"Powering America: Defining Reliability in a Transforming Electricity Industry"

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SUMMARY

The electricity sector is undergoing significant change that is unprecedented for both its transformational nature and rapid pace, presenting new challenges and opportunities for reliability. With appropriate insight, careful planning, and support, the electricity sector can continue to navigate these changes in a manner that results in enhanced reliability and resilience. Even with all the changes underway, the bulk power system (BPS) remains highly reliable and resilient, showing improved reliable performance year over year.

About NERC and NERC's Role in Evaluating BPS Reliability and Security

The North American Electric Reliability Corporation (NERC) is a private non-profit corporation certified by the Federal Energy Regulatory Commission (FERC) as the Electric Reliability Organization (ERO) for the United States. NERC reliability assessments evaluate the performance of the BPS, identify reliability trends, anticipate challenges, and provide a technical platform for important policy discussions. NERC's analysis of system disturbances also provide critical insights.

Reliability and How the Changing Resource Mix Affects It

Adequate capacity must be maintained to serve firm load. It is important to understand and plan for the different operating characteristics of variable resources. These resources also contribute to reliability and resilience.

Changes occurring in the generation resource mix and new technologies are altering the operational characteristics of the grid and will challenge system planners and operators. Conventional baseload generation has important reliability attributes. Reliability of the electric grid depends upon the operating characteristics of replacement resources.

Learning from System Events – A Case Study

NERC's analysis of a frequency excursion event in California revealed that protection settings on certain solar facility inverters caused erroneous tripping. This led to a recommendation to adjust the inverter settings. It is an example of NERC's focus on identifying small, isolated events that could pose greater threats to reliability.

DOE Staff Report

The Department of Energy's (DOE) recent staff report cites NERC's assessments. Many topics, findings, and recommendations in the staff report are consistent with NERC's work.

The Changing Resource Mix: NERC Recommendations

Baseload Retirements – Regulators and market operators should keep in mind the changing reliability aspects of the grid when considering resource needs, adequacy requirements, distribution-level interconnection requirements, and long-term resiliency.

Essential Reliability Services – All new resources should have the capability to support voltage and frequency. Policies and market mechanisms may not provide enough incentive or clarity.

Natural Gas Regulation and Markets – Regulators and policy makers should evaluate the natural gas regulatory framework for transportation priority and construction. Market operators should also evaluate whether market rules should be revised to provide assurances that generators will perform in normal and extreme circumstances.

Introduction

Good morning Chairman Upton, Ranking Member Rush, members of the subcommittee and fellow panelists. I am Gerry Cauley, President and Chief Executive Officer of NERC. On behalf of NERC, I appreciate the committee's focus on reliability in a transitioning electricity industry.

The electricity sector is undergoing significant change that is unprecedented for both its transformational nature and rapid pace. Such extraordinary change presents new challenges and opportunities for reliability. Dramatic advances in technology, customer preferences, public policy, and market forces are altering the generation resource mix and challenging the conventional understanding of baseload power, traditionally provided by large generating units with low maintenance and forced outage rates. These changes also are pressuring regulatory policy, sometimes blurring the lines between federal and state jurisdiction. Within the North American continent, cross-border electricity trade between the United States, Canada, and Mexico requires enhanced cooperation. Security is yet another major challenge as the threat landscape becomes ever more complicated with the rise of malicious actors seeking to attack critical infrastructure through cyber warfare.

With appropriate insight, careful planning, and support, I am confident the electricity sector will continue to navigate these changes in a manner that results in enhanced reliability and resilience.[1] Even with all the changes underway, the BPS remains highly reliable and resilient, showing improved reliable performance year over year.[2] This record demonstrates the strong commitment to reliability by industry and all stakeholders, and the effectiveness of the model adopted by this committee in the Energy Policy Act of 2005.

[1] The National Infrastructure Advisory Council provides this definition of "resilience" – "Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event." This definition is cited in a NERC report, "Severe Impact Resilience: Considerations and Recommendations" (May 9, 2012).

[2] *See* "State of Reliability 2017" (NERC, June 2017).

