"Reliability, Resiliency, and Affordability of Electric Service in the United States Amid the Changing Energy Mix and Extreme Weather Events"

March 11, 2021

Before the Committee on Energy and Natural Resources
United States Senate
Washington, DC

Testimony of James B. Robb
President and Chief Executive Officer
North American Electric Reliability Corporation

The bulk power system is undergoing major transformation that must be understood and planned for to preserve reliability. A rapidly changing generation resource mix is driving this transformation. Traditional baseload generation plants are retiring, while significant amounts of new natural gas and variable generation resources are being developed. During this transition, natural gas-fired generation is becoming more critical to provide both "bulk energy" and "balancing energy" to support the integration of variable resources. Extreme weather exacerbates the challenges of the transforming grid while also stressing the system in unique ways. This transition requires the electric industry to reconsider how the system is planned and operated.

With a highly reliable and secure bulk power system (BPS) at the core of NERC's mission, NERC is focused on proactively addressing the reliability risks of the transforming grid. This testimony examines BPS reliability through the lens of recent extreme weather events. Through this examination, we discern key observations and steps for consideration to further assure reliability and resilience during this transformation.

About NERC

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority with a mission to assure the effective and efficient reduction of risks to the reliability and security of the grid. Designated by the Federal Energy Regulatory Commission (FERC) as the Electric Reliability Organization (ERO) for the United States, NERC develops and enforces reliability and security standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC performs a critical role in situational awareness and information sharing to protect the electricity industry's critical infrastructure against cyber and physical threats to the BPS. Through delegation agreements and with oversight from FERC, NERC works with six

Regional Entities on compliance monitoring and enforcement activities. Collectively, NERC and the Regional Entities comprise the ERO Enterprise. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves nearly 400 million people in the continental United States, Canada, and Mexico.[1]

Central United States Cold Weather Event of February 2021

Extreme, record-breaking arctic weather descended upon the central part of the nation during the second week of February, forcing power outages throughout the region. States in the middle south were especially hard hit, particularly Texas where the extreme cold forced generators offline, resulting in a massive deficit of energy to serve customers during record winter demand conditions. The system operator for the majority of Texas – the Electric Reliability Council of Texas (ERCOT) – was forced to order unprecedented load shedding as a last resort measure to restore frequency and protect system stability. At its peak, 52,277 MW of generation across *all* fuel types within ERCOT were unavailable, or 48.6% of total installed capacity.[2] The crisis lasted more than a week, ultimately subjecting more than 4 million Texans to localized blackouts and millions more to a range of compounding impacts. Many municipal water systems failed with 14 million under boil-water notices. Natural gas deliveries were curtailed due to frozen infrastructure and little to no dual-fuel capability was available in Texas. This serves as a sobering reminder of the essentiality of electric service to support all other critical infrastructures. And, most tragically, lives were lost in the crisis.

While the scale in Texas was especially dramatic, extreme winter weather also caused significant forced outages and load shedding in states throughout the central part of the country from North Dakota to Louisiana. To maintain system stability, the Midcontinent Independent System Operator (MISO) ordered 1,430 MW of load shedding on February 16, affecting citizens from southern Louisiana, Arkansas, Mississippi, east Texas, and Illinois. MISO reported a peak of 59,322 MW of generation was unavailable throughout the entire balancing authority area on February 14. This includes 8,081 MW that was weather related. The Southwest Power Pool service area experienced 3,443 MW of load shedding and the loss of 25,000 MW of generation across a range of resources. Outages occurred in Arkansas, Louisiana, Texas, Oklahoma, Kansas, Missouri, Nebraska, North Dakota and South Dakota. This crisis shows the increased vulnerability of the electric supply system to an extreme common condition that spans electric systems.

The human toll – suffering, death, and economic loss – makes the 2021 extreme cold weather event highly significant. To be clear, load shedding is an unwelcome last resort measure to avoid uncontrolled cascading outages across an entire interconnection. Faced with untenable choices during an emergency event when decisions must be made within minutes, actions taken by grid operators helped prevent even more widespread suffering. Data presented by

[1] See appendix for a map depicting the footprints of NERC and the Regional Entities.

