"The Reliability and Resiliency of Electric Service in the United States in Light of Recent Reliability Assessments and Alerts"
February 1, 2024

Before the Ohio and Pennsylvania Joint Energy Committee
Columbus, Ohio

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Good morning. Thank you for the opportunity to discuss with you reliability challenges we face as we transition to our grid of the future. My name is Tim Gallagher and I serve as the President and Chief Executive Officer at ReliabilityFirst (RF), one of the six federally recognized Regional Entities. I am an electrical engineer and have held various engineering and leadership roles in the electric industry including systems planning, system protection, and system operations.

RF is one of the six North American Electric Reliability Corporation[1] (NERC) Regional Entities responsible for preserving and enhancing the reliability, resilience, and security of the bulk power system (BPS).[2] Collectively, NERC and the Regional Entities make up the ERO Enterprise. With specific authorities through a delegation agreement with NERC, RF's mission serves the public good and supports health and safety by assuring BPS reliability for over 73 million customers in our 13 states and the District of Columbia.[3] We are responsible for auditing and enforcing the NERC Reliability Standards for more than 270 registered entities in our footprint, which include Regional Transmission Organizations (specifically PJM and MISO), utility companies, and generators. We also provide outreach, training, and education to registered entities in our footprint, and technical expertise to state public utility commissions, legislators, and other stakeholders.

The ERO Enterprise is committed to working with states and policy makers as an objective, expert resource on reliability topics such as resource adequacy, essential reliability services, winterization, inverter-based resources (IBRs), and physical and cyber security. Our staff is comprised of employees with past industry experience such as power system engineers, control area operators, and forensic cyber experts, as well as data analysts, auditors, attorneys, and others. We participate with FERC and NERC on inquiries, task forces, and working groups, and have a unique perspective working on these complex challenges.

To that end, RF's role in today's discussion is to serve as a technical resource concerning the reliability risks associated with the rapidly changing generation resource mix, and describe actions taken by RF and the ERO Enterprise to help mitigate these risks. While energy policy

[1] The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority designated by the Federal Energy Regulatory Commission (FERC) to assure the effective and efficient reduction of risks to the reliability and security of the grid. Through delegation agreements and with oversight from FERC, NERC works with six Regional Entities (including RF) on compliance monitoring and enforcement activities. Collectively, NERC and the Regional Entities comprise the ERO Enterprise. The ERO Enterprise jurisdiction includes users, owners, and operators of the BPS, which serves nearly four hundred million people in the continental United States, Canada, and Mexico.
[2] See the appendix for a map depicting the footprints of NERC and the Regional Entities.
[3] RF does not have jurisdiction over the local distribution of electricity, which is a state responsibility.

should appropriately prioritize BPS reliability, our statements are not intended, and should not be interpreted, as advocating for a specific policy outcome.

NERC reliability assessments are well-known resources for policymakers, regulators, and industry stakeholders.[4] They evaluate various factors, including the reliability impacts of the retirement of conventional generation, such as coal and nuclear, and the addition of new, inverter-based resources. They also consider severe weather scenarios, incorporating generation outages under peak load conditions.[5] Regional Entities like RF also conduct reliability assessments specific to their regions.

These assessments provide insights for ensuring the reliability and security of a rapidly changing grid. Section 215 of the Federal Power Act requires that the ERO conduct these periodic assessments, but it also states that the ERO does not have the authority to require the construction of generation or transmission assets. Communication, coordination, and collaboration among policy makers, state stake holders, and industry is key to ensure a reliable grid transformation.

The transformation of the grid presents an "energy trilemma," that is, the need to ensure reliability while also balancing cost and environmental factors. Electricity is vital to modern life: to ensure the health and well-being of citizens, and to maintain the economy and national security. As such, electric reliability is of critical importance, and it is RF's area of expertise. Cost also plays a key role, as unaffordable electricity can hinder economic opportunities and disproportionally affects the most vulnerable among us. Finally, grid transformation solutions must be environmentally sustainable.

