NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2025 State of Reliability

Assessment Overview of 2024 Bulk Power System Performance

June 2025

[2025 SOR Infographic]

[2025 SOR Technical Assessment]

[2025 SOR Video]

RELIABILITY | RESILIENCE | SECURITY

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Preface

Electricity is a key component of the fabric of modern society and the Electric Reliability Organization (ERO) Enterprise serves to strengthen that fabric. The vision for the ERO Enterprise, which is comprised of NERC and the six Regional Entities, is a highly reliable, resilient, and secure North American bulk power system (BPS). Our mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Reliability | Resilience | Security
Because nearly 400 million citizens in North America are counting on us

The North American BPS is made up of six Regional Entities as shown on the map and in the corresponding table below. The multicolored area denotes overlap as some load-serving entities participate in one Regional Entity while associated Transmission Owners/Operators participate in another.

MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
Texas RE	Texas Reliability Entity
WECC	WECC

About This Overview

This year's *State of Reliability* (*SOR*) is comprised of two publications: this *2025 SOR Overview*, which is a high-level summary of the most important topics impacting the BPS and how they are being addressed, and the *2025 SOR Technical Assessment*,[1] which provides NERC's comprehensive annual analytical review of BPS reliability for the 2024 calendar year. The analysis fulfills a key role in NERC's mission by providing an unbiased, data-driven look at BPS reliability, identifying ongoing challenges, and informing future-looking assessments. This overview seeks to inform regulators, policymakers, and industry leaders of the most significant reliability risks facing the BPS and describe the actions that the ERO Enterprise has taken, and will take, to address them.

Development Process

ERO staff developed this overview and the corresponding *2025 SOR Technical Assessment* with support from the Performance Analysis Subcommittee (PAS). Both documents draw conclusions from an established set of reliability indicators and mandatory information reported by industry to the Transmission Availability Data System (TADS), the Generating Availability Data System (GADS), the Misoperation Information Data Analysis System (MIDAS), voluntary reporting into the Event Analysis Management System (TEAMS), Bulk Power System Awareness monitoring and processes, and the Institute of Electrical and Electronics Engineers (IEEE) Distribution Reliability Working Group.

Considerations

- Data in the *SOR* represents the performance for the January–December 2024 operating year unless otherwise noted.
- Analysis in this report is based on data from 2020–2024 that was available in Spring 2025 and provides a basis to evaluate 2024 performance relative to performance from the last five years. All dates and times shown are in Coordinated Universal Time (UTC).
- The *SOR* is a review of industry-wide trends—not a review of the performance of individual entities.
- When analysis is presented by Interconnection, the Québec Interconnection is combined with the Eastern Interconnection unless specific analysis for the Québec Interconnection is shown.

[1] NERC SOR 2025 Technical Assessment

Executive Summary

NERC's 2025 *SOR* provides an in-depth analysis of the BPS, identifies system performance trends and emerging reliability risks, and reports on the relative health of the interconnected system. The BPS remains highly reliable and resilient, and underlying key performance metrics (e.g., frequency response and misoperation rates) continue to improve or remain stable. **Table 1** provides an overview of key performance measures of the BPS that compare 2024 performance to the previous four years.[2]

Severe weather remained responsible for the most severe outages in 2024, with two significant winter storms and five major hurricanes that made landfall. NERC saw an improvement in performance during the winter events, with no operator-initiated load shed, in part due to industry's efforts to improve generator performance during extreme cold weather following NERC and Federal Energy Regulatory Commission (FERC) recommendations and regulatory updates. Industry demonstrated the results of grid hardening, ever-improving coordination, and mutual aid agreements during hurricanes, resulting in rapid restoration of the Bulk Electric System (BES), although significant distribution outages remained.[3]

A significant near-term reliability challenge facing the ERO is the size and speed at which large data centers, typically developed to support the computing needs for AI and cryptocurrency mining, are expanding across the country. Data centers can be developed faster than the generation and transmission infrastructure needed in the area to support them, resulting in lower system stability. Additionally, the voltage sensitivity and rapidly changing, often unpredictable, power usage of these facilities creates new operating challenges. As such, more accurate models of the operational characteristics of these impactful loads are essential to reliability to prevent instability caused by these large changes in electricity demand.

Improvements in frequency response are being observed in areas of the country that have high concentrations of battery energy storage systems (BESS) and incentives in place to encourage or require participation.

Some inverter-based resources (IBR) continue to unexpectedly reduce output following disturbances that generators have historically been expected to ride through. These sudden, often widespread, reductions can exacerbate instability on the system following these disturbances. NERC, FERC, and industry are in the process of addressing these known issues through various reliability alerts, standards, and other regulatory means.

Each of these topics is covered in more detail in the sections that follow this summary.

[2] Reliability metrics

[3] Distribution consists primarily of equipment below 100 kV, acting to get power from the BES to customers. This equipment is not in NERC's regulatory jurisdiction.