[2] Presentation to ERCOT Board of Directors, "Review of February 2021 Extreme Cold Weather Event," ERCOT, February 24, 2021.

ERCOT show the entire electric system was within minutes of frequency and voltage collapse, necessitating the dramatic action they took.

To promote learning and risk reduction, NERC and the Regional Entities study reliability events and take appropriate and positive actions. On February 16, FERC and NERC announced a joint inquiry into the Midwest and South-Central states cold weather event. The joint inquiry will examine how the extreme weather impacted operations of the bulk power system in the affected regions of the country. The joint inquiry team includes Regional Entities from the impacted areas[3] and the Department of Energy (DOE). The FERC/NERC/Regional Entity Joint Staff Inquiry (Joint Inquiry) will cover three general themes:

1. Comprehensive, detailed analysis of the event and root causes
2. Commonalities with other cold weather events, including the 2011 winter event that also impacted Texas
3. Findings and recommendations for further action

Prior to the next winter preparation season, the inquiry team expects to issue a preliminary summary with the final report to follow. Working with FERC, NERC will move forward expeditiously on action items within our authority, including any necessary enhancements to mandatory reliability standards. As recently stated by FERC Chairman Glick, actions calling for further attention must not languish on the shelf.

Cold Weather Preparation – Reliability Guidelines and Mandatory Standards

February 2011 was the first well-studied cold snap to hit Texas and the southwest region since NERC was certified as the ERO. Temperature lows were in the teens for five consecutive mornings and there were many sustained hours of below freezing temperatures throughout Texas and in New Mexico. In 2011, between February 1-4, 210 individual generating units within ERCOT's footprint experienced either an outage, a derate, or a failure to start.[4] At the peak of the crisis, a controlled load shed of 4,000 MW affected 3.2 million customers in Texas. During the course of the event, power losses also occurred in parts of New Mexico and Arizona.

The extreme low temperatures also affected natural gas production and service. From February 1 through February 5, an estimated 14.8 Bcf of production was lost. These declines propagated downstream through the rest of the gas delivery chain, ultimately resulting in natural gas curtailments to more than 50,000 customers in New Mexico, Arizona, and Texas.[5]

[3] Texas RE, Midwest Reliability Organization, and SERC Reliability Corporation.

[4] FERC/NERC report, "Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011: Causes and Recommendations."

[5] FERC/NERC staff report, *"Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011,"* 9 .

Following the 2011 event, FERC and NERC produced a joint inquiry report, "Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011: Causes and Recommendations." Key recommendations included:

- Generation owners and operators should ensure adequate construction, maintenance and inspection of freeze protection elements such as insulation, heat tracing and wind breaks.
- Reliability coordinators and balancing authorities should require generators to provide accurate data about the temperature limits of units so they know whether they can rely on those units during extreme weather.
- Balancing authorities should review the distribution of reserves to ensure that they are useable and deliverable during contingencies.
- Finding that natural gas service was also impacted by the event, state lawmakers and regulators in Texas and New Mexico, working with industry, should determine if weather-related production shortages can be mitigated through the adoption of minimum winterization standards for natural gas production and processing facilities.

After significant consideration, NERC and the electric industry pursued and published a Reliability Guideline in 2012 to help industry develop their own readiness program for generating units throughout North America. NERC holds a "Winter Preparation for Severe Cold Weather" webinar every year before the winter season to reinforce the guideline's recommendations. Regional Entities conduct similar outreach to industry within their respective footprints.