There are three reliability topics that apply across our region regarding the changing resource mix: the pace and complexity of change, resource adequacy, and essential reliability services. These are not the only reliability considerations, but they drive many conversations with states.

I will start with the pace and complexity of change. The rapidly changing generation resource mix is driving BPS transformation. Traditional baseload generation plants are retiring, and replacement energy is largely supplied by significant amounts of new natural gas and variable generation resources (mostly wind and solar) that do not yet have the same operating features essential for reliability, commonly referred to as Essential Reliability Services (ERS). Until energy storage is fully developed and available at scale, sufficient amounts of flexible, dispatchable generation will be needed as a balancing resource for grid reliability. Transmission is also critical for reliability. New inter-regional transmission can provide operating flexibility to import power where it is needed most during potential energy shortages. In addition, new transmission is critical to supporting state clean energy goals, where it is necessary to import renewable energy from remote sources to load centers.

Natural gas dependency also presents reliability challenges, as a greater reliance on natural gas-fired generation elevates the risk from weather-induced natural gas fuel supply disruptions. Given the new portfolio of generation resources, the BPS has grown more sensitive to the effects of extreme weather. As the grid continues to undergo rapid transformation, managing the pace of change is a central challenge for reliability. RF and the ERO Enterprise are taking specific

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[4] See NERC's reliability assessments here.
[5] Areas of the United States at risk of extreme weather impacts are identified in NERC's Winter and Summer Reliability Assessments. See NERC's 2023/2024 Winter Assessment, and NERC's 2023 Summer Assessment.

actions to identify, assess, and mitigate these risks. We are also making it a priority to serve as a resource for the states on these issues, in forums such as this hearing.

Resource adequacy is the next key area I would like to discuss. Resource adequacy refers to matching supply with demand to ensure that the grid has adequate resources to supply loads twenty-four hours per day, three-hundred sixty-five days per year, during all operating conditions. Over a ten-year horizon, NERC's 2023 Long-Term Reliability Assessment finds that numerous areas of North America are at risk of energy shortfalls during extreme weather conditions and even during normal peak conditions:[6]

