NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

FERC Reliability Technical Conference

Panel I: Overview on the State of Reliability

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June 22, 2017

Introduction

Thank you for the opportunity to appear before the Commission to discuss the substantial progress and key challenges facing the reliable operation of the bulk power system (BPS). I am pleased to report that the state of reliability in North America remains strong, and the trend line shows continuing improvement year over year.

The electricity sector is undergoing a period of revolutionary change that is unprecedented for both its transformational nature and rapid pace. Dramatic advances in technology, customer preferences, public policy, and market forces are changing the generation resource mix and challenging the conventional understanding of baseload power. Even as new business models emerge, models in place for nearly a century are now under considerable stress. As the Commission well appreciates, factors influencing these changes also are pressuring regulatory policy, sometimes blurring the lines between federal and state jurisdiction. Cross-border electricity supply to the United States from 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. During this period of revolutionary change, the North American Electric Reliability Corporation (NERC) remains the steward of reliability dedicated to the singular mission of reliability and security of the BPS.

My testimony provides an overview of the Electric Reliability Organization's (ERO) strategic focus and key findings in our *State of Reliability 2017*, which focuses on the performance of the BPS during 2016 and notes trends from previous years.[1] This differs from NERC's other assessments, such as our Long-Term Reliability Assessment (LTRA), which is an annual update of our ten-year outlook for reliability. This report reflects numerous other efforts, including the ERO's Reliability Risk Priorities report approved in November 2016. This report identified cyber-security vulnerabilities and the changing resource mix as two evolving high-risk profiles that could impact BPS reliability.

In calling today's technical conference, we appreciate the Commission's leadership in assembling a diverse spectrum of stakeholders to review the complex array of reliability issues we face, as well as those emerging just over the horizon. As the ERO, we work every day with industry stakeholders, regulators, and policy leaders to anticipate, identify, and communicate new and emerging risks. Today I will describe what NERC has accomplished and how we are developing our strategic direction to address the key challenges we see facing the BPS.

[1] *State of Reliability 2017*.

A Strategic Focus on Risk

Working with industry and all stakeholders, NERC has made very substantial progress since 2006 when the Commission certified NERC as the ERO. As discussed in *State of Reliability 2017*, system performance has improved – fewer relay misoperations, reduced equipment failure, and improved human performance. Overall, the BPS is more resilient.

When analyzing system performance, studying BPS events, and conducting reliability assessments, NERC continues to improve risk-based data gathering and analysis. NERC also has supported the development of new planning tools necessary to enable timely, probabilistic assessments of emerging risks, including those risks involving multiple interdependencies. Ongoing improvements in these activities are central to maintaining effective risk-based programs and efficient resource allocation, as well as maintaining the trust and support of stakeholders.

In conducting assessments of emerging risks, the ERO Enterprise must further refine our ability to evaluate the reliability impact of electricity market forces and policies. These skills are becoming increasingly relevant given the influence that markets and policies have on the generation mix, the location and growth of renewables, demand, fuel supply, and technology.

Cyber and physical security threats are constantly evolving, thus requiring continuous vigilance and diverse, agile defense strategies. As you will hear from Marc Sachs, the Electricity Information Sharing and Analysis Center (E-ISAC) has developed new and expanded capabilities, informed through enhanced alignment with industry member needs.

NERC's compliance monitoring and enforcement programs are similarly focused on risk. Risk-based compliance enforcement is not a paper exercise. Fundamentally, it means aligning compliance with outcomes that improve operational reliability and security. The Commission has supported NERC's move toward a more risk-based approach in compliance. Effective compliance monitoring and enforcement focuses proper allocation of resources on key risk factors facing an entity but also helps find smaller, isolated problems, and prevent them from becoming bigger and more widespread.

Emerging Risks

As NERC now enters its second decade as the ERO, the ERO Enterprise remains focused on the execution of risk-based strategies to support the performance of our statutory responsibilities. In doing so, it is essential to continually identify and address emerging risks and their potential to significantly impact BPS reliability.

<u>Addressing the Changing Resource Mix and New Technology Risk</u>

Policy and regulatory developments occurring with respect to renewable energy development, storage, conservation, demand response, and micro-grids have the potential to significantly affect BPS reliability. Market structures and developments also are impacting fuel supply, generation and transmission infrastructure planning, operations, and investment decisions. Given the rapidly changing generation resource mix, and related new technologies, it is critical to understand impacts on essential reliability

services (ERS) – specifically frequency response, voltage support, and ramping capability. It is also important to appreciate the operating characteristics of new technology at the interface of the BPS.

