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Panel II: Advancing Reliability and Resilience of the Grid

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On behalf of the North American Electric Reliability Corporation (NERC), I appreciate the Commission's focus on advancing the reliability and resilience of the grid. As the Electric Reliability Organization (ERO), a highly reliable and secure grid is at the heart of our vision and the very foundation of the ERO Enterprise. NERC, and the Regional Entities (REs) which make up the ERO Enterprise, work with industry every day to identify risks to reliability, prioritize actions, and implement mitigation strategies. This panel is an opportunity to review the ERO Enterprise's leadership on advancing the reliability and resilience of the grid. NERC's response herein expands upon its filing outlining its comments to FERC's New Proceeding.

A bulk power system (BPS) that provides an adequate level of reliability is a resilient one. NERC's activities, since its inception, have focused on the ability to withstand, manage event impacts, and respond to emerging issues and risks to ensure the Reliable Operation of the BPS. As the ERO, NERC must identify new and emerging risks to reliability. Resilience is a performance characteristic of the Reliable Operation of the BPS, and is a critical part of the ERO Enterprise's activities. Per its statutory mission, NERC has an essential leadership role in analyzing risks to reliability and resilience. Further, as a learning industry, NERC has supported sharing of lessons learned, and monitors system performance to identify existing and emerging risks. For over 50 years, as NERC's 50th anniversary was just celebrated in June 2018, "reliability" for the BPS has been defined to consist of two fundamental and aspirational concepts:

- ***Adequacy*** *is the ability of the electric system to supply the aggregate electric power and energy requirements of the electricity consumers* ***at all times****, taking into account scheduled and reasonably expected unscheduled outages of system components.*
- ***Operating reliability*** *is the ability of the electric system to* ***withstand sudden disturbances*** *such as electric short circuits or unanticipated loss of system components.*

While construction and operation of a system able to withstand impacts from all potential risks is a difficult and costly goal to realize, it is feasible and imperative to establish an adequate level of reliability. A balance is achieved by coupling the ability to withstand impacts to certain design levels, while incorporating resilience measures, all meant to mitigate impacts from risks to reliability and maintain the Reliable Operation of the BPS.

In August, 2017, the United States Department of Energy (DOE) issued a Staff Report to the Secretary on Electricity Markets and Reliability. A recommendation made in the report requested NERC consider resilience in its mission. Namely:

> *NERC should consider adding resilience components to its mission statement and develop a program to work with its member utilities to broaden their use of emerging ways to better incorporate resilience.*

After review of the aforementioned DOE report and its recommendations, NERC's Board of Trustees (Board) took action to advance NERC's existing leadership in resilience. The Board directed the Reliability Issues Steering Committee (RISC) to reexamine resilience and its definition, propose a resilience framework, review NERC's ongoing activities and their contributions to resilience, and make recommendations for any additional actions. The initial results of this work appeared in NERC's comments to FERC's New Proceeding, and will be further documented in a RISC report to the Board.

Resilience is part of the Reliable Operation of the BPS

As called for in section 215 of the Federal Power Act, NERC develops Reliability Standards based on what is necessary to achieve an adequate level of reliability for Reliable Operations. When the Commission certified NERC as the ERO, they ordered that a definition of the adequate level of reliability be submitted to FERC.

NERC developed, filed, and later updated a definition of the adequate level of reliability along with a technical report to guide Reliability Standards development, Reliability Assessments, and technical committee work. In particular, the adequate level of reliability is defined as the state that design, planning, and operation of the Bulk Electric System (BES) will achieve when five performance objectives are met. The adequate level of reliability Performance Objectives are as follows:

1) The BES does not experience instability, uncontrolled separation, Cascading, or voltage collapse under normal operating conditions and when subject to predefined Disturbances.
2) BES frequency is maintained within defined parameters under normal operating conditions and when subject to predefined Disturbances.
3) BES voltage is maintained within defined parameters under normal operating conditions and when subject to predefined Disturbances.
4) Adverse Reliability Impacts on the BES following low probability Disturbances (e.g., multiple contingences, unplanned and uncontrolled equipment outages, cyber security events, and malicious acts) are managed.
5) Restoration of the BES after major system Disturbances that result in blackouts and widespread outages of BES elements is performed in a coordinated and controlled manner.