Table 1: Reliability Indicators			
Improving	**Stable**	**Monitor**	**Actionable**
Frequency Response: Texas and Western Interconnections	**Transmission-Related Events Resulting in Loss of Load:** Supported by Event Analysis Data	**Winter Reserve Margin**[4]	**Transmission Outages Caused by Human Error:** Transformers[5]
Inertia and Rate-of-Change-of-Frequency: Texas Interconnection	**Frequency Response:** Eastern and Québec Interconnections	**Inertia and Rate-of-Change-of-Frequency:** Québec Interconnection	
Interconnection Reliability Operating Limit (IROL) Exceedance	**Inertia and Rate-of-Change-of-Frequency:** Eastern and Western Interconnections	**Energy Emergency Alerts**	
Protection System Misoperations Rate	**Transmission Outages Caused by Failed Protection System Equipment:** Transformers	**Transmission Outages Caused by Failed AC Substation Equipment:** Transformers	
Transmission Outages Caused by Failed Protection System Equipment: AC Circuits	**Transmission Outages Caused by Human Error:** AC Circuits	**Transmission Outage Severity**	
	Automatic AC Transmission Outages Caused by Failed AC Substation Equipment: AC Circuits		
	Transmission Outages Caused by Failed AC Circuit Equipment		
	Transmission Element Availability: AC Circuits and Transformers		
	Transmission Physical Security Metric		

[4] Driven by NPCC-Maritimes.

[5] The number of human error events has remained stable; however, some of the events involved multiple transformers, which drove this indicator's actionable status.

Severe Weather Responsible for the Most Severe Outages in 2024

In 2024, NERC reliability metrics indicated that the BPS remained reliable but challenged by adverse weather conditions and transitions in resource mix and usage. Because of industry's continuous adaptation to these transitions, most related concerns were able to be mitigated before having catastrophic results. Despite the increasing frequency and severity of weather events, efforts to combat the more familiar challenges posed by weather have led to consistently reliable performance except in the most extreme circumstances.

Based on the severity risk index (SRI) (see **Figure 1**), transmission and generation measures, and external sources,[6] severe weather continued to represent the greatest threat to the BPS. In 2024, 27 events occurred in the United States[7] and 3 in Canada[8] with losses exceeding $1 billion within the BPS footprint; 10 of these events had notable impacts on the BES, based on the SRI.[9]

Severity Risk Index

The **SRI** is a quantitative measure that assesses the relative severity of the combined impact of load, generation, and transmission loss on the BPS daily. It offers a simple snapshot of the performance of the BPS, allowing NERC to assess year-on-year reliability trends.

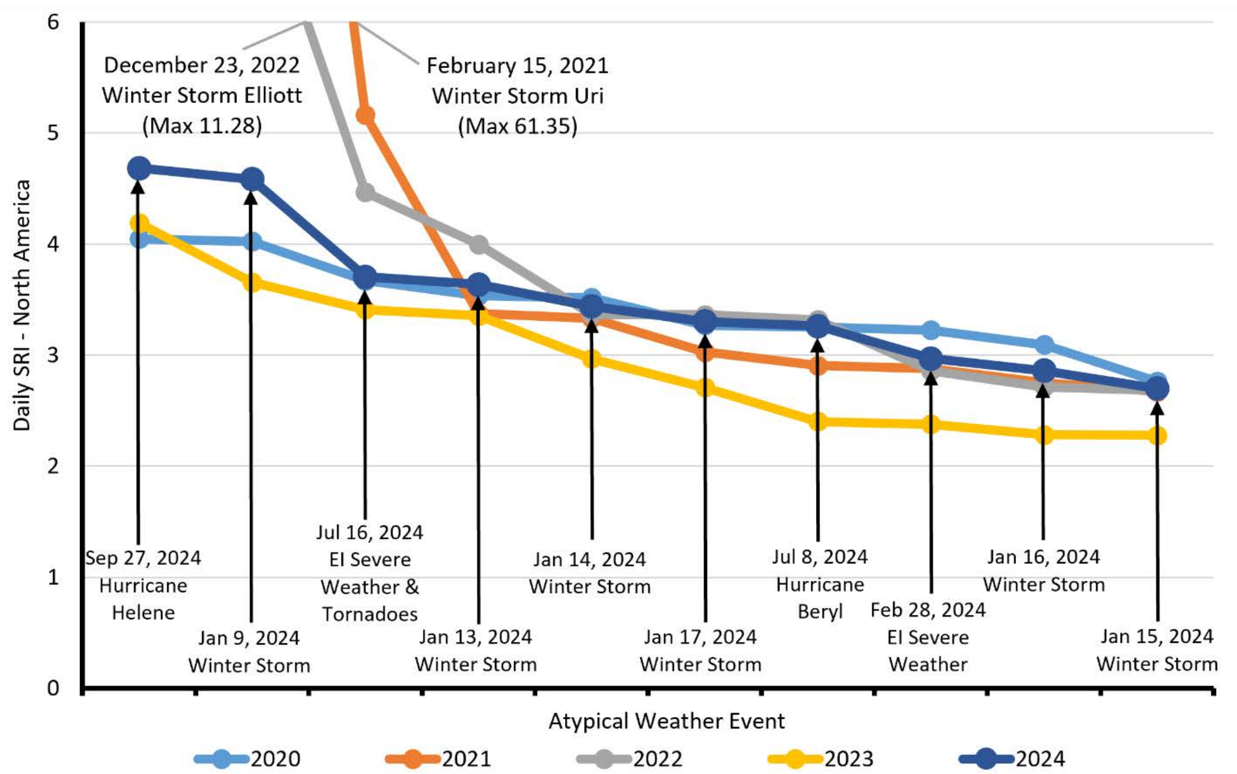

Figure 1: Top Annual Daily SRI Days Sorted Descending

The most severe single day was September 27, after Hurricane Helene made landfall as a Category 4 storm causing catastrophic damage that resulted in more than 4.7 million customers losing power.[10] The storm caused

[6] Weather-related Power Outages Rising | Climate Central

[7] Billion-Dollar Weather and Climate Disasters | National Centers for Environmental Information (NCEI)

[8] Canada Insured Catastrophic Losses in 2024 | Insurance Beau of Canada (IBC)

[9] Notability is determined based on comparison to seasonal control limits described in Chapter 2 of the SOR Technical Document. Days include all those in **Figure 1**, except January 9. Additional days include: April 2–4 (tornados and severe weather), April 9 (severe weather), May 16 (southern derecho), and May 20 and 22 (severe storm).

