NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Written Statement of Gerry Cauley
President and CEO
North American Electric Reliability Corporation
to the
Quadrennial Energy Review Task Force
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On behalf of the North American Electric Reliability Corporation ("NERC"), thank you for the opportunity to participate in this initial public meeting on the second installment of the Quadrennial Energy Review ("QER"). I welcome the opportunity to provide NERC's perspective during today's panel discussion, "Bulk Power Generation and Transmission: How Can We Plan, Build, and Operate the Appropriate Amount for Future Needs?" I will focus in particular on the importance of maintaining reliability as the electricity resource mix changes; the need to assure the availability of essential reliability services; and the cyber and physical security of the electric grid.

Summary of Main Points

A key priority for our energy future is to ensure that reliability is maintained as the generation resource mix changes. We've had transitions to our energy base before and then, as now, this change can be managed. As we move forward with this transition, however, we are experiencing a change of operating characteristics for the grid. For this reason, policy makers need to include provisions for essential reliability services of the grid: ramping, frequency control, voltage control, and also to address emerging issues, such as inertia. NERC is focused on essential reliability services 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, through mandatory standards, improved information-sharing through the Electricity-Information Sharing and Analysis Center (E-ISAC), and exercises to increase learning about threats and vulnerabilities. NERC has worked closely with our private and public sector partners, including the Department of Energy through the Electricity Sub-sector Coordinating Council (ESCC). Recent legislation providing emergency authority to the Department of Energy (DOE) was an important addition to the security framework.

NERC has identified other imperatives in ensuring future grid reliability. One is adequate infrastructure, both in terms of electric transmission lines and fuel delivery systems, particularly for natural gas. We also must address the challenge of integrating controls to accommodate large amounts of distribution-centric resources and demand response with the grid to support continued reliable operation

3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
404-446-2560 | www.nerc.com

of the Bulk Electric System (BES). Further, while NERC's *State of Reliability*[1] report shows improvement in the management of conventional risks, there is a need to increase the resilience of the grid in the face of recurrent risks, while beginning to investigate ways to strengthen the system for weather- initiated events.

Finally, as the international ERO, NERC in particular recognizes the important efforts of DOE and its North American Energy Integration initiative. NERC participated in DOE's workshops held earlier this year. NERC is extensively involved with reliability and security efforts with both Canada and Mexico. Our partnership on standards, compliance and security initiatives are focused on assuring the reliability of the interconnected grid in North America and we share DOE's prioritization of cross border opportunities.

NERC has developed a positive and effective partnership with DOE focused on reliability and security of the grid. NERC looks forward to further enhancing these efforts with DOE through the important priorities identified in the QER and further informed through today's panel discussion.

Introduction to NERC

NERC is a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system (BPS) in North America. NERC is the electric reliability organization for North America, subject to oversight by the Federal Energy Regulatory Commission and governmental authorities in Canada. In its role as the Electric Reliability Organization (ERO) in the United States, NERC has responsibility under Section 215 of the Federal Power Act for the development and enforcement of risk-based Reliability Standards, and for assessing reliability and adequacy of the BPS (the high-voltage transmission and generation system). NERC monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

As part of its mission as the ERO, NERC develops annual and special assessments to advise industry and policymakers of future risks to the reliability of the bulk power system. NERC annually reviews and assesses the electric industry's long-term resource and transmission plans.[2] Additionally, NERC depends on a wide range of stakeholder and subject-matter experts to identify and assess both standing and emerging reliability risks. It is within this periodic assessment activity that key emerging reliability issues are identified.

NERC's assessments provide a technical platform for important policy discussions on reliability challenges facing the interconnected North American BPS. As emerging risks and potential impacts to reliability are identified, special assessments are conducted that provide insights and recommendations for maintaining and considering reliability. NERC engages policymakers, regulators and industry to address these emerging risks, and continues to monitor them through special assessments, and data collection from actual system performance. NERC has been very successful in collecting and maintaining key performance data on power system resources and transmission equipment. This data is instrumental for developing

[1] *State of Reliability 2015*
[2] *2015 Long-Term Reliability Assessment*

special reliability assessments designed to help inform policy makers, industry leaders, and the general public.

In 2015 and going forward, a key focus of these assessments is the reliability challenges and opportunities yielded by the transformation of generation resources used to meet industrial and residential electricity demand. NERC's 2015 assessments showed that one of the biggest challenges of the North American BPS' evolving resource mix is assuring reliability amid new retirements of predominately coal-fired and nuclear generation capacity, the rising reliance on renewable distributed energy resources, such as wind and solar, and increased dependence on natural gas generation. Different resources have different operating characteristics. Understanding how these different characteristics impact the essential components of a reliable BPS is key to ensuring a smooth transition. As discussed below, NERC has identified three essential reliability services (ERS) that warrant attention – frequency response, ramping, and voltage support. While these three services are among the first to manifest, we see other issues such as inertia beginning to emerge. Going forward, NERC will continue to monitor and identify emerging trends. As other elements of ERS are identified, we will further deepen our assessment of potential impacts and solutions.