The adequate level of reliability also lists two assessment objectives for purposes of assessing risks to reliability:

1) BES transmission capability is assessed to determine availability to meet anticipated BES demands during normal operating conditions and when subject to predefined Disturbances.
2) Resource capability is assessed to determine availability to the Bulk Electric System to meet anticipated BES demands during normal operating conditions and when subject to predefined Disturbances.

Each objective addresses Reliable Operation of the B over four time frames:

1) **Steady state:** the period before a disturbance and after restoration has achieved normal operating conditions
2) **Transient:** the transitional period after a disturbance and during high-speed automatic actions in response
3) **Operations response:** the period after the disturbance where some automatic actions occur and operators act to respond
4) **Recovery and system restoration:** the time period after a widespread outage through initial restoration to a sustainable operating state and recovery to a new steady state

These periods of time correspond to the four outcome-based abilities of both the National Infrastructure Advisory Council (NIAC) resilience framework and the Commission's proposed definition of resilience outlined in its New Proceeding on "Grid Resilience in Regional Transmission Organizations and Independent System Operators": (1) robustness; (2) resourcefulness; (3) rapid recovery; and (4) adaptability/lessons learned. Hence, resilience is part of the Reliability Operation of the BPS, pertaining to reliability before, during, immediately after, and in the longer-term after an event.

By defining specific performance and assessment objectives for the BPS that include elements of resilience, the adequate level of reliability as defined by NERC supports a highly reliable and secure grid. Namely, as indicated in the NIAC framework and FERC's proposed definition, industry has designed a reliable BPS that is robust to absorb disturbances, resourcefully operated, and rapidly recovers in a coordinated and controlled manner after an event. Lessons learned are actively considered during and after any events for potential structural and non-structural improvements.

The RISC recommended resilience framework is based on the adequate level of reliability and the NIAC Framework for Establishing Critical Infrastructure Goals (relied upon by the Commission for its proposed definition of resilience). The RISC suggested two enhancements to the NIAC proposed outcome-based abilities, shown in red:

- **Robustness**—The ability to continue operations in the face of disaster. In some cases, it translates into designing structures or systems to be strong enough to take a foreseeable punch. In others, robustness requires devising substitute or redundant systems that can be brought to bear should something important break or stop working. Robustness also entails investing in and maintaining elements of critical infrastructure so that they can withstand low probability but high consequence events.