[10] SERC - Hurricanes Helene and Milton Impact

approximately 431 transmission element outages, the highest recorded for a single event as well as extensive, ongoing damage to the distribution system. Functional transmission restoration[11] was achieved 7.6 days after the first outage, significantly faster than the 15-day average of previous years' Category 4 hurricanes (see **Figure 2**) and 9-day average of all hurricanes in the past five years. Load loss attributed to transmission equipment outages was in line with previous Category 3 and 4 hurricanes.

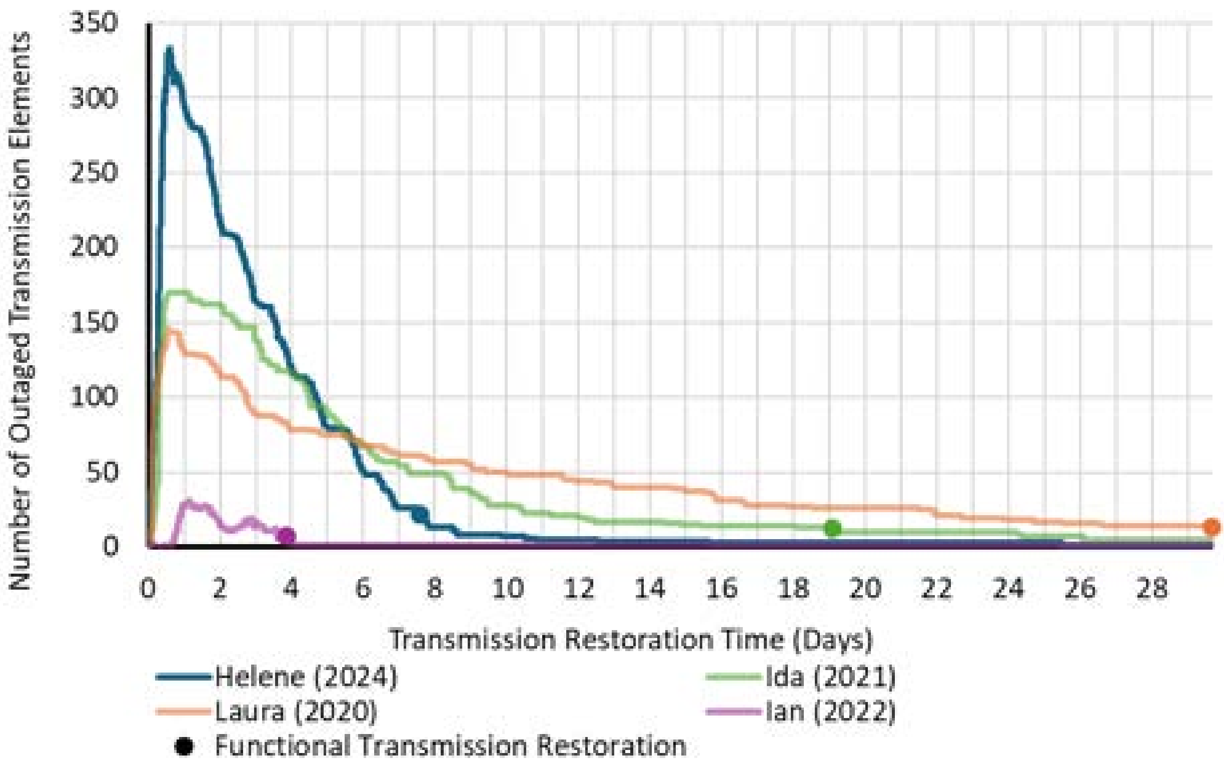

Figure 2: Category 4 Hurricane Transmission Restorations

Also of note were winter storms Gerri and Heather, which traveled back-to-back from the Northwest to the Southeast. While no single day's severity during these storms was as severe as Hurricane Helene, the duration of their impact caused an accumulation of generation outages that left the BPS in a higher risk state than normal even though fewer customers lost power. Further details are provided in the section titled, **2024 Data Suggests that Generator Performance is Improving during Winter Storms**.

[11] Functional transmission restoration: Functionality was restored to the BPS. It is important to recognize that end-use customers may remain without power following transmission restoration due to other factors.

Although severe storm events remained the largest events impacting the BPS, they did not cause any operator-initiated load shed.[12] The only instance of operator-initiated load shed in 2024 was the result of a failed dispatch following an unplanned generator outage in Wisconsin. Load was restored in half an hour, representing approximately 0.005% of the year (see **Table 2**).

Lastly, there were no physical security outages on conventional generation, a stable number of physical security transmission outages, and no outages due to cyber security reported on BES equipment in 2024.

