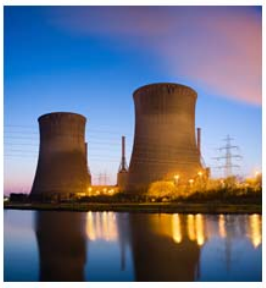
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Electric Reliability Organization Enterprise Strategic Plan and Metrics

2017–2020

RELIABILITY | ACCOUNTABILITY

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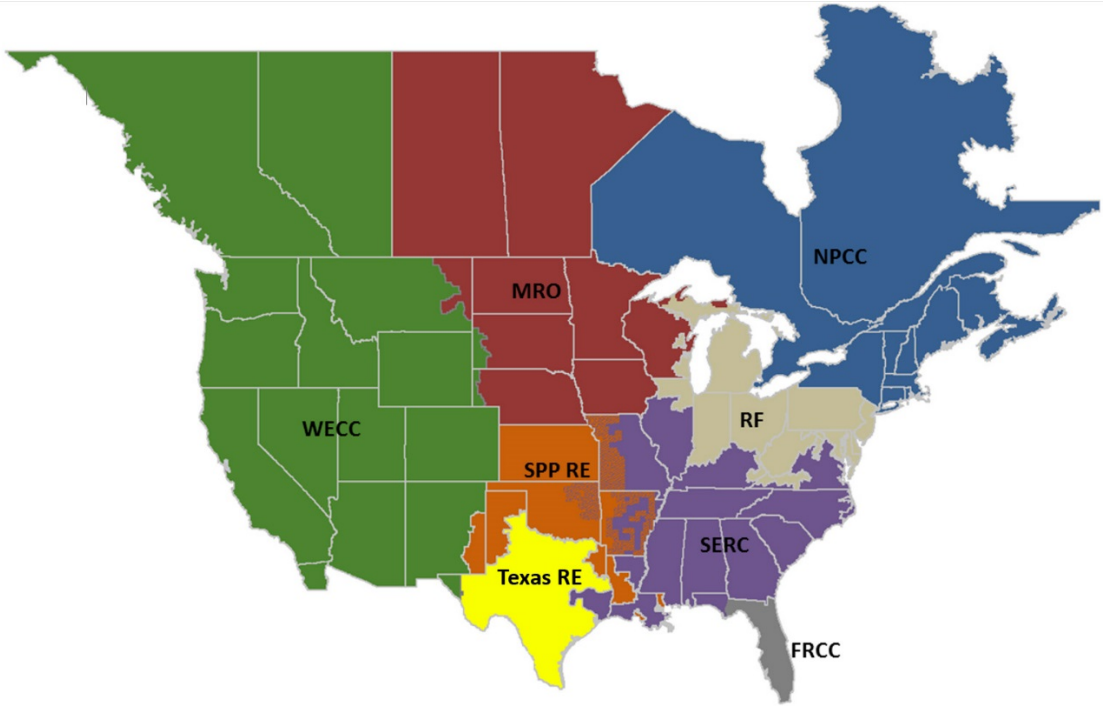
Preface

The North American Electric Reliability Corporation (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 develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; 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 is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into eight Regional Entity (RE) boundaries as shown in the map and corresponding table below.



The North American BPS is divided into eight Regional Entity (RE) boundaries. The highlighted areas denote overlap as some load-serving entities participate in one Region while associated transmission owners/operators participate in another.

FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP RE	Southwest Power Pool Regional Entity
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Introduction

The ERO Enterprise Strategic Plan and Metrics details the ERO Enterprise's[1] mission, vision, values, goals, and metrics as well as the planning process, direction, and priorities.

The ERO Enterprise annual planning process is informed by (1) *NERC's State of Reliability Report*; (2) the Reliability Issues Steering Committee's (RISC's) *ERO Reliability Risk Priorities Report*, which includes identified risk profiles; and (3) input from stakeholders, the NERC Board of Trustees, and Regional Entity Boards. These inputs are used by ERO Enterprise leadership as follows:

- **Review the Goals** – The ERO Enterprise considers whether the plan's goals, which reflect its view of its mission and key activities over the longer term, should be revised.
- **Update the Contributing Activities to the ERO Enterprise Goals** – The ERO Enterprise makes necessary adjustments to the contributing activities for each goal to identify focus areas over a rolling three year period.
- **Update the Metrics** – The ERO Enterprise makes necessary changes to the metrics, which are intended to measure progress in supporting the goals. Specifically, the metrics' measures of success, thresholds, and target are evaluated and adjusted annually as necessary.
- **Develop Annual Business Plans and Budgets (BP&Bs)** – Working collaboratively, NERC and each of the Regional Entities develop annual BP&Bs that reflect the resources necessary to support achievement of the goals and contributing activities set forth in the plan.