In 2014, NERC created the Essential Reliability Services Task Force (ERSTF) to consider the issues that may result from the changing generation resource mix. The task force would identify ERS, monitor the availability of these services, and develop measures to ensure the industry has sufficient awareness of the change in reliability services in the future. In December 2015, the ERSTF issued the, "*Essential Reliability Services Task Force Measures Framework Report*,"[3] designed to explore important directional measures to help stakeholders and policymakers understand and prepare for the changing resource mix. The ERSTF concluded that to maintain an adequate level of reliability through the transition, generation resources need to provide sufficient voltage control, frequency support and ramping capability. – The ERS effort is an example of how NERC continually scans the horizon to identify and attempt to quantify risks to reliability of the bulk-power system. These emerging risks and their potential impacts are often identified in NERC's assessments and key areas, like ERS, are also amplified in special assessments conducted to provide a technical framework and insights about the range, and specific aspects to guide steps to manage their impacts.

By identifying and quantifying emerging reliability issues, NERC is able to provide risk-informed recommendations that drive NERC's activities 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, and NERC Reliability Standards.

NERC's focus on risk based approaches is inherent throughout the organization. NERC's Reliability Risk Management (RRM) group analyzes events to identify significant risks to BPS reliability, ensuring that industry is well informed of system events, emerging trends, risk analysis, lessons learned, and actions to mitigate risks to reliability. These functions may also identify areas in which new or enhanced compliance

[3] *Essential Reliability Services Task Force Measures Framework Report December 2015*

monitoring and enforcement initiatives are warranted, pursuant to the ERO's statutory responsibility to monitor, enforce, and achieve compliance with mandatory Reliability Standards.

Changing Resource Mix and Essential Reliability Services

North America's resource mix is undergoing a significant transformation at an accelerated pace with ongoing retirements of fossil-fired and nuclear capacity and growth in natural gas, wind, and solar resources. This shift is caused by several drivers, including existing and proposed federal, state, and provincial environmental regulations. Other drivers include lower natural gas prices due to abundant supply, along with policies incentivizing the transition from established energy resources toward integration of both distributed and utility-scale renewable resources. The power system may change further as microgrids, smart networks, and other advanced technologies continue to be deployed. It will be vital, therefore, to understand the pathway towards continued reliable operation of the BPS, as integration of these technologies will require a reliable and robust bulk electric system.

Changes to electricity generation and energy-use patterns changes the way the system is applied. The reliability of the electric grid must be maintained through additional engineering and implementation activities. There are several important facets of the changing resource mix and implications for continued reliable operation of the BES:

- Higher reliance on natural gas further exposes the need for a stable and reliable fuel transportation system;
- More system flexibility will be required to accommodate the ongoing growth in wind and solar resources;
- Sufficient essential reliability services including frequency response, ramping and voltage support, must be maintained as the resource base shifts from predominately coal-fired base-load generation, to a combination of natural gas-fired generation, energy efficiency, demand response and renewable variable energy resources; and
- Transmission enhancements and reinforcements are needed to support reliability to maintain system performance as unit retirements proceed and penetration of variable energy resources increases.

Essential Reliability Services: ERS are necessary to balance and maintain the North American BPS. Conventional generation (steam, hydro, and combustion turbine technologies) inherently provides ERS needed to reliably operate the system. NERC has identified the building blocks of these ERS, which includes voltage support, ramping capability and frequency support. Generators must be able to continuously balance load and demand throughout the BPS to support transmission voltage and frequency response. Wind, solar and other variable energy resources that are an increasingly greater share of the BPS provide a significantly lower level of ERS than conventional generation.

Given the transformation of North America's resource mix, NERC is more closely examining corresponding impacts on frequency response, ramping capabilities, and other important operational characteristics. The NERC Essential Reliability Services Task Force (ERSTF), established in 2014, continues to

examine these issues and develop new metrics that will help measure and ensure the BPS continues to maintain an adequate levels of ERS.[4] A recent ERSTF report provides details on the value and importance of essential reliability services and identifies next steps.