Table 2: Hours with Operator-Initiated Firm Load Shed (Hours/Year)

Year	Event	Event Hours	Total Annual Hours
2020	California Heat Wave	7.4	22.4
	California Wildfires	4.1	
	Hurricane Laura	10.9	
2021	Winter Storm Uri	70.5	70.5
2022	June Heat Wave	21.0	56.5
	Winter Storm Elliott	35.5	
2023	N/A	0.0	0.0
2024	WI: Generator Trip, Subsequent Failure of Dispatched Units	0.4	0.4

Related Actions

Recommendations

- NERC recommends that industry and state legislatures continue to implement grid-hardening efforts as geographically and economically appropriate.
- NERC recommends that industry continue to leverage mutual aid agreements and coordination process improvements to maintain exceptional restoration times.

ERO Existing and Ongoing Efforts

- The ERO Enterprise continues to do the following:
  - Monitor BES performance during adverse weather conditions
  - Further analyze notable trends and then communicate them with industry and legislators
  - Issue lessons learned,[13] reliability guidelines,[14] or standards[15] as necessary
  - Collaborate with industry subject matter experts to identify new and relevant methods to measure BES reliability

[12] Operator-initiated load shed is when customers' power is intentionally disconnected to prevent a larger-scale blackout from occurring. Frequent or major operator-initiated load shed can be indicative of an unreliable BPS for a number of reasons, such as: lack of available generation or transmission capacity, poor operator practices, or a lack of voltage or frequency stability.

[13] Lessons Learned

[14] Reliability Guidelines, Security Guidelines, Technical Reference Documents, and White Papers

[15] Reliability Standards

2024 Data Suggests that Generator Performance is Improving during Winter Storms

Over the past decade, many of the largest reliability events recorded by NERC have been due to severe winter storms that resulted in extensive generator outages and derates. In extreme events, such as the Texas-South Central United States event in February 2021,[16] significant operator-initiated firm load shedding has been required to maintain reliability in the area (see **Table 3**).

Table 3: Winter Storm Generation Outages[17]

Winter Storm Dates	Unique Units That Experienced Outages or Derates (U1, SF, D1)	Cumulative Megawatts (MW) Net Maximum Capacity Lost[18]	Cumulative MW Hours (MWhrs) of Potential Generation Lost	Average Outage Duration per Unit (Hours)	Maximum Units Lost in a Single Day	Operator-Initiated Firm Load Shed (MW)	Approximate Area of Storm (Sq. Miles)	Degrees Fahrenheit Below Normal
Jan 6–8, 2014[19]	1,435	184,124	13,969,932	81	746	<300	1,923,000[21]	20–30[21]
Jan 15–19, 2018[20]	793	118,765	13,201,903	131	256	0	418,000[21]	12–28[21]
Feb 8–20, 2021[12]	1,656	259,088	113,382,224	554	502	23,418	869,600[21]	40–50[21]
Dec 21–26, 2022[21]	1,633	233,277	59,231,859	205	666	5,400	1,517,000[21]	20–30[21]
Jan 10–17, 2024[22]	1,182	169,682	35,555,786	263	305	0	1,396,553[23]	20–35[22]

Due to their outsized impacts on reliability, NERC has always reviewed the largest events to assess causes, share lessons learned, and initiate corrective actions to better prepare for future events. While winter storms can differ dramatically in scope and severity, the January 2024 storms featured weather conditions that were similar enough to those experienced in January 2014 and December 2022 that some comparisons can be made.[24]

Based on the similarities and differences, NERC has determined that there have been improvements in generator performance and system reliability during winter storms. Most importantly, where both prior storms required some amount of operator-initiated load shed, none was required in 2024. In addition, there were significantly fewer generator outages that were more geographically dispersed, indicating that the issues were not as localized as in the past, helping to alleviate potential operator-initiated load shedding. Furthermore, natural gas production losses declined.

[16] The February 2021 Cold Weather Outages in Texas and the South Central United States
[17] All generation data is from conventional GADS as of April 29, 2025.
[18] Limited to the highest single loss per unit over the event duration.
[19] 2014 Polar Vortex Report
[20] The South Central United States Cold Weather Bulk Electric System Event of January 17, 2018
[21] Winter Storm Elliott Report: Inquiry into Bulk-Power System Operations During December 2022
[22] System Performance Review of the January 2024 Arctic Storms
[23] Regional Snowfall Index (RSI) | RSI and Societal Impacts | Historic Storms | National Centers for Environmental Information (NCEI)
[24] While similar, there were some important differences. The 2014 winter storm lasted only three days yet affected a larger geographic area. It also involved a generation resource mix that had more coal and less natural gas. The 2022 winter storm was also shorter in duration and less severe in the range of below-normal temperature. Still, the 2022 winter storm also recorded more freezing precipitation (as measured by the National Oceanic and Atmospheric Administration (NOAA) regional snowfall index (RSI)) and sudden temperature drops.

Related Actions

Recommendations

- Further analysis by NERC and the PAS of the meteorological characteristics of the 2024 event is recommended to support a more thorough comparison with past events. More analysis will also help establish a consistent methodology for future winter weather-related comparative analysis.

ERO Existing and Ongoing Efforts

- Multiple NERC reliability alerts[25, 26, 27] and webinars were issued and hosted.
- Regional Entities performed generator site visits to review cold weather preparedness and freezing protection vulnerabilities and to evaluate both current design thresholds and impacts based on preparedness for the future.
- NERC and FERC issued reports and recommendations for each winter storm.[19, 20, 21, 22, 28]
- The Extreme Cold Weather Preparedness and Operations Standard was issued (EOP-012-2) and is now subject to enforcement.[29, 30]
- NERC intends to continue monitoring to determine any reliability gaps.