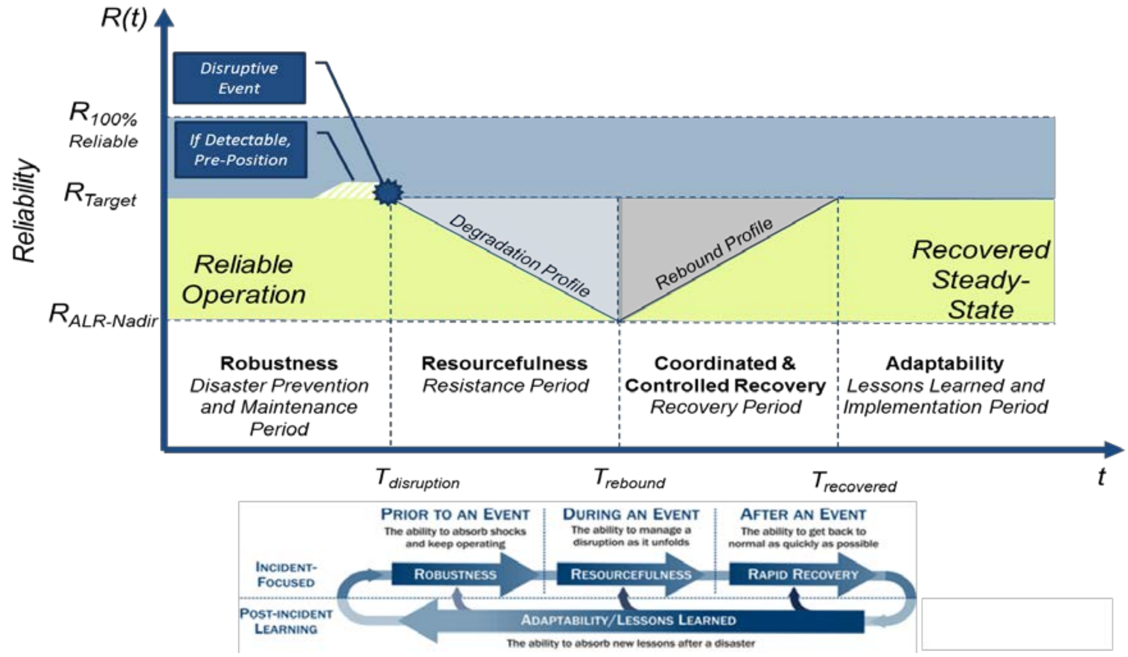
- **Resourcefulness**—The ability to skillfully detect and manage a disaster as it unfolds. It includes identifying options, prioritizing what should be done both to control damage and to begin mitigating it, and communicating decisions to the people who will implement them. Resourcefulness depends primarily on people, not technology.
- **Rapid recovery**—The capacity to get things back to normal as quickly as possible after a disaster in a coordinated and controlled manner. Carefully drafted contingency plans, competent emergency operations, and the means to get the right people and resources to the right places are crucial.
- **Adaptability**—The means to absorb new lessons that can be drawn from a catastrophe. It involves revising plans, modifying procedures, and introducing new tools and technologies needed to improve robustness, resourcefulness, and recovery capabilities before the next crisis.

"Detect" was added to "resourcefulness," specifically focused on the ability to "detect" a cyber or physical attack enabling industry response. Further, "coordinated and controlled manner" was added to "rapid recovery" to represent the actions industry employs to ensure that system restoration is performed in a thoughtful and deliberate manner in harmony with all other impacted entities. Though these proposed enhancements do not significantly alter the direction of NIAC's defined abilities, it provides an update and clarification.

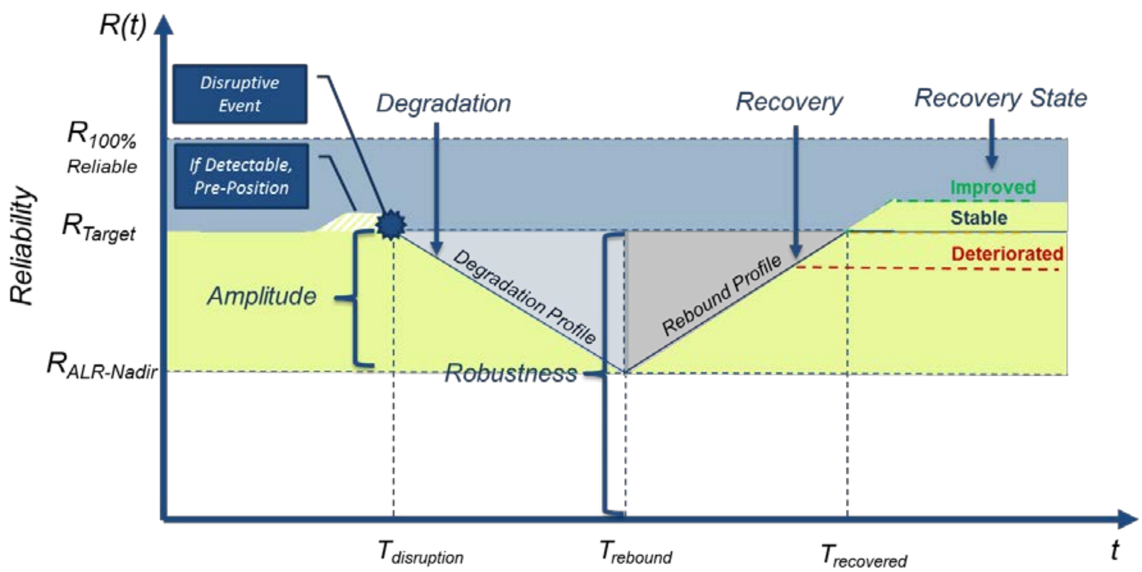
A Model for Reliable Operation of the BPS