While the reliability attributes and contributions of conventional generators are well documented, many of the new resources are capable of providing essential reliability services supporting frequency, ramping, and voltage, but may not be required to perform these functions today. During and after the transition from large generators (such as coal plants) toward these newer resources, these reliability services will be required if reliability of the BPS is to be maintained. Proper planning and providing system operators with the ability to manage resources in real time will continue to be required to ensure that the appropriate levels of essential reliability services are available and that reliability is maintained as the resource mix evolves.

Whereas distinct market mechanisms and wholesale services are regulated by FERC, states plan for policies on resource mix and establishing Reserve Margin requirements. Therefore it is important to note that while states may not control policy around ERS, state resource decisions and planning around those decisions have ERS as a distinct factor. States also have the authority to approve interconnection standards and requirements, which establish the physical and performance capabilities of generators that are interconnected to the distribution system and/or behind the customer meter.

It is necessary for policy makers to recognize the need for these services by ensuring that interconnection requirements, market mechanisms, or other reliability requirements provide sufficient means of adapting the system to accommodate large amounts of variable and/or distributed energy resources (DERs). Policy makers are increasingly recognizing these needs, which will become more significant as larger penetrations of renewables and retirements of base load coal (and some nuclear) occur.

Natural Gas-Electric Coordination: In 2015, natural-gas surpassed coal as the predominant fuel for electric generation and is the leading fuel type for capacity additions. Despite substantial progress in coordination between the electricity and gas industries, the growing reliance on natural gas continues to raise reliability challenges regarding the interdependence of the industries and the adequacy of gas and electric infrastructures. Both industries have an opportunity to further enhance planning approaches by considering fuel deliverability, availability and responses to pipeline contingencies that are unique to each area.

The electricity sector's growing reliance on natural gas raises concerns regarding the electricity infrastructure's ability to maintain BPS reliability when facing constraints on the natural gas pipeline system. The extent of these concerns from Independent System Operators (ISOs), Regional Transmission Organizations (RTOs), electricity market participants, industrial consumers, national and regional regulatory bodies, and other government officials varies throughout North America; however, concerns are most acute

[4] The mission of the ERSTF is to provide a roadmap for the North American BPS for the transition to a generation mix with a high penetration of renewables and reduced conventional and synchronous generation.

in areas where power generators rely on non-firm pipeline transportation as natural gas used for power generation continues to rapidly grow.

Natural gas supply and transportation infrastructure adequacy concerns, particularly in certain parts of North America, are causing NERC, industry, and policymakers to refocus attention on the interdependency between natural gas and electricity industries. While coordination efforts between the gas and electric industries continue to improve, the potential still exists for a mismatch between the availability of natural gas delivery and natural gas demand for electricity generation. This can be particularly challenging in areas where a significant amount of the capacity — or more importantly, reserve capacity — is susceptible to natural gas transportation interruptions, potentially resulting in more frequent generator outages.

The gas and electric industries have recently made substantial progress to enhance coordination and develop new strategies to address system reliability due to fuel supply and transportation concerns. However, additional areas need attention. Specifically, system planners in areas where natural gas constitutes a large portion of the generation mix need to more thoroughly examine system reliability needs to determine if more Firm fuel transportation or units with dual-fuel capability are needed. Additionally, fuel availability and deliverability should be specifically considered and integrated into resource adequacy and other planning assessments.

More attention is also needed regarding operational coordination strategies between gas and electric industries. System operators should develop or enhance coordination strategies to address potential fuel interruptions – especially prior to anticipated extreme weather events. Generator owners should consider securing on-site secondary fuel in the event that non-firm gas service is curtailed.

Outlook: A diverse fuel mix is the most dependable approach for reliability; overdependence on a single fuel can create reliability risks. The changing resource mix can be managed, but policy makers need to address requirements for essential reliability services, both to assure for ramping, frequency control, voltage control, and also to address emerging issues, such as inertia.

Cybersecurity

Cybersecurity is a constant and evolving threat, requiring diverse defense strategies. NERC continues to facilitate implementation of the Critical Infrastructure Protection (CIP) Version 5 Standards that initially become enforceable in April 2016. Work also continues on implementing CIP-014, the physical security standard, with the first requirement becoming enforceable in October 2015. The energy sector remains the only sector with mandatory, enforceable standards to address security issues.

Standards are one piece of a complex, dynamic, and comprehensive approach to grid security and reliability. The threat of cyber and physical attacks on the grid by nation states, terrorist groups, and criminal actors is at an all-time high; the challenge will continue to grow exponentially. NERC is working hard to provide effective leadership, in coordination with our public and private partners, in securing the grid.