[25] Cold Weather Preparations for Extreme Weather Events
[26] Cold Weather Preparations for Extreme Weather Events II
[27] Cold Weather Preparations for Extreme Weather Events III
[28] Reliability Spotlight: Cold Weather Preparedness | Federal Energy Regulatory Commission
[29] EOP-012-2
[30] EOP-012-3 – Pending approval

Large Loads are Creating New Challenges for Reliability

The size and speed at which data centers are being connected to and operated on the BES is creating one of the greatest near-term reliability challenges. Recent events have demonstrated the importance of improving industry's understanding of data center collective behavior during times when the BPS is under stress.

For example, approximately 1,500 MW of data centers disconnected simultaneously and unexpectedly from the BES due to a transmission line fault in 2024.[31] A loss of load of this size is comparable to a large nuclear power plant coming on-line immediately and unexpectedly, creating an imbalance due to too much generation on the system. In this instance, while system voltages and frequency rose rapidly, the overall impact on the BES was limited. ERCOT has also reported experiencing several similar events on a smaller scale (100–400 MW).[32] Improving the ability to model the behavior of data centers when events such as transmission faults occur is key to reliability planning.

Another emerging reliability challenge is positioning resources so that the system can rebalance itself quickly in response to rapidly changing loads caused by the increased use of data centers supporting AI and cryptocurrency-mining facilities. Such rapid changes in load are part of normal operations for these facilities, which raises concerns for balancing, frequency stability, and voltage stability. Current models do not accurately portray these data center loads. Model analysis tools are used when planning to identify things like worst-case scenarios and how to deal with them. Poor models can result in sub-optimal planning and operator practices being implemented. Better models[33] of data center loads are needed to improve planning and preparations for operating with these large loads in the mix.

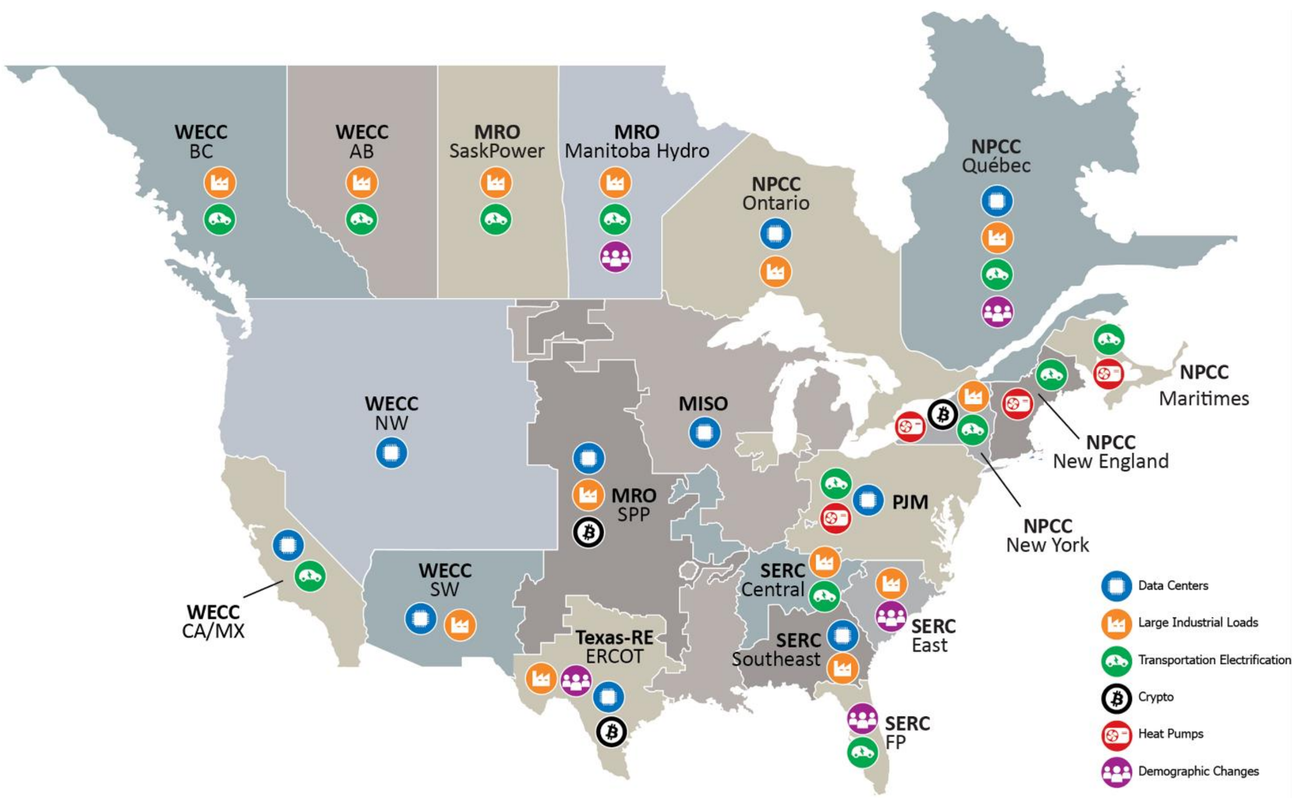

Figure 3: Data Centers Driving Load Growth in the United States[34]

[31] Incident Review – Considering Simultaneous Voltage-Sensitive Load Reductions
[32] https://www.nerc.com/comm/RSTC/LLTF/LLTF_Presentations_December_12_2024.pdf
[33] Modeling tools are used when planning to identify things like worst-case scenarios and how to deal with them. Poor models can result in sub-optimal operator practices being implemented.
[34] NERC *Long-Term Reliability Assessment*

A final challenge is adapting load forecasting, system planning, and interconnection procedures to accommodate the speed with which these large loads can and are being built and the uncertainty that announcements of new data centers create for planners (see **Figure 3**). The size of individual facilities often represents a step-change increase in the load forecast for a geographic area, often within a two-year timeframe. This is in sharp contrast to the more gradual increase in load due to traditional sources of load growth or more traditional large loads, such as industrial loads, which can take several more years to plan and construct. Planning generation and transmission to accommodate such large step-changes in load is made even more complicated by the speculative nature of where and if these new facilities will be built.

