NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

FERC Reliability Technical Conference

Panel I: 2016 State of Reliability Report

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June 1, 2016

Introduction

Chairman Bay, Commissioners, and fellow panelists, thank you for the opportunity to appear before the Commission to discuss continuing progress and challenges toward assuring reliability of the bulk power system (BPS). I am pleased to report that the state of reliability in North America is strong and continues to trend in the right direction. While much has been accomplished working with industry and stakeholders, I have learned from my 35 years of professional experience that reliability assurance requires constant vigilance. Recognizing the need for continuous improvement, the Commission convenes this annual conference to review performance of the BPS while asking the important questions about key challenges, both immediate and emerging. Along with my fellow NERC colleagues and panelists, I am pleased to be part of the conversation today.

Ten years after the Commission certified NERC as the Electric Reliability Organization (ERO), NERC has matured as a strategic organization that is focused on identifying and addressing the greatest risks to reliability. Reliability Standards and the standards process have improved. We are focused on strong program management and smart enforcement. NERC's assessments and event analysis are at the leading edge of identifying reliability risk. At the Electricity Information Sharing and Analysis Center (E-ISAC), we have expanded stakeholder engagement, completed the largest cyber and physical security exercise of its kind, and enhanced tools required to confront evolving security threats. All of this progress relies upon collaborative partnerships with stakeholders and regulators, including those in Canada and Mexico.

We value our partnership with the Commission and appreciate your leadership is asking important questions today. From his perspective as a Trustee, Roy Thilly discusses the Board's priorities and the ERO's evolution as a strategic, risk-based organization. Mark Lauby will speak to emerging issues in Panel II. And, Marcus Sachs will review grid security issues and how the E-ISAC is addressing those challenges. I've included a few comments in my remarks related to the cyber standards and compliance issues identified for the third panel, given our code of conduct requiring separation between our E-ISAC staff and compliance issues. I will be available during the third panel in case any questions come up regarding these topics.

Overview of the State of Reliability

Each year, NERC's *State of Reliability* report assesses BPS trends to objectively analyze the state of reliability and provide an integrated view of reliability performance. This independent report focuses on the reliability performance of the BPS over the past year; identifies and quantifies risk and key areas for improvement; and highlights ongoing work by industry to improve reliability and resiliency. The report summarizes the results from ongoing activities to assure reliability across multiple horizons, including reliability assessments and system performance. Importantly, analysis of system performance data enables NERC to identify risks to reliability, set priorities, and determine the effectiveness of mitigation efforts developed to control risks

to reliability. Finally, analysis of system performance data and trends are translated into key findings and recommendations as feedback into risk assessment and mitigation activities, standard development, and other process improvements.

The *2016 State of Reliability* conclusions, drawn from available data compiled through December 2015, found that the BPS provided an Adequate Level of Reliability (ALR) for the year. The ALR is the state the design, planning, and operation of the BPS achieves when the ALR Reliability Performance Objectives are met. The objectives include stable BPS frequency and voltage within predefined ranges; and no instability, uncontrolled separation, cascading loss of elements such as transmission lines or transformers, or voltage collapse. Significant findings include:

- Instances of protection system misoperations have decreased.
- BPS resiliency to severe weather has improved.
- Human error has decreased.
- There were no Category 4 or 5 events in 2015.
- There was no load loss due to reported cybersecurity events.
- Frequency and voltage remained stable.
- Steady-state and dynamic modeling has improved.

Protection System Misoperations Decline; Causes Remain Unchanged

There was a statistically significant decline in protection system misoperations. Due to a decrease in the number of events initiated by misoperations, there was an improvement in 2015 in the Relative Transmission Outage Severity Risk. Automatic AC circuit outage frequency for outages initiated by failed protection system equipment also showed a statistically significant improvement in 2015. While the overall misoperations rate has declined, the three largest causes of misoperations remain in 2015: incorrect settings/logic/design errors, relay failure/malfunctions, and communication failures. These continue to be the area of focus for remediating this risk. For example, the instantaneous ground overcurrent protection function accounted for 11 misoperations in 2014 that caused events and, because of the strength of our voluntary entity reporting, were able to be well-analyzed. That number was reduced to six event-related misoperations in 2015. Similarly, one Region experienced a statistical improvement in relay misoperations from 2013 to 2014, which was maintained through 2015, primarily due to the targeting of a reduction of communication failures, within the protection systems. The statistics pointed to the broad areas for focus on reliability gain. The tactics used for the specific areas of concentration were supplied in collaboration with industry expertise, including vendors.