This document organizes and provides additional information regarding the items above in three sections as follows:

- **Vision, Mission, and Values** – Provides the ERO Enterprise's mission, vision, and an overview of the goals to carry out the mission. This section also details the ERO Enterprise's core values and principles.
- **Goals** – Describes each goal, the contributing activities that will be implemented over the next three years to achieve each goal, as well as metrics used to measure progress in accomplishing the goals. Where applicable, the contributing activities include references to related risk profile near-term and mid-term recommendations from the RISC.
- **Appendices** – Two separate appendices are included that provide additional supporting detail regarding the metrics (Appendix 1) and risk profiles (Appendix 2).

[1] The ERO Enterprise is comprised of NERC and the eight Regional Entities, which collectively bring together their leadership, experience, judgment, skills, and supporting technologies to fulfill the EROs' statutory obligations to assure the reliability of the North American BPS.

Vision, Mission, and Values

Vision

A highly reliable and secure North American bulk power system.

Mission

To identify, prioritize, and assure effective and efficient mitigation of risks to the reliability and security of the North American bulk power system.

Goals

The ERO Enterprise has five goals to help it to successfully carry out its mission.

Goal 1: Risk-responsive Reliability Standards

Goal 2: Objective and risk-informed compliance monitoring, enforcement, and organization certification and registration

Goal 3: Identification and mitigation of significant reliability risks

Goal 4: Identification and assessment of emerging risks

Goal 5: Effective and efficient ERO Enterprise operations

Core Values and Principles

The following core values and principles guide the conduct and behavior of all involved in the ERO Enterprise.

Accountability and Independence

- Be accountable for maintaining the public trust and fulfilling responsibilities delegated to an international ERO.
- Be impartial, independent of special interests, and impervious to improper influence.
- Balance the need for independent regulatory judgment with the need to involve those with expert knowledge and experience in reliability matters.

Responsiveness

Act in a timely manner on the basis of unfolding events, emerging reliability risks, and the needs of the public interest and stakeholders.

Fairness and Inclusiveness

- Be open and transparent.
- Provide access for clear communication with stakeholders.
- Ensure interests of all reliability stakeholders, including costs imposed on registered entities and the public, are duly considered and balanced.

Innovation and Adaptation

- Continuously assess and prioritize ERO Enterprise goals.
- Embrace change and encourage new ideas that contribute to effective, efficient reliable operations.

Excellence and Efficiency

- Promote the active participation of the best technical experts.
- Strive for excellence and efficiency in all aspects of ERO Enterprise business operations.
- Make informed decisions regarding efficient use and allocation of resources.

Integrity and Ethics

- Maintain the highest levels of professional competency and ethics.
- Maintain respectful relationships.
- Protect the security of confidential information.

Goal 1: Risk-responsive Reliability Standards

Goal Description

Reliability Standards establish threshold requirements for assuring the Bulk Electric System (BES) is planned, operated, and maintained to minimize risks of cascading failures, avoid damage to major equipment, or limit interruptions of the BPS. Reliability Standards are clear, timely, effective in mitigating risks to reliability, and consider cost-effectiveness/impact.

Contributing Activities

- Develop, modify, and conduct periodic reviews of the Reliability Standards to assure they are clear and properly structured for existing and emerging risks.
- Develop and implement ERO Enterprise and stakeholder feedback loops to identify and address any gaps or ambiguities in Reliability Standards. *(Risk Profile 9, Recommendation 12)*
- Review the recommendations from the Essential Reliability Services Task Force to determine if the current body of NERC's planning Reliability Standards sufficiently addresses the need for essential reliability services. *(Risk Profile 2, Recommendation 5)*
- Evaluate options for assessing the cost effectiveness/impact of Reliability Standards.
- Address regulatory issues and orders (e.g., supply chain and critical infrastructure protection Reliability Standards) and technical analysis supporting geomagnetic disturbance requirements. *(Risk Profile 7, Recommendation 1; Risk Profile 9, Recommendations 1 and 2)*
- Facilitate implementation of Reliability Standards by providing guidance or outreach for approved Reliability Standards. *(Risk Profile 8, Recommendation 1)*