The guideline provides a framework for developing an effective winter weather readiness program for generating units. The focus is on maintaining individual unit reliability and preventing future cold weather-related events. A collection of best industry practices, the guideline calls for an evaluation of potential problem areas with critical equipment, systems testing, training, and event communications. The guideline has been updated based on industry experience and learnings from subsequent cold weather events. These events include the 2014 Polar Vortex and the cold weather event of January 17, 2018 that impacted the south-central area of the country.[6] Version three of the winter readiness guideline was published in June 2020.[7]

Reliability Guidelines have the advantage of addressing certain risks where quick action is desirable or those risks categorized as high impact, low frequency or rare. However, the extremes of 2011, 2014, and 2018 demonstrated that these events could no longer be treated

[6] FERC/NERC staff reports, "Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011" and "The South Central United States Cold Weather Bulk Electric System Event of January 17, 2018."

[7] "Reliability Guideline: Generating Unit Winter Weather Readiness – Current Industry Practices – Version 3," NERC.

as rare. Further, in the past decade, the generation fleet has transformed to one that is more sensitive to weather with extreme temperatures.

Accordingly, to address the risk of extreme cold weather, NERC concluded that mandatory standards addressing cold weather risks were warranted. In September 2019, NERC initiated development of new cold weather requirements through enhancements to existing mandatory reliability standards.[8] After considering stakeholder comments, NERC expects to submit the proposed standards to NERC's Board of Trustees (BOT) in June. The final winterization requirements will be filed with FERC following BOT approval. The standards will support reliability of the BPS by helping to ensure that generator units are prepared for cold weather and enhancing situational awareness in the operational planning and operations timeframes. A set of draft standards are posted for comment through March 12 and include draft requirements for the following:

- Cold weather preparedness plans developed, maintained, and implemented by generators for each unit, incorporating freeze protection measures based on geographic location and plant configuration
- Annual maintenance and inspection of generation unit freeze protection measures
- Adoption of cold temperature operating parameters, including minimum design temperature and historical performance during cold weather in the previous five years
- Awareness training on the roles and responsibilities of site personnel
- Communication of specific unit limitations to Reliability Coordinator and Balancing Authorities for use in setting operating processes, determining contingency reserves, and performing operational planning analysis

Until a cold weather standard is approved and enforceable, NERC is also considering use of additional reliability tools, such as our alert system, to understand winter preparation status and incorporate plant preparation status into our annual seasonal assessment.

Western Heatwave Event of August 2020

During the middle of August, a massive heat wave developed across the West, forcing high temperatures 15 to 30 degrees above normal, breaking many daily highs. The California Independent System Operator (CAISO) reported that the August extreme heat was a 1-in-30 year weather event. On August 18, the Western Interconnection hit a new peak demand of 162,000 MW.[9] CAISO implemented numerous operational actions to balance resources with customer demand. In terms of energy supply, the extreme heat reduced electricity output from thermal resources, which typically operate less efficiently during temperature extremes. In addition to below normal hydro conditions, utility-scale and behind-the-meter solar generation output was reduced due to wildfire smoke and cloud cover.[10] High electricity demand across

[8] Project 2019-06 Cold Weather, NERC.

[9] Presentation, "Western Interconnection August Heat Wave Event," WECC, October 20, 2020.

[10] "Final Root Cause Analysis: Mid-August 2020 Extreme Heat Wave," CAISO, CPUC, CEA joint report, January 13, 2021, 21-22.

the West limited CAISO's ability to import energy from neighboring areas. During the early evening hours of August 14-15 when solar energy production naturally declines, CAISO was forced to resort to controlled load shedding of approximately 1,800 MW to maintain system stability. Power outages lasting between 8-to-150 minutes, impacting approximately 800,000 customers served by utilities regulated by the California Public Utilities Commission.[11]

This heatwave event occurred across the entire Western Interconnection. The widespread nature of this heatwave reduced options to mitigate impacts as exports to California dried up due to the need for organizations to serve their native loads. Though not as dramatic as the recent cold weather event, it is another example of an extreme common condition that overwhelmed the electric system. It demonstrates that these conditions can occur in summer or winter and for which industry needs to plan.