Results indicate that targeting the top three causes of misoperations should remain an effective mitigation strategy. A sustained focus on education regarding the instantaneous ground overcurrent protection function and on improving relay system commissioning tests will continue as we remain focused on improving the misoperation rates.

BPS Resiliency to Severe Weather Improved

Winter reliability and resiliency, in terms of avoided generation outages improved as evidenced by better BPS performance, due in part to the emphasis on seasonal preparation activities. Performance outcomes were gathered using the severity risk index (SRI), which is a measure of stress to the BPS on any day resulting from generation loss, transmission loss, and load loss components. There were no days in 2015 for which the daily SRI made the top ten most severe list compiled between 2008 and 2015, despite extreme winter weather conditions in parts of the Eastern Interconnection (EI) rivaling the polar vortex of 2014, which contributed two days to the top ten list. NERC is considering performing daily SRI calculations on a Regional basis to investigate the feasibility of correlating performance with regional weather data.

Impact of Human Error has Decreased

Transmission line outages caused by human error were significantly reduced to 0.028 outages per circuit in 2015 versus 0.039 in 2014 and 0.047 in 2013. NERC will continue to encourage focus on human performance training and education.

Overall Reduction in Qualifying Events

The Event Analysis process assigns qualifying events into one of five categories based on their impact to the BPS with category 5 being the most severe. There were no category 4 or 5 events in 2015, and only one category 3. Overall, there was a reduction in total events assigned a category 2 or higher. The majority of contributing causes by major category continue to show equipment failure as the primary initiating cause. The review of system disturbances submitted on a voluntary basis resulted in the publishing of 16 lessons learned to share actionable information with industry. NERC will continue to support the Events Analysis Subcommittee (EAS) to encourage registered entities to actively contribute to publishing lessons learned from qualifying system events.

Modeling Improvements Lead to Improved Blackout Risk Assessments

Industry currently is leveraging the rapid deployment of synchrophasor technology for individual power plant dynamic model verification. Similarly, BPS model validation is helping to ensure case fidelity, a measure of how well a model's simulation matches actual system response to a given event. These improvements follow the successful development of a composite load model for more accurate dynamic studies of phenomena, such as fault induced delayed voltage recovery, wherein large concentrations of primarily low inertia residential air-conditioning load can stall and cause local or wide area voltage collapse. Cumulative modeling improvements and the increased understanding of load and generator characteristics and responses are moving industry toward more accurate assessment of blackout risk, as well as other threats. System models must continue to improve in order for accurate simulations to be developed toward identification and mitigation of potential risks to reliability -- both in the operational and planning time horizons. As the resource mix and load composition changes, system models must continue to evolve to support pathways for operational and planning reliability. NERC will continue to support efforts to improve system model validation, particularly dynamic models, including the use of synchrophasor and other advanced technology.

Essential Reliability Services Trend is Stable; Face Potential Challenges

The prospect of a changing resource mix presents a potential challenge to essential reliability services (ERS), in particular frequency and voltage support. The Essential Reliability Services Task Force (ERSTF) recommended two new measures that are moving toward implementation.[1] The first, "Frequency Response at Interconnection Level," comprises a comprehensive set of frequency response measures at relevant time frames. The second, "Reactive Capability on the System," measures static (also called steady-state) and dynamic reactive reserve capability at critical load levels such as at peak, shoulder, and light loads. The latter is aimed at ensuring continued adequate voltage support.

Stable frequency is a key ALR performance outcome. Frequency response is essential in supporting frequency during disturbances that result in large frequency deviations, as well as during system restoration efforts. The BPS has demonstrated generally stable frequency response performance from 2012 to 2015, although below historic levels for at least some interconnections as discussed in Chapter 4. Further, changes in the BPS resource mix could have reliability implications for ERS that include frequency support.

The Interconnection Frequency Response Obligation (IFRO) is intended to be the minimum amount of frequency response that must be maintained by an interconnection and is reviewed and determined annually in the Frequency Response Annual Analysis. The EI, Western Interconnection, and Québec Interconnection experienced no frequency events with measured frequency response below their IFRO. The Electric Reliability Council of Texas (ERCOT) Interconnection experienced one frequency event with measured frequency response slightly below their IFRO, but load resource reserves that are under contract to trip on low frequency more than adequately supplemented the shortfall in frequency response during this event.

During the 2012-2015 operating years, the EI frequency response showed a statistically significant increasing trend, although the interconnection continues to exhibit frequency response withdrawal characteristics. The delayed recovery increases the risk that a subsequent contingency could occur from a lower starting frequency during that period. The ERCOT Interconnection frequency response also showed a statistically significant increase in the 2012-2015 operating years. The Québec Interconnection frequency response experienced a slight statistically significant decline. The Western Interconnection frequency response time trend was neither statistically increasing nor decreasing.