Metrics

- Metric 1: Fewer, less severe events
- Metric 2: No gaps in Reliability Standards and compliance monitoring
- Metric 3: Resource deficiencies are foreseen
- Metric 4: No unauthorized physical or cyber security access resulting in disruption to BES facilities
- Metric 5: Reduced reliability risk from noncompliance
- Metric 6: Reduced risks in targeted areas

Goal 2: Objective and Risk-informed Compliance Monitoring, Enforcement, and Organization Certification and Registration

Goal Description

The ERO Enterprise is a strong enforcement authority that is objective, fair, and promotes a culture of reliability excellence through risk-informed compliance monitoring, enforcement, certification, and registration.

Contributing Activities

- Implement registration program improvements to ensure consistent technical basis for registration and deregistration of entities.
- Implement the certification program consistently across the ERO Enterprise.
- Develop and implement compliance oversight plans for registered entities focusing on relevant risks, including consideration of inherent risk assessments and internal control evaluations.
- Implement compliance monitoring and enforcement timely and transparently, using a consistent framework.
- Enhance and implement training for ERO Enterprise Compliance Monitoring and Enforcement Program (CMEP) staff.
- Provide guidance and outreach to registered entities, including the review of Implementation Guidance for endorsement.
- Reduce recidivism through rigorous assessment of registered entities' plans to mitigate noncompliance.
- Evaluate the existing compliance, reporting, and analysis tracking system and other compliance tools to support risk-based activities that meet the needs of the CMEP.

Metrics

- Metric 1: Fewer, less severe events
- Metric 2: No gaps in Reliability Standards and compliance monitoring
- Metric 4: No unauthorized physical or cyber security access resulting in disruption to BES facilities
- Metric 5: Reduced reliability risk from noncompliance
- Metric 6: Reduced risks in targeted areas

Goal 3: Identification and Mitigation of Significant Risks to Reliability

Goal Description

The ERO Enterprise identifies the most significant risks to reliability, provides assurance for mitigating reliability risks, and promotes a culture of reliability excellence. The ERO Enterprise supports the Electricity Information Sharing and Analysis Center, the Cybersecurity Risk Information Sharing Program, reliability assessments, performance analysis, event analysis, situational awareness, and physical security and cybersecurity preparedness.

Contributing Activities

- Develop guidelines and industry practices to maintain accurate system models that include the resources (synchronous and inverter based), load, and controllable devices providing essential reliability services. *(Risk Profile 1, Recommendation 1; Risk Profile 2, Recommendations 1, 3, and 4; Risk Profile 3, Recommendation 1)*
- Develop advanced and probabilistic methods to evaluate resource adequacy. *(Risk Profile 3, Recommendations 1 and 3)*
- Gather additional phasor measurement unit datasets to advance analytics and modeling improvements. *(Risk Profile 2, Recommendation 3)*
- Analyze system performance, events, and relationships among data sources to identify risks and mitigation strategies, and provide recommendations and lessons learned. *(Risk Profile 4, Recommendation 4; Risk Profile 6, Recommendations 3 and 4)*
- Expand the use, availability, and value of physical security and cybersecurity threat and vulnerability information sharing, including cross sector communications, and analytics. *Risk Profile 7,Recommendations 2 and 5; Risk Profile 8, Recommendations 2 and 3; Risk Profile 9, Recommendations 4–7)*
- In collaboration with the Critical Infrastructure Protection Committee and industry stakeholders, develop a risk process to address the potential impacts of cyber and physical security threats and vulnerabilities. *(Risk Profile 8, Recommendation 8; Risk Profile 9, Recommendations 3 and 7–9)*
- Conduct assessments of system resiliency and develop guidance for operations in a more secure state. *(Risk Profile 7, Recommendations 4 and 8; Risk Profile 8, Recommendations 6 and 7)*
- Engage industry, forums, and technical committees in identifying and mitigating risks, including reducing misoperations, AC substation equipment failures, vegetation-related outages, and improving cold weather preparedness and human performance. *(Risk Profile 4, Recommendations 1–3 and 5–7; Risk Profile 5, Recommendations 1–4; Risk Profile 6, Recommendations 5 and 6; Risk Profile 7, Recommendation 9)*

Metrics

- Metric 1: Fewer, less severe events
- Metric 2: No gaps in Reliability Standards and compliance monitoring
- Metric 3: Resource deficiencies are foreseen
- Metric 4: No unauthorized physical or cyber security access resulting in disruption to BES facilities
- Metric 6: Reduced risks in targeted area

Goal 4: Identification and Assessment of Emerging Risks to Reliability

Goal Description

The ERO Enterprise identifies, evaluates, studies, and independently assesses emerging risks to reliability.