In 2016, attention to the changing resource mix primarily targeted establishing approaches for measuring ERS, especially as the penetration of inverter-based generation continues to increase (e.g., solar and wind turbine technologies). NERC's Essential Reliability Services Working Group (ERSWG) has produced multiple deliverables. Among these are an ERS concept paper,[2] a framework report,[3] and several videos[4] that explain frequency support, ramping, and voltage support. Regulators and industry have since taken additional actions in 2016 to address frequency response and voltage support.

Learning from Unplanned Loss of Renewable Generation

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 (CAISO), Southern California Edison (SCE), and Peak Reliability confirmed that no conventional generators tripped, and that the near instantaneous loss of resources were all utility-scale renewables, primarily solar. NERC's work following this event is an example of detecting "faint signals" – identifying small, isolated events that could pose greater threats to reliability.

While not a qualifying event in the ERO Event Analysis Process, 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 settings on the solar facility inverters caused erroneous tripping. Manufacturers of inverters that experienced this type of tripping during the event have recommended a change in their inverter settings to avoid this erroneous tripping. 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. Two weeks ago, we published a report prepared by a NERC/WECC Joint Task Force assembled by the NERC Operating Committee to analyze this disturbance, determine the causes, and develop key findings and recommendations for the industry. Also we 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. I would like to take this opportunity to complement the efforts by the task force, which included manufacturers, vendors and representatives from the renewable industry, who worked with NERC to identify the problem and develop solutions to address this risk to the BPS.

Strengthening Security Capabilities

Over the past several years, the E-ISAC has focused on improving its technical and analytical capabilities with a goal of becoming the electricity industry's leading, trusted source for analysis and sharing of security

[2] ERSTF Concept Paper
[3] Framework Report
[4] Frequency, Voltage, and Ramping Videos

information. Significant support from the Electricity Subsector Coordinating Council (ESCC), the ESCC Members Executive Committee (MEC), the U.S. Department of Energy, and other stakeholders have helped the E-ISAC be responsive to the industry's needs in order to provide unique insights, leadership, and coordination for security matters.

In coordination with these partners, the E-ISAC has developed a Long-term Strategic Plan. The focus of this long-term plan is to transform the E-ISAC into an even stronger world-class organization for intelligence collection and analysis. Consistent with this vision, the E-ISAC plans for continuous improvement and evolution, reflecting the changing threat landscape, changing technologies and business processes. This strategy recognizes the growing threats to the grid from human and cyber actors and highlights the need for a more robust security information sharing and analysis capability within NERC, while also reflecting an approach based upon sound fiscal planning. To achieve this goal, the E-ISAC remains focused on increasing its capability to collect security intelligence; conduct sophisticated and specialized analysis; acquire additional data storage, management, and sharing technologies; and increase its access to classified networks and facilities.

Single Point of Disruption Risk

NERC continues to assess the increasing risk of fuel disruption impacts on generator availability from the dependency of electric generation and natural gas infrastructure as a single point of disruption (SPOD). NERC has conducted two special assessments on gas-electric interdependencies – a primer highlighting key considerations in 2011[5], and a detailed framework for incorporating risks into reliability assessments in 2013.[6] As highlighted in NERC's recent LTRAs, substantial progress has been made in the last five years to improve coordination between natural gas pipelines, gas distribution companies, and electric industries. Even so, there are remaining concerns and opportunities to address on this subject. NERC published its *Short-Term Special Assessment: Operational Risk Assessment with High Penetration of Natural Gas-Fired Generation*[7] in May 2016. In the assessment, NERC recommended incorporating fuel availability into national and regional assessments.

Until recently, natural gas interdependency challenges were more often experienced during extreme winter conditions and focused almost exclusively on gas delivery through pipelines. However, the recent outage of an operationally-critical natural gas storage facility in Southern California — Aliso Canyon — demonstrates the potential risks to BPS reliability of increased reliance on natural gas without increased coordination between the two industries. Mark Lauby will discuss Aliso and SPOD risk in more detail.