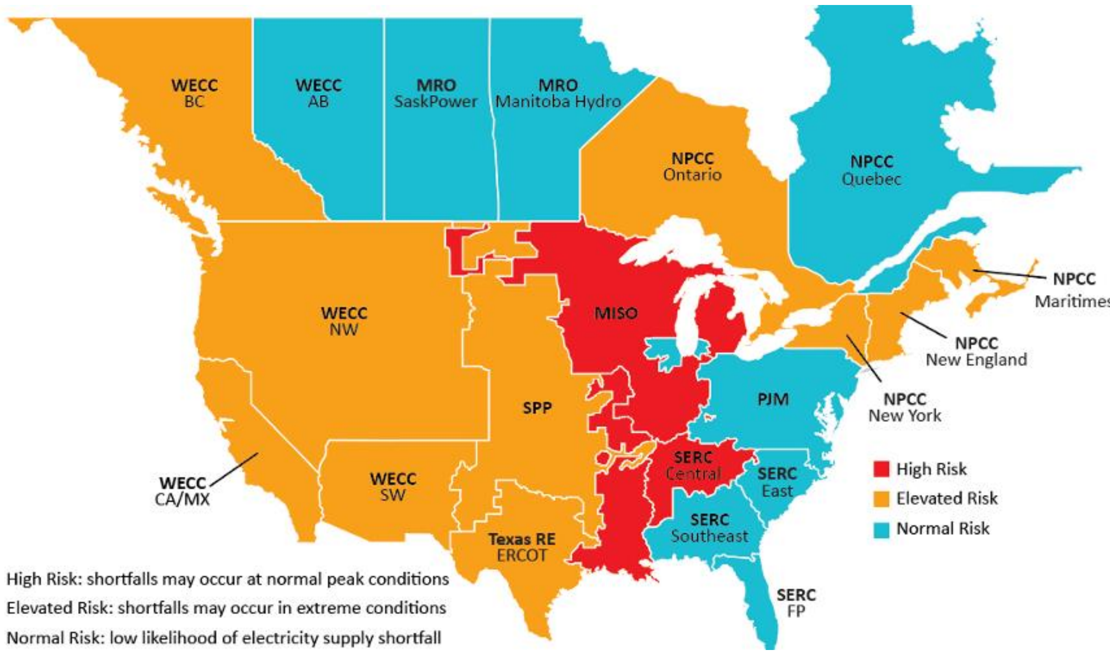

Figure 1. Risk Area Summary 2024-2028

This risk is driven by generation retirements that reduce reserve margins (commonly understood as available, dispatchable energy that can be quickly brought online to satisfy demand). In some cases, retirements can require extensive transmission reinforcement projects to sustain reliability. Within PJM, we have seen Reliability-Must-Run (RMR) contracts offered, but these are costly and generation owners do not have to accept them. This can force further actions such as a 202(c) emergency order pursuant to the Federal Power Act, to keep the unit(s) available and running until transmission reinforcements are complete, which may take several years. While the reliability protections RMR contracts and 202c orders can provide are beneficial, they are not an ideal way to manage the reliability of the Bulk Power System. We believe we are just beginning to see these types of situations surface. One current example is the Brandon Shores coal plant in Maryland, which is scheduled to retire in June 2025 due to policy and economic reasons. PJM has identified reliability challenges related to the retirement and has offered an RMR contract for the plant, which has not been accepted to date. PJM has included upgrades in its latest RTEP to support the constrained area.[7]

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[6] See NERC 2023 LTRA, p. 6.

[7] See https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20231108-3068&optimized=false.

Winter Storm Elliott and its lessons learned demonstrate the risks of generation retirements dovetailing with extreme weather events. Winter Storm Elliott was the fifth major storm with reliability impacts in the last eleven years. There were unprecedented electric generation outages coinciding with winter peak electricity demands, resulting in about 5,000 MW of load shed as rolling blackouts. FERC, NERC, and the Regions recently released a Joint Inquiry Report on Winter Storm Elliott, and I encourage you to read that report.[8] In situations like this, every megawatt matters, and the accelerated retirement of generating units puts additional stress on the grid. RTOs may rely on transfers from their neighbors; however, these transfers may stress the transmission system. If the energy is not available, emergency actions may include depleting operational reserves, voluntary curtailments, or rolling blackouts and load shedding to maintain reliability.

What we have learned from our assessments is that our margins are getting thinner. The Eastern Interconnection is very resilient, as described in the latest NERC State of Reliability Report,[9] however there are scenarios in the near and long-term future where certain transmission line and generation outages may be much more impactful than they are today.

Traditionally, resource adequacy meant asking, "How much supply do I need to ensure I have enough megawatts to serve my peak demand for the year?" The industry was able to do that because of the flexibility that conventional resources offer, including having fuel on site and the ability to quickly ramp up or down in response to changes in demand. However, as the generation resource mix evolves to include more intermittent resources, the questions become more complex, such as:

- How much load is in my forecast at 3PM and will the wind be blowing then?
- What hours will the sun be shining tomorrow, and in what areas?
- During periods of low output from variable resources, is there sufficient available energy from other generation resources or import capability from another area to meet demand?

The changing resource mix is necessitating a shift in the electric industry from a demand forecasting model to a supply forecasting model. Wind and solar resource availability depends on the wind and sun, requiring the study of weather patterns and a new, more probabilistic, approach to planning and forecasting.

There are also emerging complexities on the demand side to consider, such as electrification in transportation and other sectors, and the proliferation of Distributed Energy Resources (DERs). A surge in projected electricity demand, coupled with increased reliance on variable resources and natural gas, means that balancing and forecasting is becoming more complex, and keeping that balance between supply and demand is essential to reliability.