Relative to BPS voltage support, the concern is twofold. The first involves the expected increase in reliance on high-tech devices, such as the latest generation of static VAR compensators (SVCs) and Flexible Alternating Current Transmission Systems (FACTS) to provide BPS voltage support. These serve as dedicated reactive generators, supplying no real power (to do work), but sufficient reactive power to support stable BPS voltage and ensure that no voltage collapse occurs. They will likely replace the reactive power component (currently supporting BPS voltage) of conventional generators being retired.

[1] *Essential Reliability Services Task Force Measures Framework Report*, NERC, November 2015.

The *2016 State of Reliability* report leverages BPS reliability history including not only analyses of the equipment availability databases, but also latent data from past event analysis results. While the prolific use of these devices is relatively new and technically sound, more study is needed.

As highlighted by the ERSTF Framework Report and other industry research, in addition to the electronic reactive power generators, rotating machinery known as synchronous condensers, are being used at a greater rate to provide these services. These not only generate reactive power for voltage support as do their electronic counterparts, but can supply inertia and short circuit fault current vital to support continued BPS reliability in its weaker areas. Currently, the ERO has begun discussions with its committees and industry experts on how long electronic and rotating devices should remain tied to the BPS to support voltage needs in cases of dramatic voltage deviations, and when they can appropriately be allowed to trip to avoid damage to themselves.

The ERO will continue to closely monitor the impacts of resource mix changes with concentration on the following:

- Continue to support ERS measures for frequency and voltage support that have been developed and adopted.
- Explore methods to increase the population and capability of resources providing frequency response, especially under the scenario that conventional generation continues to be replaced with variable energy resources.
- Further investigate and ensure the reliability of reactive power generators, such as SVCs, FACTS devices, and synchronous condensers such as low-voltage ride-through capability, when applied to replace the voltage support function of retiring conventional generators.
- Protection for these devices as well as compatibility and coordination with other BPS protection and controls should be explored to ensure optimal BPS performance.

No Load Loss Due to Cyber Security Events

The year-over-year increase in global cyber security incidents relative to global cyber security vulnerabilities indicates that vulnerabilities are increasingly being successfully exploited, and reinforces the need for organizations to continue to enhance their cybersecurity capabilities. In 2015, there were no reported cyber security incidents that resulted in loss of load.

NERC continues to monitor industry's implementation of approved Critical Infrastructure Protection (CIP) Reliability Standards. Industry received lessons learned and transition guidance that included training, outreach, and workshops. To date, three grid security exercises (GridEx) have been conducted to develop, assess, and continually improve coordination, communication, and emergency response actions relative to cyber or physical attack. The GridEx III report[2] reviewed findings from the scenario to measure attainment of exercise goals, and includes feedback from GridEx III participants. NERC will continue to strengthen its situation awareness for cyber and physical security, providing timely and coordinated information to

[2] *Grid Security Exercise – GridEx III Report*, NERC, March 2016.

industry. In addition, industry should review its planning and operational practices to mitigate potential vulnerabilities on the BPS from cyber and physical attacks.

Emerging Issues

I would like to further emphasize two key challenges that will be thoroughly discussed on the following panels – the importance of maintaining ERS as the resource mix changes; and the cyber and physical security of the grid.

The generation resource mix is changing rapidly. Maintaining reliability during this transition is a key priority. We've had transitions to our energy base before and then, as now, this change can be managed. As we move forward with this evolution, however, we are experiencing a change of operating characteristics for the grid. For this reason, policymakers and stakeholders need to take a closer look at ERS including ramping, frequency control, voltage control, and also to address emerging issues, such as inertia. NERC is focused on ERS as a key area of education and emphasis for policymakers and stakeholders.

Cybersecurity is a constant and evolving threat, requiring diverse defense strategies. NERC continues to lead a multi-faceted approach to enhancing cybersecurity, with support from FERC through mandatory standards, improved information-sharing through the E-ISAC, and exercises to increase learning about threats and vulnerabilities. NERC has worked closely with our public and private sector partners, including the Department of Energy (DOE) through the Electricity Sub-sector Coordinating Council (ESCC). Recent legislation providing emergency authority to the DOE was an important addition to the security framework.