Overview of State of Reliability 2017

The *State of Reliability 2017* is NERC's annual independent assessment developed by NERC staff with support from the Performance Analysis Subcommittee. The report builds upon several existing NERC activities and deliverables, including those developed by task forces or working groups under the direction

[5] Gas Electric Interdependencies Phase I
[6] NERC Phase II
[7] NERC Short-Term Special Assessment Gas Electric

of NERC's Planning, Operating, and Critical Infrastructure Protection Committees. These industry groups support NERC in developing recommendations and mitigation strategies for reliability issues.

State of Reliability 2017 finds that the BPS provided an adequate level of reliability (ALR)[8] during 2016. In addition, risks to reliability, key areas for improvement, and highlights of ongoing work by industry to improve system reliability and resiliency were identified and quantified. The report summarizes the results from ongoing activities to promote reliability across multiple fronts including reliability assessments and system performance analyses. Analysis of system performance enables NERC to examine trends and identify potential risks to reliability, establish priorities, and develop effective mitigation strategies to control reliability risks, which are then translated into the key findings. The corresponding recommendations promote further risk assessment and mitigation efforts as well as help to focus the work and resources of the ERO and the industry.

Key findings include:

- No Category 4 or 5 events in 2016.
- Protection system misoperation rate continues to decline but remains a priority.
- Frequency response shows improvement, but requires continued focus.
- Cyber and physical security risk increases despite no loss of load events.
- Transmission outages rates caused by human error show slight increase, but no increase in outage severity.
- BPS resiliency to severe weather continues to improve.

No Category 4 or 5 Events in 2016

Events on the Bulk Electric System (BES) are categorized sequentially from 1 to 5 with 5 being the highest in severity. While the number of lower category events did not significantly decline, there were no Category 4 or 5 events, for the second consecutive year, and only two Category 3.

Reviews of these events and those of lower severity resulted in the publishing of 13 lessons learned that shared actionable information with the industry to mitigate risks to BES reliability. For example, the Blue Cut wildfire in California caused transmission faults that cleared as designed, but a number of dispersed solar generation facilities were lost due to erroneous calculations of system frequency. The NERC Event Analysis (EA) process scans beyond just qualified events to identify and analyze faint signal events that are not at mandatory reporting thresholds.

Protection System Misoperation Rate Continues to Decline, but Remains a Priority

The overall NERC misoperation rate is lower in 2016 than last year (8.7%, down from 9.5%), continuing a four-year trend of declining rates across North America. The three largest causes of misoperations in 2016

[8] Definition of "Adequate Level of Reliability," Adequate Level of Reliability Definition (Informational Filing

remained the same as in 2015: Incorrect settings/logic/design errors, relay failure/malfunctions, and communication failures.

While the misoperation rate for some Regions increased in 2016, the overall NERC 2016 misoperation rate is lower than last year (from 9.5%[9] to 8.7%), continuing a four-year declining trend across North America. For the first time, the Western Electricity Coordinating Council's (WECC) overall operation count was collected, enabling the WECC misoperation rate to be developed for the last two quarters of 2016 (calculated to be 6.0%). Using this newly acquired WECC data, results in the collective NERC misoperation rate are calculated as 8.3% for the measured 2016 year.

Frequency Response Shows Improvement, but Requires Continued Focus

Three of the four interconnections trended "improving" while the Québec Interconnection frequency trend moved from "declining" to "stable." No interconnection experienced frequency response performance below its interconnection frequency response obligation.

Frequency response for all four interconnections improved during the 2012–2016 time frame. Frequency response arrests and stabilizes frequency during system disturbances. The addition of a large number of variable energy resources (VERs) onto the BPS has resulted in the need for operational flexibility to accommodate demand while also effectively managing the resource portfolio. This metric should continue to be monitored as the rapidly changing resource mix presents a potential challenge to frequency response.[10] ERS are comprised of primary frequency response, voltage support, and ramping capability. All are needed for the continued reliable operation of the BPS. As VERs are becoming more widespread, NERC is developing sufficiency guidelines in order to establish requisite levels of ERS, most notably in this case, frequency response.

Additionally, increasing installations of distributed energy resources modify how distribution and transmission systems interact with each other. Many utilities currently lack sufficient visibility and operational control of these resources, increasing the risk to BPS reliability. This visibility is a crucial aspect of power system planning, forecasting, and modeling that requires adequate data and information exchanges across the transmission and distribution interface. The most significant growth in DER penetration is occurring in the Northeast Power Coordinating Council and WECC regions. NERC's Distributed Energy Resources Task Force released their initial report in February of 2017.[11]

Cyber and Physical Security Risk Increases, Despite No Loss-of-Load Events

In 2016, there were no reported cyber or physical security incidents that resulted in a loss of load. Nonetheless, grid security, particularly cyber security, is an area where past performance does not predict future risk. Threats are increasing and becoming more serious over time.