Related Actions

Existing and Ongoing Efforts

- NERC initiated the Large Loads Task Force (LLTF) [35] to better understand the reliability impacts of emerging large loads on the BPS[36] and the Load Modeling Working Group (LMWG)[37] to drive Interconnection-wide advancement and the use of dynamic load modeling.
- NERC presented activities and plans to address reliability impacts from large load integration to FERC.[38]
- The LLTF is expected to publish a white paper covering characteristics and risks later this year.
- The frequency response metric will continue to be monitored to measure the response to frequency events during large load tripping events.

Recommendations

- The System Protection and Control Working Group (SPCWG) should assess possible protection system impacts to the BPS from emerging large loads.
- The Energy Assessment Working Group (EAWG) and Probabilistic Assessments Working Group (PAWG) should investigate methods for grid operators and planners to assess the risks potentially posed by emerging large loads to resource adequacy.
- Grid operators and planners should collect data from load developers, owners, and operators to help understand the unique risks associated with each emerging large load connecting to their system.
- Communication and coordination with the Electric Power Research Institute (EPRI), the Energy Systems Integration Group (ESIG), large load industry groups, and the electric industry at large should be continued.
- NERC should continue incident analysis and lessons learned and share findings with industry.

[35] Large Loads Task Force (LLTF)
[36] LLTF Work Plan
[37] Load Modeling Working Group (LMWG)
[38] NERC Seeks to Address Reliability Impacts from Large Load Integration | Federal Energy Regulatory Commission

Initial Evidence Suggests Battery Energy Storage Systems Can Improve Primary Frequency Response

BESS in the Texas and the Western Interconnections are contributing to improvements in frequency control and frequency response.

Primary Frequency Response

The North American BES operates at a nominal frequency of 60 Hz. This is maintained by balancing the amount of generation with the amount of load. In instances where a sudden, unexpected imbalance between these occurs, the system frequency will deviate. If the frequency changes too much, it can damage equipment, cause instability that trips equipment, and eventually cause blackouts. To address this, many generators are equipped with governors that will increase or decrease output in response, restoring the frequency; this is called **primary frequency response** (see Figure 4).

The effectiveness can be most simply evaluated by assessing the low (or high) point of the frequency, known as the **C-Point** or **Nadir**.

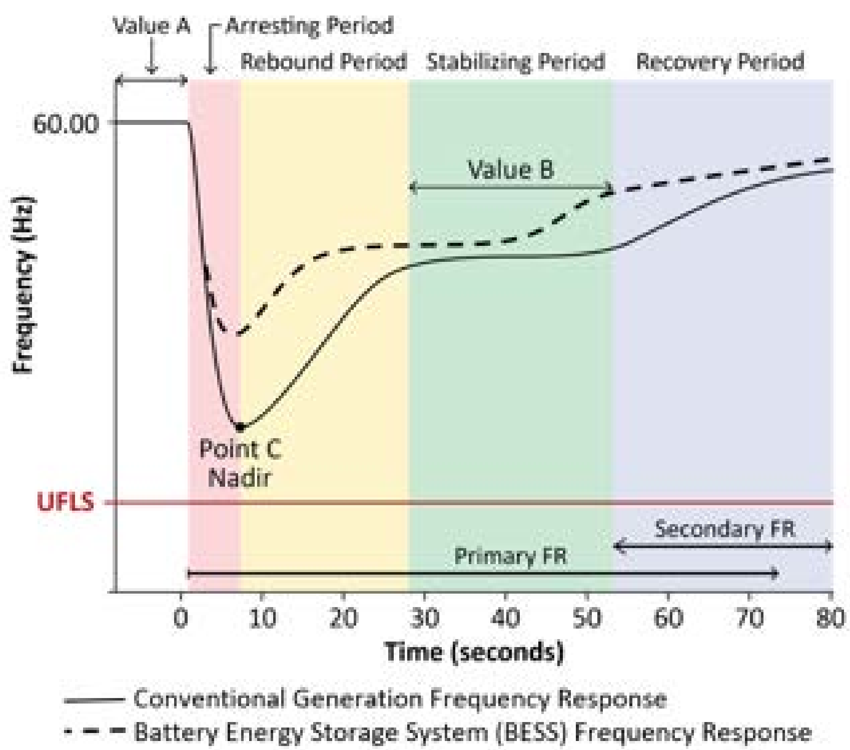

Figure 4: Frequency Response Comparison Example

BESS installations in Texas increased to 10,027 MW in December 2024 from 1,307 MW in January 2022, with significant additions planned (see **Figure 5**), approaching 19,000 MW by the end of 2025. While all industrial battery installations can provide frequency support, in Texas RE, the provision of frequency support (when available) is mandated through Reliability Standard BAL-001-TRE-2 BESS. This requirement combined with the increasing amount of installed capacity, quick response times, and BESS often being in a state of partial charge has positioned these installations as a key part of the Texas Interconnection's frequency response. BESS is an ever-increasing portion of ERCOT's ancillary service market, primarily for frequency regulation services, responsive reserve services,[39] fast frequency response,[40] contingency reserve[41] services, and non-spinning reserves.[42] For example, in 2024, ERCOT experienced several instances where batteries provided up to 100% of the total capacity for frequency regulation services. All of these services act cohesively to ensure that additional generation, also known as reserves, is available to compensate for major generator outages, which also enables rapid frequency recovery.