While these accomplishments are highly significant, I have learned from more than 35 years of experience that reliability requires constant vigilance. This is more true now than at any point in history. Working with FERC, DOE, industry, and numerous other stakeholders, NERC remains focused on identifying, assessing, and responding to reliability risks posed by change in the electricity sector. I am pleased to discuss NERC's work to address this critical priority.

About NERC and NERC's Role in Evaluating BPS Reliability and Security

NERC is a private non-profit corporation that was founded in 1968 to develop voluntary operating and planning standards for the users, owners and operators of the North American BPS. Pursuant to Section 215 of the Federal Power Act (FPA) (16 U.S.C. §824o) and the criteria included in Order No. 672 for designating an ERO, FERC certified NERC as the ERO for the United States on July 20, 2006. On March 16, 2007, FERC issued Order No. 693 which approved the initial set of reliability and security standards. These reliability standards became mandatory in the United States on June 18, 2007.

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 real-time situational awareness and information sharing to protect the electricity industry's critical infrastructure against threats to the BPS. NERC's responsibility spans the continental United States, Canada, and Mexico. Our jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

Section 215(g) of the FPA requires NERC to assess the reliability and adequacy of the BPS. NERC reliability assessments evaluate the performance of the BPS, identify reliability trends, anticipate challenges, and provide a technical platform for important policy discussions. Each year, NERC assesses the overall reliability, adequacy, and associated risks that could impact the upcoming summer and winter seasons, and the long-term, 10-year period. As emerging risks and potential impacts to reliability are identified, NERC also conducts special assessments on focused reliability topics that provide a similar technical framework and insights.

By identifying and quantifying emerging reliability and security issues, we are able to provide risk-informed recommendations and support 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 objective assessments provide critical insights necessary for assuring reliability and security of a rapidly changing electricity sector.

Reliability and How the Changing Resource Mix Affects It

The North American BPS is designed to be highly reliable, robust, and resilient. The system is interconnected, and the integrated networks work together to maintain reliability through both wide-area interregional planning and coordinated system operations. The adequacy of the system is maintained by having the right combination and amount of resources and transmission to deal with unexpected facility outages or extreme weather events. Operating reliability is maintained in real-time through highly coordinated operator actions across many operating companies.[3] The system is also planned as many as 15 years in advance through highly detailed, complex, and data-intensive power system simulations.

The BPS resource mix is changing in fundamental ways. As some conventional baseload generation from coal and nuclear retires, variable energy resources – especially wind and solar – are rapidly expanding and capturing the majority share of new capacity additions. The balancing resource tends to be natural gas. It is essential to understand the implications of these trends in order to maintain reliability.

The changing resource mix can fundamentally impact reliability in two major ways:

[3] NERC defines "reliable operation" in the following manner: "Operating the elements of the [Bulk-Power System] within equipment and electric system thermal, voltage, and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements. *See* "Glossary of Terms Used in NERC Reliability Standards."

- Resource Adequacy – A balancing authority responsible for managing the balance of demand and resources through unit commitment and forecasting must maintain sufficient capacity at all times to serve firm load.

- Planning for Variable Resources – It is important to understand and plan for the different operating characteristics of variable resources. These include planning for adequate essential reliability services, managing faster fault-clearing times, reduced oscillation dampening, and unexpected inverter action. Variable resources significantly diversify the generation portfolio and can contribute to reliability and resilience in important ways.

The rapid changes occurring in the generation resource mix and new technologies are altering the operational characteristics of the grid and will challenge system planners and operators. More specifically:

- Impact of Retirements – Conventional baseload electric generating units, such as coal and nuclear plants, provide frequency support services as a function of their large spinning generators and governor-control settings along with reactive support for voltage control. Power system operators use these services to plan and operate reliably under a variety of system conditions. These units also have relatively high availability rates and on-site fuel.

- Replacement Resource Capability and Characteristics – As the generation resource mix evolves, the reliability of the electric grid depends upon the operating characteristics of the replacement resources. Natural gas-fired units, variable generation, storage, and other resources can provide reliability services. However, as a practical matter, operating characteristics, economics, and market rules can affect whether these resources are equipped and available to provide reliability services. New generator and load resources must maintain the balance between load and generation, especially during ramping periods. In addition, in some areas, substantial amounts of generation is now being added "behind the meter" (e.g., rooftop solar). It will become increasingly important for system operators to have visibility into these resources.