[9] The 2016 *State of Reliability* stated the 2015 rate as 9.4%. Further analysis resulted in corrections to data which increased the 2015 rate by 0.1%, not significantly impacting the conclusions on protection system performance.
[10] ERSTF Framework Report
[11] Distributed Energy Resources Report

Responsible entities report cyber-security incidents to the E-ISAC as required by NERC Reliability Standard CIP-008-5 – Incident Reporting and Response Planning. The above finding reports the total number of reportable cyber security incidents[12] that occurred in 2016 and identifies how many of these incidents have resulted in a loss of load. There were no reportable cyber-security incidents during 2016 and, therefore, none that caused a loss of load. However, because the number of cyber-security vulnerabilities continues to increase, this does not necessarily suggest that the risk of a cyber-security incident is low.[13]

Responsible entities also report physical security events to the E-ISAC as required by the Reliability Standard EOP-004-2 – Event Reporting. The above finding is a result of the total number of physical security reportable events[14] that occurred in 2016 and identifies how many of these events resulted in a loss of load. This finding does not include physical security events affecting equipment at the distribution level (i.e., non-BES equipment). Both mandatory and voluntary reporting indicate that distribution-level events are more frequent than those affecting BES equipment.

Transmission Outage Rates Caused by Human Error Show a Slight Increase, but no Increase in Outage Severity

The number of momentary transmission outages from human error significantly declined from 2014 to 2015. Yearend 2016 data demonstrates a return to 2014 levels. While no increase in outage severity was discovered, human error remains a major contributor to transmission outage severity and will remain an area of focus.

Industry's increased efforts to lower the number of outages defined as "unknown in cause" has resulted in a marked improvement of causal identification, thus less use of the "unknown" descriptor in Transmission Availability Data System reporting. It is not clear whether some portion of the increase in human error for 2016 may be a result of more deliberate cause coding, thereby reducing outages with an unknown cause, but increasing the rate of outages caused by human error. It is important to note that the while the outage rate has increased, the overall correlation with transmission line outage severity has not markedly increased from past years.

Additionally, outages from failed alternating current (AC) circuit equipment (insulators, conductors, etc.) have increased from past trends, potentially for the same reason as mentioned previously. Transmission line outages caused by failed AC substation equipment (breakers, transformers, etc.) have remained flat as a trend, with neither an increase nor a decrease in the rate of occurrence.

[12] Ref. NERC Glossary of Terms: "A Cyber Security Incident that has compromised or disrupted one or more reliability tasks of a functional entity."
[13] ERO Reliability Risk Priorities, RISC Recommendations to the NERC Board of Trustees, November 2016, p. 9 Risk Mapping chart depicts Cyber Security Risk as having high potential impact and relative likelihood of BPS-wide occurrence.
[14] Reportable events are defined in Reliability Standard EOP-004-2 Event Reporting, Attachment 1.

BPS Resiliency to Severe Weather Continues to Improve

In 2016, for the second consecutive year, there were no days that the daily severity risk index (SRI) was part of the top-10 most severe list of days between 2008 and 2015, despite days with extreme weather conditions across North America.

Performance outcomes were determined using the SRI, which is a measure of stress to the BPS in any day resulting from the combination of generation, transmission, and load loss components. During no day in 2016 did the daily SRI make the top-10 most severe list of days between 2008 and 2015; this is despite days with extreme weather conditions across North America. Improvements in the 2016 SRI demonstrate that industry preparedness continues to have a positive influence on BPS resiliency.

Conclusion

Rapid transformation of the electricity sector creates new challenges and opportunity for reliability. As the steward of reliability, NERC's risk-based approach is highly effective in navigating this period of unprecedented change. *State of Reliability 2017* demonstrates that NERC's work with industry and all stakeholders keeps the ERO Enterprise in the vanguard of risk identification while supporting continuous strong performance of the BPS and operational improvement. However, dynamic industry change and emerging security threats mean there is no room for complacency. In organizing today's conference, the Commission plays a key leadership role in bringing together a diverse array of stakeholders to review important questions. We value our partnership with the Commission and I look forward to this continuing dialogue.