” for the three Interconnections (i.e., Eastern, ERCOT, and Western) combined to be 19% for wind and 70% for solar PV.

<sup>8</sup> See page 45, NERC 2022 Summer Reliability Assessment:  
[https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC\\_SRA\\_2022.pdf](https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2022.pdf)

Also, as detailed in the NERC report *Multiple Solar PV Disturbances in CAISO, Disturbances between June and August 2021, Joint NERC and WECC Staff Report*, April 2022,<sup>9</sup> many non-BES solar PV facilities had active power reductions of more than 10 MW during these events. As shown in Appendix B: Detailed Review of Affected Facilities, there were a total of 12 plants across the events listed that were impacted (out of 30 total plants, or approximately 40% of the impacted plants) that are non-BES resources and whose capacity is between 20 MW and 75 MW. Also, the NERC report *Odessa Disturbance, Texas Events: May 9, 2021 and June 26, 2021, Joint NERC and Texas RE Staff Report*, September 2021<sup>10</sup> showed that two non-BES solar PV plants and one non-BES wind plant whose capacity is between 20 MW and 75 MW were impacted.

The RTTF has concluded that the changing resource mix, as described above, with large amounts of non-BES IBRs being added to the BPS that have no NERC Reliability Standards obligations, has resulted in a current and increasing gap in reliability of the BPS that must be addressed. This gap is exacerbated when considering reduced nameplate capacity availability due to the weather dependency of these resources. Further, the events as described in the referenced disturbance reports showed numerous non-BES plants that were impacted during these events, which is an indication that future events may continue to see increasing non-BES IBR impacts.

### **RTTF Recommendation**

The RTTF is proposing the following recommendation to address the potential risk to the reliability of the BPS driven by the significant increase of unregistered IBR capacity connecting to the BPS that do not meet the criteria established by Inclusion I4 of the BES definition and therefore the owners of these resources are not subject to adherence with the NERC Reliability Standards. These facilities are connected to the BPS and can impact the reliability of the BES. The RTTF recommends the following:

Creation of a new Functional Registration under Section 500 and Appendices 5A and 5B of the NERC Rules of Procedure (ROP) identified as Generator Owner – Inverter-Based Resource (GO-IBR) to include the owners of the following:<sup>11</sup>

- an IBR whose aggregate total capacity (i.e., gross nameplate rating) is less than or equal to 75 MVA and greater than or equal to 20 MVA and interconnected at a voltage of greater than or equal to 100 kV, and
- an IBR whose aggregate total capacity (i.e., gross nameplate rating) is greater than or equal to 20 MVA and interconnected at a voltage less than 100 kV.

This proposal will require expanding the ‘applicability’ of certain NERC Reliability Standards to include the new GO-IBR functional entity, where needed to reduce risk to the BPS.

<sup>9</sup> [https://www.nerc.com/pa/rrm/ea/Documents/NERC\\_2021\\_California\\_Solar\\_PV\\_Disturbances\\_Report.pdf](https://www.nerc.com/pa/rrm/ea/Documents/NERC_2021_California_Solar_PV_Disturbances_Report.pdf)

<sup>10</sup> [https://www.nerc.com/pa/rrm/ea/Documents/Odessa\\_Disturbance\\_Report.pdf](https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf)

<sup>11</sup> In accordance the NERC Rules of Procedure (ROP), Section 501.1, “NERC shall establish and maintain the NCR of the Bulk Power System owners, operators, and users that are subject to approved Reliability Standards.” GO-IBR is used for purposes of this White Paper, although another name may be considered in the future.

The applicable group of Reliability Standards would include those focused on the key parameters for BPS reliability – facility interconnection analysis, data for modeling and verification, and protection coordination and resource performance. The standards include, but are not limited to, FAC-002 (facility interconnection), IRO-010 and TOP-003 (Data), MOD-025, -026, -027, and -032 (modeling), and PRC-019 and -024 (protection and performance).

The RTTF recommendation for the creation of the new GO-IBR function and inclusion into the needed NERC Reliability Standards will address the risks presented by the analysis outlined above. It will address the potential reliability gap of unregistered IBRs not meeting BPS interconnection, data, modeling, protection, and performance criteria which can materially impact the reliability of the BPS.<sup>12</sup> This recommendation can be implemented in the most expeditious manner. ~~Since the focus is on all IBRs and it would will include specific IBRs (i.e., BESS, solar PV, and power electronic driven wind) turbine generators or WTGs (e.g., Type III and IV), as well as certain types of wind resources that are not considered IBRs.~~<sup>13</sup>

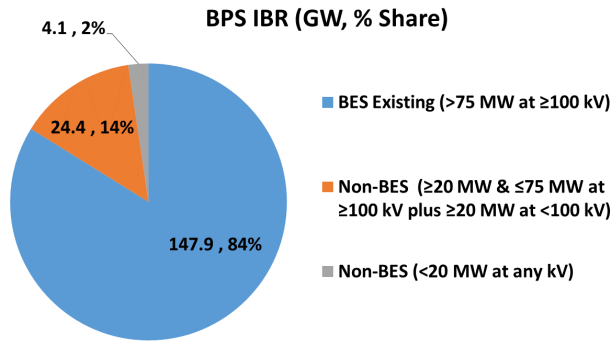
Given the above referenced events, historical data, and the urgent need to ensure IBRs do not exacerbate events, revising the NERC Registry Criteria will provide the timeliest way to close the potential reliability gap. **Figure 8** highlights this first step to specifically register IBRs that are less than or equal to 75 MVA and greater than or equal to 20 MVA at an interconnection voltage greater than or equal to 100 kV and IBRs that are greater than or equal to 20 MVA at an interconnection voltage less than 100 kV will close the reliability gap.

Registering IBR entities (e.g., GO-IBR function) will allow specific performance and risk related standards such as FAC-002 (facility interconnection), IRO-010 and TOP-003 (Data), MOD-025, -026, -027, and -032 (modeling standards), and PRC-019 and -024 (protection and performance) to be modified by adding the new function to the applicability of these NERC Reliability Standards. This approach is estimated to increase awareness and visibility of existing IBRs by approximately 16% bringing the total IBRs subject to the necessary NERC Reliability Standards to 98%, commensurate with conventional resources.

<sup>12</sup> In accordance with ROP, Appendix 5B, Statement of Compliance Registry Criteria (Revision 7), Statement of Issue, “As the ERO, NERC intends to comprehensively and thoroughly protect the reliability of the grid. To support this goal NERC will include in its Compliance Registry each entity that NERC concludes can materially impact the reliability of the BPS.” Furthermore, as stated in Limitation of responsibilities to a sub-set of Reliability Standards, “NERC may limit the compliance obligations of... a similarly situated class of entities, as warranted based on the particular facts and circumstances, to a sub-set list of Reliability Standards (which may specify Requirements/sub-Requirements).”

<sup>13</sup> “... inverter-based resources are Type 3 and 4 wind turbine generators (WTGs), solar photovoltaic (PV) resources, and battery energy storage systems.” See page ix, NERC Reliability Guideline Power Plant Model Verification for Inverter-Based Resources, September 2018, [https://www.nerc.com/comm/RSTC\\_Reliability\\_Guidelines/PPMV\\_for\\_Inverter-Based\\_Resources.pdf](https://www.nerc.com/comm/RSTC_Reliability_Guidelines/PPMV_for_Inverter-Based_Resources.pdf)

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**Figure 8: Recommended BPS IBRs in GWs by Percent Share (2021)**