NERC and the Western Electricity Coordinating Council, the Regional Entity serving the Western Interconnection, are conducting a review of the Western heatwave event through our Event Analysis program. This review is nearing completion. We will provide the committee with the final report. A separate joint analysis by CAISO and California energy regulators was published on January 13, 2021. The report finds that issues with calculating resource planning targets and market practices contributed to the supply deficits during the extreme heat contradictions.

Identifying and Communicating Reliability Risk

Section 215(g) of the Federal Power Act requires NERC to assess the reliability and adequacy of the BPS. Through our reliability assessments, NERC evaluates the performance of the BPS, identifies reliability trends, anticipates challenges, and provides a technical platform for important policy discussions. The breadth and fidelity of NERC assessments evolve with our understanding of risk and improved tools. As the resource mix has shifted to be increasingly reliant on variable generation, wind and solar, and "just in time" natural gas deliveries, we began introducing fuel risks into our seasonal assessments and developed more probabilistic analysis of reliability.

By identifying and quantifying emerging reliability and security issues, NERC provides risk-informed recommendations and supports a learning environment for industry to pursue improved reliability performance. These recommendations, along with the associated technical analysis, provide the basis for actionable enhancements to resource and transmission planning methods, planning and operating guidelines, security, as well as NERC reliability and security standards. In short, NERC's independent assessments provide critical insights necessary for assuring reliability and security of a rapidly changing electricity sector.

Applying peak demand scenarios, the *2020/2021 Winter Reliability Assessment* includes the below map depicting regions in North America where there is heightened reliability risk due to potential extreme weather or fuel supply disruptions. In this assessment, NERC warns of the

[11] Ibid, 35.

potential for extreme generation resource outages due to severe weather in winter and summer, and the potential need for grid operators to employ operating mitigations or Energy Emergency Alerts (EEA) to meet peak demand.[12] The assessment highlights that during extreme and prolonged winter conditions, vital natural-gas fuel supplies for electricity generation can be at risk in New England, California and the southwestern United States. High reliance on natural gas-fired generation and limited natural gas infrastructure elevates reliability risk in these areas.

For this assessment, NERC analyzed severe weather scenarios that incorporated generation outages under peak load conditions. NERC noted particular reliability risk in areas within MISO, the Canadian Maritimes, Texas, the Rocky Mountain Reserve Group and the Northwest Power Pool.