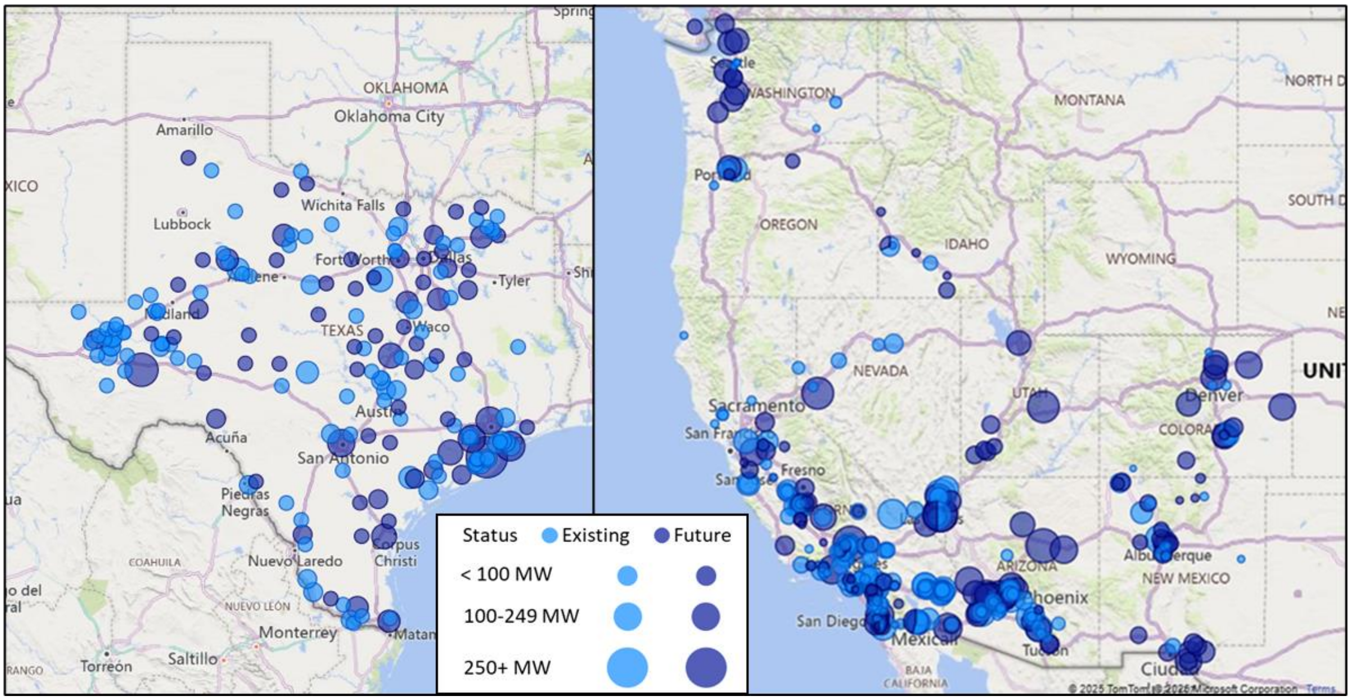

Figure 5: Texas RE and WECC Existing and Planned BESS Installations[43]

There was an upward trend in frequency responsive capacity for the total generation fleet from 2021 to 2024, as more generators had extra capacity to respond to a frequency event. Conversely, over the same period, this extra capacity decreased for conventional generation with the difference primarily being BESS. This has had the additional and positive effect of arresting the frequency nadir faster and at higher levels than were historically seen for the same size MW loss under similar inertia conditions. By arresting the frequency decline at higher levels, the potential for under-frequency load shedding is reduced.

When looking at individual frequency disturbances and analyzing the response by different unit types, BESS have been noted as providing greater than 70% of the overall MW response for individual disturbances. Additionally, a

[39] Ancillary Service: Services necessary to support the transmission system's ability to get energy from resources to loads.
[40] Fast Frequency Response: Full, automatic self-deployment of resources within 30 cycles of a frequency event for at least 15 minutes.
[41] Contingency Reserve: Resources that can be rapidly dispatched to the grid to mitigate sudden loss of resource.
[42] Non-Spinning Reserve: Generating reserve not connected to the system but capable of serving demand within a specified time.
[43] Texas RE BESS map background obtained from TomTom.com

large portion of the BESS resources have a 1% droop setting[44] (compared to a 5% droop for conventional units), which is partially responsible for the excellent governor response from the BESS fleet.

Related Actions

ERO Existing and Ongoing Efforts

- NERC, Texas RE, and WECC will continue monitoring the impacts of greater BESS penetration as inertia on the respective Interconnections decreases.
- NERC, Texas RE, and WECC will continue monitoring the reduced number of measurable frequency events per the criteria set forth by the NERC Resource Subcommittee in its procedures for calculating the frequency response obligations for these Interconnections.

[44] Droop setting: The governor setting that dictates the rate of power change from a generator based upon the amount of frequency change that occurs. A smaller number indicates a larger response to a frequency deviation.