Reliability Issues Steering Committee – Alignment with *State of Reliability*

The *State of Reliability* is aligned with priorities identified by the Reliability Issues Steering Committee (RISC). The RISC is an advisory committee that reports directly to the Board and provides leadership and accountability on issues of strategic importance to BPS reliability. This year, as in years past, the 2016 *State of Reliability* will be one of the major inputs into developing the annual RISC report. In 2015, the RISC's annual report to the Board provided several recommendations and areas of focus, and NERC provided support on many of the risk profiles that needed to be addressed.[3] The specific areas identified in 2015 focus on the complex interdependencies and multiple jurisdictions between the electric industry and other industries; resource management amidst the changing resource mix; resiliency; regulatory uncertainty; system assets management and maintenance; the role of human performance; and event response and recovery. The 2016 *State of Reliability* was further aligned with the risk report and the RISC priorities by highlighting misoperations, BPS resiliency, human performance and event response and recovery. The *State of Reliability* was aligned with the risk report and the RISC priorities by reporting on some of the issues highlighted such as misoperations, BPS resiliency, human performance and event response and recovery. These risks have also been topics of joint FERC-NERC efforts. For instance, the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery plans, which assessed an organizations ability to respond and recover from serious events and identification of good industry practices.

[3] *See ERO Reliability Risk Priorities, RISC Recommendations to the NERC Board of Trustees*

Reliability Standards

Today's third panel has been asked to address the effectiveness of NERC Standards as well as improving compliance with CIP and Protection and Control (PRC) standards. During my tenure, I have prioritized improvements to the NERC standards and compliance processes. With FERC's support, NERC's Reliability Standards have evolved as the ERO matured. Standards are results-based, and over the years we have refined standards as we learn from our assessments, events data and analysis work and overall risk management approach. We have retired requirements that do little to promote reliability. Since December 31, 2012, NERC Reliability Standards development activities have addressed 224 FERC directives. Future Reliability Standard development projects will specifically consider the Integration of Variable Generation Task Force recommendations, the ERSTF recommendations, communication with the RISC on emerging risks, and other input from industry on BPS reliability concerns.

One month from today, the fifth version of the CIP standards goes into effect. This has been a multi-year effort by industry to improve the body of cybersecurity and physical security standards that has resulted in one of the most comprehensive approaches to security to date. I do not underestimate how big of a task that has been for much of industry. But the work does not stop here. Work will continue on implementation and compliance with these standards. Over the last several years the number of CIP violations has decreased while industry and Regional outreach and training has increased. NERC and the Regions recognized the opportunity to be more engaged with industry, the Regions and FERC to proactively resolve implementation questions, as well as increasing our efforts to provide training and outreach opportunities for industry. With regard to working proactively to resolve implementation questions, NERC issued guidance in the form of lessons learned and frequently asked questions which were developed during weekly coordination meetings with key industry stakeholders, Regional Entities, and FERC. NERC will continue to closely monitor noncompliance trends to identify future needs and resolve issues that entities have in their understanding of these standards.

The ERO Enterprise has continued to provide training through NERC and Regional Entity standards and compliance workshops to increase industry understanding of the PRC standards. An array of standards have become enforceable (PRC-005-3 through 6), are pending enforcement (PRC-004-4, which becomes enforceable on July 1, 2016), and are in the final stages of standards development (PRC-027-1, which has been adopted by the NERC Board and is pending filing with FERC). In addition to the outreach that has been conducted following FERC approval, there has been significant outreach to industry stakeholders and FERC during the development of the standards. This array of standards is part of a suite of solutions designed to reduce the percentage of misoperations. Other outreach activities include a keynote address at a Georgia Tech Protection Relay Conference on April 30, 2015, a presentation to share data with Texas A&M, March 31, 2015, and a presentation to the Western Protective Relay Conference, October 22, 2015. Other supporting solutions include developing technical solutions working with vendors, and information sharing with and through the North American Transmission Forum (NATF). As noted above, the *2016 State of Reliability* report includes a key finding that protection system misoperations declined by a statistically significant margin.

Conclusion

The *2016 State of Reliability* demonstrates strong performance of the BPS and positive trends. NERC continues to measure ongoing system performance to identify emerging risks, prioritize mitigation activities, and assess the effectiveness of risk control activities. NERC has a number of activities focused on addressing risks to reliability that are based on early analysis of system performance data. I am proud of our record on reliability and the trends we are seeing. At the same time, the industry is facing some of the greatest challenges. Raising awareness of these issues for reliability, analyzing the impact and providing a path forward will be a key conversation for NERC and the Commission.

I welcome this opportunity to discuss the *State of Reliability* and the key challenges for continuing reliable performance of the BPS. We value our partnership with the Commission appreciate your support for the ERO's mission. I look forward to your questions.