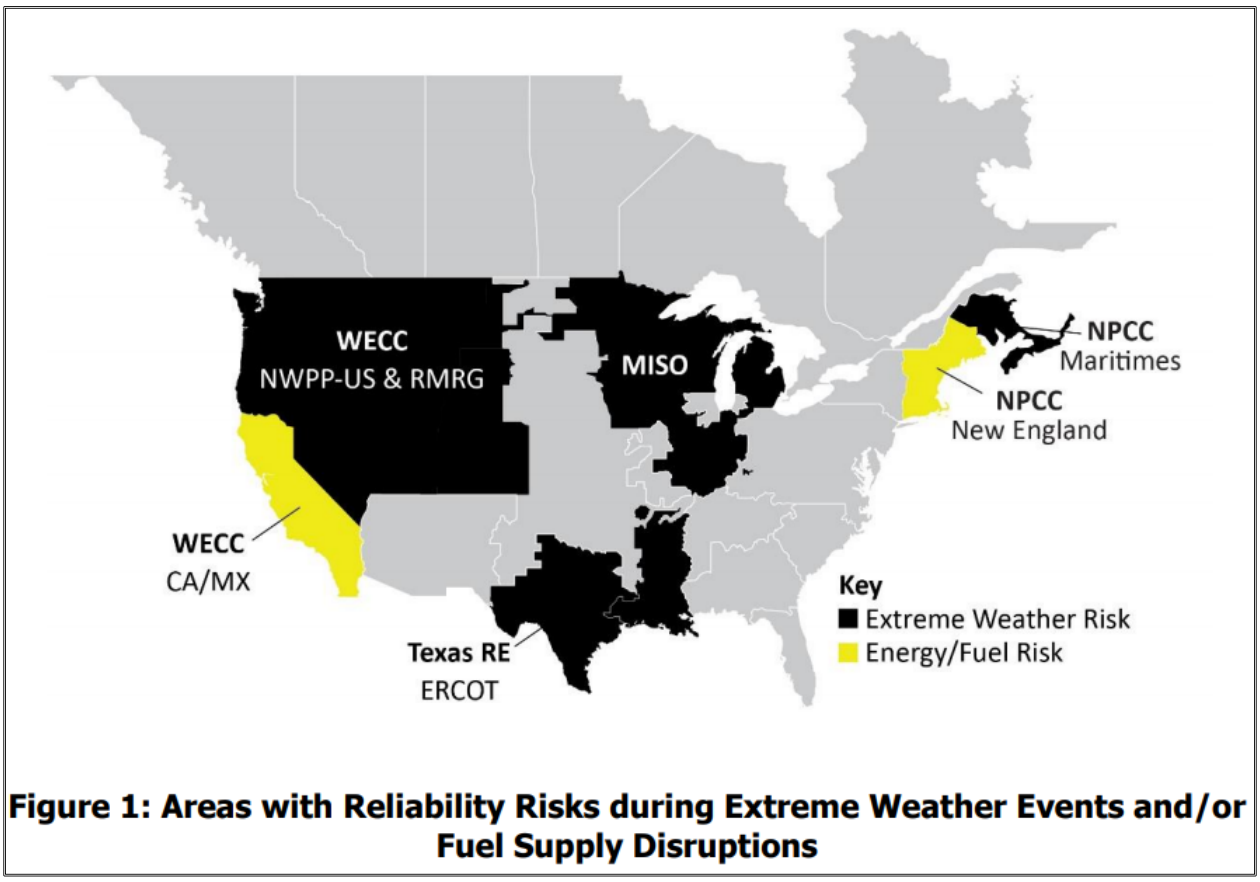

Figure 1: Areas with Reliability Risks during Extreme Weather Events and/or Fuel Supply Disruptions

Source: *2020/2021 Winter Reliability Assessment*, NERC.

Over the years, NERC's assessments have continued to identify three areas of primary concern: California, Texas, and New England. While recent events in the central-south and western parts of the country have attracted national attention, New England is another region that NERC has identified as particularly vulnerable to extreme cold weather.

[12] *2020/2021 Winter Reliability Assessment*, NERC, 6, 27.

New England

New England's exposure to extreme weather is exacerbated by its limited pipeline capacity to import gas and its dependence on a handful of critical fuel assets. NERC has continually identified fuel supply risk in New England, noting, "A standing concern is whether there will be sufficient electrical energy available to satisfy electricity demand while satisfying operating reserves during an extended cold spell given the existing resource mix and seasonally-constrained, fuel delivery infrastructure."[13] New England secures fuel reliability through dual-fuel capability in its natural gas fleet. A cold snap in December 2017/January 2018 led to natural gas shortages and fuel oil was burned to preserve reliability. If the cold front had not dissipated after January 8, several more hours of freezing weather would have exhausted the fuel oil in inventory and ISO-New England would have been forced into load shedding to preserve reliability. It was a near-miss event.

ERCOT/Texas

NERC's assessments have consistently highlighted reliability risk in Texas. As far back as nine years ago, the *2012 Long-Term Reliability Assessment* expressed this warning about ERCOT:

> Starting as early as next year, the [ERCOT] Planning Reserve Margin is projected to be below the NERC Reference Margin Level. Specifically, for 2013 the Anticipated Reserve Margin of 13.4 percent is below the ERCOT planning target (NERC Reference Margin Level) of 13.75 percent. At these levels, the risk of insufficient generation resources to meet peak demand increases beyond the accepted target. Throughout the 10-year assessment period, the Planning Reserve Margin continues to degrade and is projected to fall below five percent by 2017 and approximately zero by 2020 if more resources are not acquired.[14]