Learning from System Events – A Case Study

NERC also gains considerable insight into reliability risk through analysis of system disturbances. An event last year in California is a recent example that is directly related to avoiding risk from the changing resource mix. It shows how NERC identifies and addresses a small problem today in order to avoid a potentially larger, more significant problem in the future.

On August 16, 2016, smoke from the Blue Cut wildfire in San Luis Obispo County, California, resulted in the tripping of two 500 kV lines in the active fire area. There was a noticeable frequency excursion with Peak Reliability reporting the loss of more than 1,000 MW across multiple renewable resources following these line outages. California ISO, Southern California Edison, and Peak Reliability confirmed that no conventional generators tripped, and that the near instantaneous loss of resources were all utility-scale renewables, primarily solar.

While the event did not rise to the level of a major disturbance by NERC criteria, the occurrence was significant and unusual because it is the first known major loss of renewable resources due to a transmission system disturbance. Subsequent analysis of this event determined that the protection settings on the solar facility inverters caused erroneous tripping. In response, manufacturers of inverters that experienced this type of tripping during the event have recommended a change in their inverter settings to avoid this issue. This recommendation calls for the addition of a time delay to their frequency tripping settings. This will allow the inverter to "ride through" the transient/distorted waveform period without tripping.

NERC has taken two additional actions in response to the Blue Cut wildfire event. In June, we published a report prepared by a joint task force of NERC, the Western Electricity Coordinating Council, FERC, and involved entities to analyze this disturbance, determine the causes, and develop key findings and recommendations.[4] We also issued a public Level II NERC Alert to industry. This alert – which requires a response – provides specific actions that NERC registered entities should consider taking to address this particular issue. NERC's work following this event is an example of detecting "faint signals" – identifying small, isolated events that could pose greater threats to reliability.

DOE Staff Report

DOE's recent study, "Staff Report to the Secretary on Electricity Markets and Reliability," cites NERC's assessments throughout the reliability and resilience chapter. We appreciate DOE's focus on reliability and resiliency as well as recognition of NERC's long time work on these issues. Many topics, findings, and recommendations in the staff report are consistent with NERC's work.

[4] *See* "1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report" (NERC, June 2017).

Specifically, as conventional resources retire, essential reliability services much be maintained. Voltage control, frequency support and ramping capability must be provided based on the configuration and needs of the system. Reliable operation of the grid depends upon these characteristics.

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 has a family of emergency preparedness and operations standards covering such topics as blackstart capability, system restoration coordination, and geomagnetic disturbance operations.[5] NERC published a report on severe impact resilience[6] and has collaborated with FERC and regional entities on industry's response and recovery plans.[7]

The combination of growth in natural gas demand within the electricity sector and its changing status among the gas-consuming sectors continues to increase significantly the interdependencies between the natural gas and electricity industries. Real-time delivery of natural gas through a network of pipelines and bulk gas storage is critical to support electric generators. It is also important to evaluate the impacts of a loss of major pipeline infrastructure. NERC has examined natural gas and electricity interdependencies in detail and has developed recommendations for the power industry.[8]

DOE's staff report also recommends expanded cooperation on grid reliability with Canada and Mexico. Cross-border interconnections require shared priorities for reliability and security throughout North America. Consistent with a set of principles signed in 2005 by DOE and Canadian provincial and federal counterparts, NERC is structured as an international organization. Under memoranda of understanding or other agreements with authorities in each province, NERC standards are adopted and enforced under provincial laws. In addition to strong

[5] *See* Emergency Preparedness and Operations Standards.
[6] *See* "Severe Impact Resilience: Considerations and Recommendations" (NERC, 2012).
[7] *See* "FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans" (2016) and "Further Joint Study Report: Planning Restoration Absent SCADA or EMS" (2017).
[8] *See "*Accommodating an Increased Dependence on Natural Gas for Electric Power*"* (NERC, 2013).

collaboration with Canadian provincial and federal government stakeholders, NERC works extensively with Canadian industry on reliability and security matters, and has partnered with DOE on numerous relevant efforts. In March, NERC signed a memorandum of understanding (MOU) with government authorities in Mexico to advance shared reliability priorities as Mexico implements comprehensive electricity reforms. NERC expects that Mexico will become a full participant, on par with the United States and Canada, as the implementation of the MOU is fully realized over the next several years.