Using the NIAC resilience framework, the RISC created a model that illustrates and enables measurement of system performance, or resilience, and provides an understanding of the elements needed to support the Reliable Operation of the BPS. The RISC resilience framework underscores NERC's longstanding focus on aspects of resilience and emphasis on reexamining the issue in the face of the changing resource mix.

The RISC resilience framework reflects the realization that reliable operation varies and is a function of time. Recognizing that the BPS cannot withstand all potential events, an adequate level of reliability must be provided so that the system can be reliably operated even with degradation in reliability due to an event. Further the system must have the ability to rebound or recover when repairs are made, or system conditions alleviated. The Figure below provides a graphic of the model.



Measuring the profile represented in this model provides relative characteristics of system performance, identifies areas where improvements may be desired, and post events, measure the success from system improvements. Some of the key areas that lend themselves for measurement are robustness, amplitude, degradation, recovery, and recovery state. The Figure below provides representation of these potential performance measures.



These performance measures are defined as:

- **Robustness:** the measured ability to withstand certain threats;
- **Amplitude:** a measure of the impact on bulk power system performance;
- **Degradation:** a measure of a change in system response with respect to an impact of varying amplitude;
- **Recovery:** a measure of the rate at which the system returns (rebounds) to a normal or stable state after the disruptive event, including any preparation time; and
- **Recovery state:** the state of bulk power system performance following the recovery period.
    - Stable
    - Improved
    - Deteriorated

These performance measures can be used for projected simulations as well as post events. Developing consistent measurement approaches will support relative comparisons towards achievable goals.

As an enhanced yardstick of reliability, resilience is reflected throughout NERC's programs. For instance, NERC's definition of adequate level of reliability includes a performance outcome providing for expeditious recovery from major system disturbances. NERC's activities focused on resilience encompass reliability standards, reliability assessments and performance analysis, and security.

Reliability Standards, Reliability Assessments and Performance Analysis, and Situational Awareness and Information Sharing Support Resilience

1) **NERC Reliability Standards** work together to establish a portfolio of performance-based outcome, risk reduction, and capability standards applicable to entities within NERC's jurisdiction and designed to support Reliable Operations. Most standards deal with fundamental parameters required to sustain reliability of the BPS under normal conditions: no instability, uncontrolled separation, cascading, or voltage collapse, with frequency and voltage held within defined parameters. NERC has a family of emergency preparedness and operations standards covering such topics as blackstart capability, system restoration coordination, and geomagnetic disturbance operations. Several Reliability Standards relate to the BPS's capability to withstand disturbances in anticipation of potential events, manage the system after an event, and/or prepare to restore or rebound after an event. In addition, certain Reliability Standards codify obligations to implement lessons learned and thereby adapt after an event. NERC also has collaborated with FERC and REs on industry's response and recovery plans called for in NERC's Reliability Standards to assess their quality and make recommendations, with the results documented in a joint report.