Concern for ERCOT's reserve margins has been a standing concern in NERC's assessments. In the most recent *2020/2021 Winter Reliability Assessment*, NERC warns of the potential for extreme generation resource outages in ERCOT due to severe weather in winter and summer, and the potential need for grid operators to employ operating mitigations or energy emergency alerts to meet peak demand.[15] *2020 State of Reliability* finds that Texas continues to have insufficient resources to meet the reference margin level but still successfully met demand throughout the 2019 summer season.[16] NERC's *2020 Long-Term Reliability Assessment* points to low operating reserves during the summer and during the months of March and October of the study years (2022 and 2024).[17]

---

[13] *2020/2021 Winter Reliability Assessment*, NERC, 18.
[14] *2012 Long-Term Reliability Assessment*, NERC, 11.
[15] *2020/2021 Winter Reliability Assessment*, NERC, 6, 27.
[16] *2020 State of Reliability*, NERC, ix.
[17] *2020 Long-Term Reliability Assessment*, NERC, 6.

California

NERC assessments have also identified energy sufficiency issues in California before the 2020 summer event. The *2019 Long-Term Reliability Assessment* discusses a need for flexible resources to meet increasing ramping and variability requirements, noting, ". . . as solar generation increases in California and various parts of North America, system planners will need to ensure that sufficient flexibility is available to operators to offset variability and fuel uncertainty."[18] In discussing the California region, NERC's *2019 Summer Reliability Assessment* concludes, "Extreme outages may result in insufficient resources at peak load."[19] The high-risk scenario in the *2020 Summer Reliability Assessment* predicted, "Operating mitigations and EEAs [Energy Emergency Alerts] may be needed under extreme demand and extreme resource derated conditions."[20]

Findings and Recommendations

Managing the pace of change is the central challenge for reliability. The rapid evolution of the generation resource mix is altering the operational characteristics of the grid. We highlighted this issue most visibly in our 2018 special assessment of baseload generation retirements and it has been a recurring theme of our outreach to federal and state regulators.[21] It is imperative to understand and plan for the different operating characteristics of variable, inverter-based resources. This includes time to study, plan for, and develop effective solutions to the challenges. Variable energy resources can provide ramping and other essential reliability services, yet existing regulatory models and contracts do not always value these capabilities. Sound policies, both public and market-based, should support a reliable energy transition.

More transmission and natural gas infrastructure is required to improve the resilience of the electric grid. Electric transmission investment must keep pace with the increase in utility scale wind and solar resources, which are generally located outside of major load centers. Transmission investments can also strengthen the ability to wheel power to different load centers improving resilience through redundancy. Additional pipeline infrastructure (including gas storage) is needed to reliably serve load and enable natural gas as a balancing resource. Many are discussing the merits of a national transmission system similar to the interstate highway system, point-to-point DC lines, and other interconnections. Whatever approaches may ultimately be pursued, few long-haul transmission lines and pipelines are actually being planned and built.

Natural gas is essential to a reliable transition. As variable resources continue to replace other generation sources, natural gas will remain essential to reliability. In many areas, natural gas-fueled generation is needed to meet energy demand during shoulder periods between times of high and low renewable energy availability. And on a daily basis in areas with significant solar

[18] *2019 Long-Term Reliability Assessment*, NERC, 8.
[19] *2019 Summer Reliability Assessment*, NERC, 29.
[20] *2020 Summer Reliability Assessment*, NERC, 33.
[21] *Generation Retirement Scenario*, NERC, December 2018.

generation, the mismatch between the solar generation peak and the electric load peak necessitates a very flexible generation resource to fill the gap. Natural gas generation is best positioned to play that role. The criticality of natural gas as the "fuel that keeps the lights on" will remain unless or until very large-scale battery deployments are feasible or an alternative flexible fuel such as hydrogen can be developed. Growing reliance on natural gas for electric generation is driving a variety of actions within the industry and across interdependent infrastructure sectors to manage risks to natural gas fuel supply. Most areas are reliant on natural gas to meet on-peak electricity demand. Unlike generation with on-site fuel storage, natural-gas-fired generators depend on the natural gas pipeline system to deliver just-in-time fuel for electricity production. Unless they are dual-fuel units with onsite fuel oil, they can be particularly sensitive to extreme cold temperature, and should be winterized to reduce the risk to their ability to operate. Further, growth in the use of natural gas as a fuel for electric generation and other applications can stress the natural gas supply infrastructure when necessary expansions do not keep pace. The problem is particularly acute during extremes.