NERC's E-ISAC is an essential information sharing hub which provides situational awareness, incident management, coordination, and communication capabilities within the electricity sector through timely, reliable, and secure information exchange. The public/private partnership NERC has through the ESCC, which addresses resiliency and reliability issues, has greatly improved the conversation between government, industry and NERC. DOE is also a key partner with NERC in addressing, identifying, and analyzing security needs of the grid. These efforts are complemented by research and technology development by DOE's national laboratories. This work has significantly helped promote computer-to-computer monitoring and information exchange.

The E-ISAC is a leading source for voluntary information sharing for many in the Electricity Subsector. It gathers information from electric industry participants across North America about security-related events, disturbances, and off-normal occurrences within the Electricity Subsector and shares that information with other electric industry participants, and key governmental entities. Governmental entities also provide the E-ISAC with information regarding risks, threats, and warnings that the E-ISAC disseminates throughout the Electricity Subsector.

The E-ISAC uses a variety of tools, programs, and activities to enhance security, such as a secure web portal, alerts, exercises, and training and education. The E-ISAC portal allows the E-ISAC to reach thousands of industry members and hundreds of organizations across the subsector and is the mechanism for industry and government to contact E-ISAC staff with questions, concerns, and security-related information in a secure manner.

Outside of the E-ISAC, the ESCC is a key organization representing all segments of the electricity industry. The ESCC, the only sector coordinating council exclusively comprised of chief executive officers, is an outstanding example of a strong public-private sector partnership and provides key communication with our government partners coordinating efforts related to disasters and threats to critical infrastructure. Its government counterparts include senior Administration officials from the White House, relevant Cabinet agencies, federal law enforcement, and national security organizations.

Together, the ESCC and the E-ISAC enhance the subsector's security efforts. The ESCC has called for the E-ISAC to be the central source of information sharing between the Electricity Subsector and the government. This support for the E-ISAC's role in information sharing has led to increased awareness and improved communication on its operation and performance initiatives.

Along with standards and information sharing, NERC continues to pursue opportunities for learning about security threats and vulnerabilities. NERC's Grid Security Conference and GridEx III, a continent-wide exercise for participants across North America, provide important forums for education and training on key security issues and provide input for lessons learned. NERC continues to make significant progress with playbooks and exercises, and will continue this combined work to deter, detect, respond, and recover from cyber incidents.

Outlook: Going forward, there will be a continuing need to rapidly expand automated monitoring, assessment and mitigation. Barriers to information sharing caused by excessive classification of information

must be removed. Recent legislation providing emergency authority to DOE was an important addition to the security framework. DOE's continued participation and support for the work of NERC, the E-ISAC and the ESCC in security matters is needed to further expand and enhance sector and cross sector coordination.

Infrastructure

The existing transmission system was planned and designed to support the existing generation fleet, which is comprised mostly of larger, central station electric generation. Therefore, accommodating new resources, particularly those located in areas different from the existing fleet, transmission lines, facilities, and/or other transmission elements will likely be necessary. In particular, increased reliance on wind and solar will require transmission expansion, and in many cases interstate transmission lines that face barriers in terms of cross-state siting and construction. As natural gas-fired generation replaces coal-fired generation, the requisite timeline for natural gas pipeline infrastructure becomes even more relevant. The resource decisions of neighboring states can also impact the transmission infrastructure required to maintain reliability within a given state. Policymakers and stakeholders need to work together to coordinate timing requirements for any additional energy infrastructure in order to support continued BPS reliability.

There is uncertainty in the timing associated with approval and construction of resource additions and related transmission system infrastructure. Retirements can happen quickly, but adequate replacement facilities must be in service prior to retirement. As natural gas-fired generation replaces coal-fired generation, the requisite timeline for natural gas pipeline infrastructure becomes even more relevant. Increased dependency on natural gas also triggers concerns with shortages during extreme cold and also with pipeline contingencies creating fuel shortages, as when a single pipeline disruption results in large loss of electricity production.

Years of effort may be required when building new generating resources or transmission lines that are necessary to support reliability or compliance with the Clean Power Plan. On average, transmission projects require between six and 15 years to engineer, site, permit, and construct, depending highly on the geography, length, and voltage class. New natural gas combined cycle can take on average five years, while siting, permitting and construction of even small interstate pipeline projects can require three years to complete. The lead times required and associated uncertainties for the planning, engineering, permitting, and construction of new generating resources, transmission facilities, and fuel infrastructure may challenge the reliability of the BPS based on when such activities are commenced and the complexity of the solution.

Outlook: Coordinated planning of transmission expansion and pipeline expansion is essential to maintain reliability for delivery of renewables from remote locations and natural gas for use in electricity generation. There must be recognition of the concern that changes in the resource mix must not be allowed to outpace enhancements to the delivery infrastructure. A focus on infrastructure needs, coordination and planning by all levels of government, working with private sector partners will help ensure a feasible transition to assist new generation and transmission needs.