Next, I will discuss the importance of Essential Reliability Services, which refers to the combination of services that provide sufficient voltage, frequency support, and ramping capability

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[8] See https://www.ferc.gov/news-events/news/ferc-nerc-release-final-report-lessons-winter-storm-elliott.

[9] https://www.nerc.com/pa/RAPA/PA/Performance%20Analysis%20DL/NERC_SOR_2023_Technical_Assessment.pdf

necessary to keep the electric grid in balance and stable. Reliably operating the grid requires voltage and frequency to be maintained within tight limits.[10]

The term conventional resources refers to synchronous generation, the spinning metal and turbines that keep the grid operating at a frequency of 60 Hz. Traditionally, the resilience of the power grid has been its ability to withstand faults and system outages due to the number and magnitude of spinning generators on the system consisting of nuclear, coal, natural gas, and oil turbines. The turbines on these resources can respond and react quickly to system disturbances to prevent cascading, voltage instability, or uncontrolled loss of load. In this way, conventional resources, by their nature, can be dispatched quickly in response to changes in demand, and in doing so, they help ensure reliable operations.

That functionality (the ability to be dispatched quickly in response to changes in supply and demand), is the essence of Essential Reliability Services, but it does not naturally exist for renewable resources. Work is being done to develop technologies for renewables to help simulate some of that functionality, such as smart inverters and battery storage. However, a full solution will require a combination of strategies and sufficient time to commercialize technologies at scale.

Before leaving the topic of Essential Reliability Services, I wanted to briefly discuss Blackstart Resources. Blackstart Resources are essential to bringing the grid back to normal operations should a blackout occur, and their distinguishing characteristic is that they can be started without being connected to the grid. While not all conventional resources have blackstart capability, Blackstart Resources are typically conventional generation units. As more conventional resources are retired, fewer Blackstart Resources are available. With fewer of these resources available, we are concerned that this may extend system restoration time.

Actions that can help address the risks I have discussed include:

- Developing new tools, methods, and skillsets as we transition to more probabilistic forecasting,
- Constructing new transmission to connect the new, more widely dispersed, resources,
- Developing technologies that can simulate Essential Reliability Services for renewable resources, and
- Ensuring effective winterization programs are in place at generators.

There is much work that has already started in these areas. While we continue to coordinate with states and policy makers to help ensure a reliable energy transition, we at RF are utilizing our outreach, training, and education program to ensure that the known risks of today are being mitigated so that we can more rapidly address the risks of the future. I will walk through a few examples.

The ERO Enterprise is publishing lessons learned from events that involved the loss of renewable generation. We are also writing reliability guidelines and developing new Reliability Standards to address risks. While there are new NERC Reliability Standards becoming effective this year and next that help address reliability concerns related to extreme weather, RF began our on-site voluntary winterization visits shortly after the 2014 Polar Vortex. RF targets generating units that experienced freezing issues the previous winter, plus new generators commissioned in

[10] See NERC's resource on Essential Reliability Services, p. 7

our footprint. RF subject matter experts go on-site to the power plants, and we spend a day visiting with their plant manager, inspecting the facility. This outreach results in a customized report for the plant including recommendations for improvement and lessons learned from other site visits and recent events. We also document best practices to share on subsequent winterization site visits. We have received testimonials from the plants thanking us for our efforts and highlighting the changes made.