Industry Continues to Address the Reliability Impacts of Inverter-Based Resources

IBRs are wind power plants, solar photovoltaic (PV) devices, and BESS, and these generation sources are rapidly growing throughout the North American BPS. In 2024, 45,037 MW of new IBR capacity became operational on the BPS.

As these resources expand, coordinated failures in response to modest system disturbances continue to be observed with four exceeding 500 MW reported to NERC's Event Analysis team in 2024 for a total of 16 since 2020. These events have identified that, during normally occurring faults on the power system (e.g., generator trip, loss of a transmission line), IBRs automatically cease their output and stop injecting power into the system. Generally, within several minutes, they resume injecting power into the system. Both the sudden drop and equally sudden resumption of IBR output pose challenges for reliability.

NERC's Engineering and Security Integration and Situation Awareness teams have analyzed 10 large-scale disturbances since 2016. In total, the 10 disturbances involved nearly 15,000 MW in unexpected reductions in output. Moreover, this trend is increasing with approximately 10,000 MW of these reductions taking place between 2020 and 2024.[45] The analysis also identified that poor modeling and study practices did not accurately reflect the poor performance.

As a result, industry remains focused on improving the ride-through capability of IBRs and more accurate modeling of the behavior of IBRs during grid disturbances.[46]

The ability of generating units and other grid-connected devices to stay connected and synchronized with the grid during and after such voltage or frequency disturbances is known as ride-through capability. Ride-through capability is essential for preventing cascading outages and maintaining the overall stability of the power grid.

The IBR Mitigation Strategy outlines NERC's approach for mitigating the IBR reliability risks.[47] The strategy outlines NERC's recommendations, created in collaboration with industry and regulatory authorities, to improve interconnection processes, develop new reliability guidelines and standards, and implement new registration requirements for IBRs. These and related activities are summarized below.

Related Actions

Existing and Ongoing Efforts

Regulatory Activities

- FERC order in Docket RD22-4,[48] Registration of Inverter-Based Resources.
- FERC Notice of Proposed Rulemaking issued November 17, 2022,[49] to address concerns regarding reliability impacts on IBRs.
- FERC Order 2023[50] required interconnection asynchronous generating facility customers to do the following:

[45] Links to individual disturbance events are available in the NERC Quick Reference Guide: Inverter-Based Resource Activities
[46] Findings from Inverter-Based Resource Model Quality Deficiencies Alert
[47] Inverter-Based Resource Strategy
[48] FERC Docket RD22-4-000 (Docket No. RM22-12-000), Registration of Inverter-Based Resources, November 17, 2022.
[49] Notice of Proposed Rulemaking re: Reliability Standards to Address Inverter-Based Resources under RM22-12
[50] FERC Order No. 2023, Improvements to Generator Interconnection Procedures and Agreements, July 28, 2023.

- Provide models needed for accurate interconnection studies
- Maintain power production at pre-disturbance levels
- Provide dynamic reactive power to support system voltage during transmission system disturbances

- FERC Order 901[51] directed NERC to develop Reliability Standards that address reliability gaps related to IBRs.
  - IBR facilities are required to provide ride-through capability consistent with standards and guidelines applied to other generating facilities in the Balancing Authority area.

Reliability Standards

- Reliability Standard[52] modifications are in progress for PRC-024, MOD-025, MOD-026, MOD-027, FAC-001, FAC-002, PRC-002, PRC-019, and EOP-004.

Reliability Alerts and Guidelines

- March 14, 2023, NERC Level 2 Alert on IBR performance issues[53]
- March 2023 NERC Reliability Guideline: *Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources*[54]
- June 2023 NERC Reliability Guideline: *Performance, Modeling, and Simulation of BPS – Connected Battery Energy Storage Systems and Hybrid Power Plants*[55]
- June 4, 2024, NERC Level 2 Alert on IBR modeling issues[56]
- May 20, 2025, NERC Level 3 Alert on Essential Actions to Industry for Inverter-Based Resource Performance and Modelling[57]

Other NERC and Industry Activities

- 2025: IBR Registration Initiative[58]
- 2023: Quick Reference Guide: Inverter-Based Resource Activities[59]
- Started in 2024: New reporting requirements for performance and event data from wind and solar generating facilities, including hybrid plants with BESS resources.[60]
- ERCOT stakeholders approved two changes to their Nodal Operating Guides in 2024 specific to IBRs, Nodal Operating Guide Revision Requests (NOGRR) 245 and NOGRR 255.[61,62]

[51] FERC Order No. 901, Final Rule Reliability Standards to Address Inverter-Based Resources, October 19, 2023.
[52] Reliability Standards
[53] March 14, 2023, Level 2 Alert: Industry Recommendation: Inverter-Based Resource Performance Issues.
[54] 2023 Reliability Guideline: Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources: Recommended Model Requirements and Verification Practices, March 2023.
[55] 2023 Reliability Guideline: Performance, Modeling, and Simulation of BPS – Connected Battery Energy Storage Systems and Hybrid Power Plants, June 2023.
[56] June 4, 2024, Level 2 Alert: Industry Recommendation: Inverter-Based Resource Model Quality Deficiencies
[57] IBR Performance & Modelling Alert
[58] IBR Registration Initiative
[59] Quick Reference Guide: Inverter-Based Resource Activities
[60] GADS Section 1600 Data Request
[61] NOGRR245 Issue
[62] NOGRR255 Issue