2) **NERC Reliability Assessment and Performance Analysis, and the Events Analysis program** activities address resilience in multiple timeframes:

   a. **Reliability Assessments** in and of itself is a component of resilience, as it serves as a credible source of information for policy makers and stakeholders. NERC has a statutory responsibility to independently assess the reliability and adequacy of the BPS. Each year, NERC publishes the 10-year outlook for reliability and seasonal reports examining adequacy for the summer and winter seasons. NERC also conducts special assessments evaluating the reliability implications of major topics and trends. Collectively, these annual and special assessments form the technical foundation upon which NERC identifies emerging risks, providing actionable information for NERC, industry stakeholders, and policymakers. At a high level, Reliability Assessments evaluate the: 1) adequacy of resources to meet demand and energy requirements; 2) sufficiency of essential reliability services; 3) capability of the transmission system to accommodate projected resources and demand; 4) vulnerabilities to fuel supply, transportation, and delivery; and 5) ability to manage extreme conditions. NERC also published a report on resilience to events that result in severe impacts, and recently published a report specifically evaluating BPS reliability impacts as a result of disruptions to the natural gas system.

   b. **Performance Analysis** assesses the current trends based on historical performance of the BPS. This is annually documented in the State of Reliability Report which provides additional detail on how NERC uses reliability indicators to tie the performance of the BES to the reliability performance objectives in the adequate level of reliability.

   c. **Event Analysis** activities also serve an integral component of NERC's resilience efforts by supporting continuous improvement and learning from past events. Through these efforts, NERC evaluates BPS events by undertaking appropriate levels of analysis to determine the causes of the events, promptly assuring tracking of corrective actions designed to prevent recurrence, and providing lessons learned to the industry.

3) **Situational Awareness and Information Sharing** activities as part of the E-ISAC and Bulk Power System Awareness (BPSA) also contribute to resilience, and are carried forward by two complementary activities:

   a. The E-ISAC serves as the primary security communications channel for the electricity industry and enhances industry readiness and ability to respond to security threats, vulnerabilities, and incidents that could affect the BPS. The E-ISAC's Cybersecurity Risk Information Sharing Program (CRISP) also provides a voluntary program to facilitate real-time, computer-to-computer data exchange involving potential security threats identified through monitoring participating utility networks. Further, the E-ISAC holds a biannual GridEx conference to allow participants the opportunity to self-assess their emergency response and recovery plans through simulated security exercises featuring stresses on the system.

   b. The NERC BPSA collects and analyzes information on system disturbances and other incidents that affect the BPS. The BPSA then disseminates this information to internal departments, registered entities, regional organizations, and governmental agencies as necessary. In addition, the BPSA monitors ongoing storms, natural disasters, and geopolitical events that may affect or are currently affecting the BPS. The BPSA issues alerts to NERC registered entities and the electricity sector upon discovering, identifying or receiving information that is critical to ensuring the reliability of the BPS. These activities by the E-ISAC and BPSA help support a BPS better able to anticipate, withstand, respond to, recover from, and learn from events.

Addressing Reliability Risks

As stated throughout, resilience is a performance characteristic of reliability. Therefore, improved reliability is completed through improvements to robustness, reliability degradation management, and system rebound and return to suitable state. A key inflection point in the model of the Reliable Operation of the BPS is the point where a disruption to reliability occurs. This disruption can occur due to the usual known risks, or if there is an appearance of a new emerging risk that can disrupt the system, such as a changing resource mix. Therefore, this risk landscape needs to be continually monitored to comprehend substantive changes. Doing so supports risk identification and an evaluation of the adequacy of NERC's reliability toolkit. Based on data collection, statistical analysis and simulations of projected systems, emerging risks can be identified. Once they are understood, the ERO Enterprise and industry can prioritize the risks and work together to mitigate them.

NERC's assessments of the changing resource mix identified significant emerging risks for reliability. For example, the past few winters have shown the potential impacts from increased reliance on natural gas and oil during cold weather conditions. These experiences underscore the importance of recommendations in NERC's recent assessments. In fact, four of NERC's assessment areas now meet their peak electric demand with greater than 50 percent of that sourced from natural-gas-fired electric generation.