Another example of a reliability risk being addressed through our outreach program is misoperations. Misoperations (relays and associated equipment that do not operate as intended) have been a risk factor measured annually by the misoperation rate, posted annually in the NERC State of Reliability Report.[11] Around 2016, RF initiated a concerted effort to reduce this rate using all our tools, including the continued auditing and enforcement of the NERC Reliability Standards plus our outreach mechanisms. Our Engineering Department began identifying the Transmission Owners with the highest misoperations rates and engaged with them in one-on-one technical discussions. Our Protection Subcommittee started performing misoperations peer reviews to learn from and prevent future misoperations. Over the past seven years, we have successfully reduced the misoperations rate. Addressing and reducing misoperations is important as we transition to the grid of the future, as relay settings need to be carefully coordinated and monitored, especially with the increase of IBRs on the system.

In another area, several years ago, we noticed a concerning trend of Energy Management System (EMS) outages, which are situations where transmission control centers would lose situational awareness tools. While an EMS outage by itself does not cause a tangible reliability impact to the grid (such as a line or generator outage), the lack of situational awareness in conjunction with system events and disturbances may result in an insufficient response to an event which can lead to cascading problems. An example of this was the 2003 Northeast Blackout,[12] where an EMS outage contributed to the event because operators were unable to respond to declining frequency following the loss of several transmission lines and generators. To address the risk of EMS outages, RF worked closely with industry to analyze hundreds of EMS disturbances to study root causes, contributing causes, and mitigations. ERO task forces and working groups also engaged with industry and vendors to discuss these risks. Real-time situational awareness will be even more important going forward as we build the grid of the future and assess the impact of voltage and frequency disturbances that may trip Distributed Energy Resources (DER) (as seen in recent NERC system event reports).

RF and the ERO are committed to addressing known reliability risks and learning from past events, plus we are turning our attention to new evolving risks. We are speaking with other countries regarding lessons learned from their own grid transformations. We also strive to learn from other critical infrastructures regarding the risks and challenges they face. For example, we have studied cyber and physical security events impacting natural gas and water to determine if the electric grid may be susceptible to the same threats and vulnerabilities. To mitigate evolving risks, especially those involving energy policy and grid transformation, the states play a vital role in shaping energy policies. RF is committed to serving as a resource regarding these issues that impact reliability, resilience, and security.

[11] The misoperation rate is the total number of misoperations divided by the total number of operations, providing a percentage of which relay operations were misoperations.

[12] RF and the ERO created a video commemorating the 20th anniversary of this event: https://www.youtube.com/watch?v=sKXVT0V7SQY

Generally, state energy policies that provide sufficient time and flexibility to align energy goals with the reliability needs of the BPS will help to ensure a smooth transition. Examples of this include maintaining a diverse portfolio of generation types and allowing the use of environmental waivers when needed to maintain reliability. Another thing to keep in mind is that electricity respects only the laws of physics and cares little for geographic or political boundaries and our electric system is highly interconnected. Actions taken by any one state can have resounding and immediate impacts on neighboring states.

There are many different factors to consider when making decisions and formulating energy plans during this unique time, including: cost, environmental impact, reliability (including the level of reliability desired), energy equity, speed, the impacts to key industries and the economy, land and space requirements, new transmission needs, siting issues, impact on blackstart resources, impact on essential reliability services, integration into wider state policies, and potential dependence on foreign nations with human rights violations or that are hostile to the U.S. It is not possible to address all these factors in equal measures (some tradeoffs will need to occur), and each state's decisions will reflect a different mix. It is also important to consider what solutions are technologically possible currently (such as battery design, mineral, and material availability[13], fuel availability, transmission capabilities and the size of the distribution system).

Reliable electricity is the backbone of economic, societal, and individual well-being. If there is one message I want to leave with you today, it is this: to successfully address the complex reliability challenges emerging as the grid is transformed, NERC, the Regional Entities, and state and federal policymakers will need continued collaboration, coordination, and thoughtful action. Managing the pace of change is a central challenge for reliability. As states craft policies for a cleaner, more sustainable grid, we are pleased to serve as a resource to help you remain well informed regarding key reliability topics.

[13] See EIA's The Role of Critical Minerals in Clean Energy Transitions.

APPENDIX

Footprints of NERC and the Regional Entities