Regulation and oversight of natural gas supply for electric generation needs to be rethought**.** – While natural gas is key to supporting a reliable transformation of the grid, the natural gas system is not built and regulated to serve the needs of an electric power sector that is increasingly dependent upon reliable natural gas service. As it relates to BPS reliability, clear regulatory authority is needed over natural gas when used for electric generation.

Planning for extreme weather. The BPS must remain reliable and resilient during all operating conditions. As the recent extreme weather events show, industry should proactively plan for and recover from rare events. NERC reliability assessments and reliability standards are identifying and attempting to address these risks within our authorities. Regulatory and market structures need to support this planning, prioritize reliability, and support necessary investments.

Resource adequacy does not guarantee energy sufficiency. A diverse generation portfolio strengthens reliability and resilience, yet the benefits of diversity are lost when all resources underperform or fail. All generation sources have energy limits and physical constraints, and these limits and constraints need to be accurately accounted for in seasonal and long-term planning assessments. While it is premature to draw hard conclusions before the joint inquiry is complete, thermal and variable resources in ERCOT, MISO, and SPP were forced offline or failed to perform as expected during the extreme cold weather event. The event is not a debate about one resource or another. The joint inquiry will look at all generation failures and their root causes.

Energy storage can and will be a game changer. As the technology continues to develop and economics continue to support the growing penetration of energy storage, these resources will become a game changer. However, we have to appreciate the gap that currently exists and the

scale that we need to obtain. NERC recently completed a battery storage study.[22] The assessment emphasizes the reliability benefits that battery energy storage systems can offer, such as providing peaking capacity; minimizing the need for new generation and transmission infrastructure; and providing essential reliability services such as frequency response. The assessment stresses the need to plan for a significant increase in the critical mass of battery storage or other balancing resource (such as hydrogen) *at scale* before natural gas reduces its role as the critical fuel for electric reliability that it is today. Investment in energy storage technologies and/or a hydrogen production and delivery system will be required if the vision of a largely/completely decarbonized electric system can be realized.

Market Issues. While electricity market issues are outside of NERC's direct purview, policymakers, planners, and market operators need to understand how electricity market policies value reliability and incentivize investments in hardening energy infrastructure.

Conclusion

Managing extreme weather impacts and a transforming grid is highly complex, requiring significant coordination among widely diverse policymakers and stakeholders. North America has four distinct interconnections. The owners, operators, and users of the BPS number in the thousands and have varied corporate structures. Some entities are vertically integrated, while others operate as unbundled entities in regional wholesale markets. These entities are overseen by a diversity of regulators at the local, state, provincial, and federal levels. Energy is being supplied from new sources that create new opportunities as well as challenges for the grid. All these factors must be well coordinated during the transformation in order to preserve reliability.

While reliability of the BPS incorporates certain standing principles, there is no one-size-fits-all approach. Rather, states and regions adopt solutions that work for them based on the availability of energy resources, energy infrastructure, and policy preferences. Reliability and resilience to extreme events must be a key factor of all discussions as we move forward. We have seen what happens when reliability is not planned for or fully incorporated into the planning and development of the changing resource mix.

Thank you for the opportunity to participate in this hearing. NERC greatly appreciates the committee's interest in our independent work. Working with FERC, industry, policymakers, and all stakeholders, NERC is uniquely situated to assure reliability for the nearly 400 million people in North America who depend on our work. Given myriad challenges, NERC's mission has never been more important.

[22] "Impacts of Electrochemical Utility-Scale Battery Energy Storage Systems on the Bulk Power System," NERC, February 2021.

APPENDIX

Footprints of NERC and the Regional Entities