To maintain reliability for the future, it is important to continue learning from events caused by cold weather, while monitoring current trends. For example, forced outage rates and unit unavailability due to lack of fuel for gas-fired power units is increasing. These incidents tend to occur during winter months, however they are also experienced during the summer when pipelines are under maintenance or storage facilities need to be topped off. Units made unavailable due to lack of fuel is becoming a more frequent occurrence and must be managed during normal operations.

Studies by planners on the one- to five-year time horizon are needed to determine the impacts on the BPS from the loss of fuel during periods when gas is diverted to firm customers, or when maintenance takes gas pipelines out-of-service for extended periods of time. Because natural gas provides "just-in-time" fuel and is not stored on site, improved fuel assurance should be considered to reduce the risk from fuel interruption that might result from common-mode failures causing widespread fuel delivery impacts. If the impacts are significant and risks increasing, Corrective Action Plan(s) may be needed to assure sufficient fuel is available to maintain the continued Reliable Operation of the BPS.

Many risks are local in nature. Consider how hurricanes impact some parts of North America, while icing impacts others areas. For this reason, NERC's standards activities focus on being performance based, enabling local solutions to provide the performance desired. In fact, this is the strength of the ERO Enterprise's regional model which enables local solutions, and, if required, Reliability Standards to address local risks. Coupled with the ability to address broad performance objectives, NERC's continent-wide standards complement and provide flexibility toward addressing high level risks, such as critical infrastructure protection overall interconnection requirements such as frequency response. Standards and requirements are reviewed, updated and in some cases retired, adapting to the lessons learned and the needs of a changing system.

Further, as discussed previously, the ERO Enterprise's reliability toolkit encompasses reliability assessments and performance analysis enabling continued monitoring of risks, and reliability/resilience improvement through Reliability Standards, guidelines, assessments, Alerts, and industry outreach. Being vigilant and monitoring the changing risk landscape and matching the reliability tools to manage and mitigate impacts are a critical part of the ERO Enterprise's activities.

Engagement with the States

State government is a member of NERC's stakeholder body, and the Commission asks an important question concerning our engagement with the states. Changes that are rapidly taking place at the distribution level can impact BPS reliability. NERC's insights into reliability risk and security can help support the states in exercising their responsibilities. Accordingly, state public service commissions are widely represented in NERC's governance structure and technical committees. For example, two state commissioners participate actively on the Member Representatives Committee which advises NERC's Board and approves Trustee appointments. Two staff members of state commissions serve on the Operating, Planning, and Standards committees, and one staff member serves on the Compliance and Certification Committee.

In addition to these activities, NERC regularly engages with the National Association of Regulatory Utility Commissioners (NARUC) and CAMPUT in disseminating reliability assessment findings and technical guidance. The REs also work directly with individual state commissions, provincial regulators, and NARUC. On the security front, NERC's E-ISAC has increased engagement with the states in promoting participation by Governors and emergency management officials in the GridEx exercise.

Conclusion

A BPS that provides an adequate level of reliability is a resilient one. Resilience is a performance characteristic of the Reliable Operation of the BPS, and is a critical part of the ERO Enterprise's activities. As the ERO, NERC has a responsibility, working with industry experts and other stakeholders, to identify new and emerging risks to reliability. One of our paramount goals is to avoid the potential for large-scale disruptions to the BPS. Further, if and when these disruptions occur, an adequate level of reliability must be sustained. By leveraging industry expertise, informed by sound technical analysis, and support by the ERO Enterprise, NERC's activities support a learning environment to identify risks and mitigate them in pursuit of improved reliability performance.

The ERO Enterprise's leadership role is essential to maintaining a focus on conventional risk, while anticipating emerging risks that are less understood during a period of revolutionary change in the electricity sector. By placing a spot-light on known and emerging risks, the ERO Enterprise, working with industry and all stakeholders, strives to ensure a highly reliable and secure BPS.

NERC will continue to assess whether further activities are appropriate to support a resilient grid, consistent with the overarching scope of the adequate level of reliability, the RISC resilience framework, and any applicable Commission orders.