Integrating distributed resources and demand response

Distributed and distribution-centric energy resources, which also include demand side management such as demand response and energy storage, are contributing to changing characteristics and control strategies in grid operations. Distribution-centric energy resources are often indirectly interconnected to the BPS though sub-transmission and distribution systems located behind the meter. Visibility and controllability of these resources and new load forecasting methods for them are essential to reliably plan and operate the bulk power system.

The integration of a growing amount of distributed energy resources is a longstanding trend. For the future of the BPS, however, the combination of environmental regulations and low natural gas price forecasts are raising expectations at NERC and in industry that the long-standing changes in the resource mix are now accelerating faster than normal planning horizons for capital expenditures.

- As distributed resources and demand response become a greater portion of the grid resource mix, controls need to be integrated: coordinating the output of all devices working together to maintain frequency, voltage, ramping and to meet aggregate demand.
- With thousands or tens of thousands of distributed control points, these resources much be coordinated and working together.
- It is important to consider the implications for analysis of 'big data' which can enhance controls and system performance, while at the same time, design a robust system that is resistant to cyber-attacks (communication between distributed devices and distributed or central control platforms).
- Policy challenges are likely given convergence of bulk power policy (federal) and distribution policy (states).

Resilience

Resiliency is becoming the yardstick of reliability. NERC is reviewing how it supports industry in addressing this challenge. For example, NERC continues to provide industry information on lessons learned from extreme weather events and is developing analytical methods to identify potential interdependencies between extreme weather and resiliency performance. A recent FERC/NERC staff report identified beneficial practices for grid restoration and recovery. The report reviewed recovery and restoration plans from nine utilities and found them to be thorough and highly detailed. The report found that effective system recovery and restoration plans are essential to a quick and orderly recovery from reliability events such as blackouts caused by weather, BPS disturbances or possible cyber/physical attacks. The report adds that broadly adopting the practices in these plans would enhance the industry's preparation for recovering from major storms and physical or cyber-attacks, and allow other entities to recover more quickly and efficiently when such events occur.

As managing conventional risks to reliability (our reports indicated declining transmission outages excluding weather) is improved, attention should be shifted to terrestrial and solar risks that are affecting reliability: severe weather such as storms, wind, snow, cold, and flooding, and geomagnetic disturbances (GMD). In addition, risk from cyber and physical attack impacts require continued vigilance and

consideration for improved system design. NERC has mandatory standards on GMD and physical security, and FERC has just approved NERC's fifth version of the Critical Infrastructure Protection standards.

North American Energy Integration

NERC works under a unique partnership with Canada and Mexico dedicated to assuring the reliability of the BPS for North America. Through bilateral principles and other agreements, NERC works with policymakers and stakeholders in all three countries on the reliability regulatory framework. The Obama administration has engaged with federal governments in Canada and Mexico on energy issues with the objective of working toward a cohesive and integrated North American energy strategy. The recent QER devoted an entire chapter (Chapter 6) to issues of integration. NERC commends this effort and as the international electric reliability organization, would like to continue our partnership with DOE to address the various cross-border issues related to electricity and security.

In October 2015, DOE conducted two workshops with stakeholders and members of the academic community to discuss cross-border issues related to electricity. The first workshop focused on US-Canada electricity issues, and the second on US-Mexico electricity issues. NERC participated in both of these workshops and joined participants in discussing policies, regulations and planning associated with the electricity sector in North America to address best practices, regulatory consistency and continuity across the three North American countries and to inform the creation of legal, regulatory, and policy roadmaps for harmonizing regulations and planning.

Throughout the workshops, the ERO model was viewed as a strong positive that supports and facilitates North American electricity integration, and the recommendations generated by the two workshops reflect this support and the high priority workshop participants place on reliability and security of electric power systems. NERC looks forward to working with DOE to assist in moving toward increased harmonization of energy policy and planning for North America.

Conclusion

NERC, as the ERO, is focused on assuring the reliability of the BPS. The changing nature of the resource mix is a transition that provides numerous challenges as well as opportunities. The QER 1.2 has identified numerous important issues as we face a new energy future. NERC's assessments, analysis, and risk-based focus identifies key reliability issues and challenges. These include topics such as ERS, infrastructure, integration of distributed resources, demand response, and resilience. A cooperative and coordinated effort between the public and private sector, between policymakers and stakeholders, can focus on identifying solutions and a path forward as we transition to a new energy future for the North American grid. NERC's top priority is reliability and security and we look forward to working with the DOE on this next step important step of the QER.