The Changing Resource Mix: NERC Recommendations

As detailed above, NERC continually assesses the reliability of the BPS to evaluate system performance, identify trends, assist policymakers, and promote a learning environment. NERC's event analysis group also supports these objectives through detailed examination of system disturbances. Based upon this recent work, NERC has formulated recommendations related to the changing resource mix. For additional findings and recommendations, the appendix includes references to recent NERC assessments.

Baseload Retirements – State regulators and market operators should keep in mind the changing reliability aspects of the grid when considering resource needs, adequacy requirements, distribution-level interconnection requirements, and long-term resiliency. States and FERC should continue review of the economic and policy issues impacting fuel secure baseload generation in order to plan for and identify reliability implications of these retirements. States and FERC should ensure that required reliability characteristics are considered when identifying future reliability and capacity needs.

Essential Reliability Services – All new resources should have the capability to support voltage and frequency. Some variable energy resources and storage technologies can contribute to essential reliability services. Policies and market mechanisms may not provide enough incentive or clarity to ensure these services are maintained across the system. Regional transmission organizations and independent system operators and FERC have taken steps in this direction, which should continue.

Natural Gas Regulation and Markets – Regulators and policy makers should evaluate whether the natural gas regulatory framework for transportation priority and construction is compatible with the requirements of the changing BPS. Market operators should also evaluate whether market rules should be revised to provide assurances that generators will perform in normal and extreme circumstances.

Conclusion

The transitioning electricity sector poses challenges and opportunities for reliability. Retirements of baseload generation and the addition of greater variable resources are altering the operating characteristics of the grid. A significant influx of natural gas generation raises unique considerations for fuel delivery and dependence. To address the challenges and capitalize upon the benefits of a more diverse resource mix, industry stakeholders and policymakers must understand and plan for the implications of the ongoing evolution. With a focus on these challenges, the grid can become even more reliable and resilient. Throughout this transition, NERC plays a critical role in identifying, assessing, and addressing risks to help navigate the transition reliably. The Subcommittee is asking highly salient questions that are central to the nation's energy future and prosperity. I appreciate the opportunity to share NERC's perspective and expertise.

APPENDIX

This appendix includes summaries of recent NERC assessments which provide additional findings and recommendations.

Distributed Energy Resources: Connection, Modeling, and Reliability Considerations (February 2017)
Increasing amounts of distributed energy resources can change how the distribution system interacts with the BPS and will transform the distribution system into an active source for energy and essential reliability services. Attention must be paid to potential reliability impacts, the time frame required to address reliability concerns, coordination of essential reliability services and system protection considerations for both the transmission and distribution system, and the growing importance of information sharing across the transmission-distribution interface.

2016 Long-Term Reliability Assessment (December 2016)
NERC prepares seasonal and long-term assessments to examine current and future adequacy and operational reliability of the North American BPS. NERC's primary objective with this assessment is to assess resource and transmission adequacy across the NERC footprint, and to assess emerging issues that have an impact on BPS reliability over the next ten years.

A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability, NERC (October 2014)
Conventional generation with large rotating mass (steam, hydro, and combustion turbine technologies) provide necessary operating characteristics, defined as essential reliability services, needed to operate the North American electric grid reliably. Essential reliability services represent a necessary and critical part of the fundamental reliability functions that are vital to ensuring reliability. They are key services and attributes that are needed to maintain operating reliability—primarily voltage and frequency support. Many of these services and attributes are provided by baseload conventional generating plants; however, as the resource mix changes, essential reliability services must be maintained.

Accommodating an Increased Dependence on Natural Gas for Electric Power (May 2013)
The combination of growth in natural gas demand within the electricity sector and its changing status among the gas-consuming sectors continues to significantly increase the interdependencies between the gas and electricity industries. As a result, the interface between the two industries has become the focus of industry discussions and policy considerations. In its effort to maintain and improve the reliability of the North American BPS, NERC examined this issue in detail and developed recommendations for the power industry. These recommendations will help improve existing coordination between the gas and electricity sectors and facilitate the reliable operation of the two industries.