Contributing Activities

- Enhance reliability assessments to reflect changing resource mix behavior, including distributed energy resources and essential reliability services, using probabilistic approaches that consider the variable and energy-limited nature of the evolving resource mix. *(Risk Profile 1, Recommendation 1; Risk Profile 3, Recommendation 4; Risk Profile 6, Recommendation 1)*
- Educate policy makers, regulators, and the industry of reliability effects and interconnection requirements for the changing resource mix. *(Risk Profile 1, Recommendations 1, 3, and 4)*
- Develop sufficiency/adequacy guidelines for essential reliability services, including considerations of reliability attributes under a more diverse resource mix and changing load behavior, such as ramping, reserve services, and voltage support. *(Risk Profile 3, Recommendations 1 and 6)*
- Assess risks associated with cross sector dependencies and single points of disruptions. *(Risk Profile 3, Recommendations 2 and 7; Risk Profile 7, Recommendation 3; Risk Profile 8, Recommendation 4)*
- Develop, acquire, and maintain necessary tools for efficient data collection, management, and analytics across the ERO Enterprise. *(Risk Profile 1, Recommendation 2; Risk Profile 4, Recommendation 4; Risk Profile 5, Recommendation 5)*
- Evaluate the reliability impacts of distributed energy resources on planning, operations, and restoration and recovery, including the identification of data and information sharing needs. *(Risk Profile 1, Recommendation 2; Risk Profile 2, Recommendations 2 and 4; Risk Profile 3, Recommendations 5 and 8; Risk Profile 6, Recommendation 7)*

Metrics

- Metric 1: Fewer, less severe events
- Metric 3: Resource deficiencies are foreseen
- Metric 4: No unauthorized physical or cyber security access resulting in disruption to BES facilities
- Metric 6: Reduced risks in targeted areas

Goal 5: Effective and Efficient ERO Enterprise Operations

Goal Description

The ERO Enterprise supports and encourages transparency, consistency, quality, efficiency, and timeliness of results and operates as a collaborative enterprise.

Contributing Activities

- Articulate a shared vision of reliability excellence and support and inspire stakeholders continent-wide in working to attain that vision.
- Acquire, engage, develop, and retain highly qualified talent with requisite technical expertise to execute the ERO Enterprise's statutory functions.
- Understand and manage ERO Enterprise internal risks.
- Enhance and implement documented oversight plans for Regional Entity delegated functions.
- Expand the efficiency and productivity of the ERO Enterprise through a disciplined approach to IT investments.
- Continue to efficiently and effectively manage resources within the ERO Enterprise.
- Quantitatively measure stakeholder satisfaction.

Metrics

Metric 7: NERC's efficiency and effectiveness

Appendix 1: Metrics

ERO Enterprise Metrics

There are six reliability metrics to measure progress on reliability improvement in support of the ERO Enterprise's goals. There is also one metric to measure NERC's efficiency and effectiveness. The metrics are designed such that the measures of success, thresholds, and targets are reviewed annually and adjusted for the next year as needed. The metrics are cumulative; in order to achieve target, threshold must be met.

1. **Fewer, less severe events**
2. **No gaps in Reliability Standards and compliance monitoring**
3. **Resource deficiencies are foreseen**
4. **No unauthorized physical or cyber security access resulting in disruption to BES facilities**
5. **Reduced reliability risk from noncompliance**
6. **Reduced risks in targeted areas**
7. **NERC's efficiency and effectiveness**

Metric 1: Fewer, less severe events		
Measure of success	Threshold	Target
Number and severity of BES events	• No Category 4 or 5 events • The slope of the cumulative trend line in the composite daily "event Severity Risk Index" (eSRI)[2] for Category 1–3 events remains flat	• No Category 3 events • The slope of the cumulative trend line in the composite daily eSRI for Category 1–3 events trends negative
Metric 2: No gaps in Reliability Standards and compliance monitoring		
Measure of success	Threshold	Target
Number of gaps in Reliability Standards and compliance monitoring	• Conduct gap analyses for five events, which include any unstudied Category 3 or above events, with the remainder being select events that occurred prior to the third quarter of the current calendar year.[3] Develop action plans to address any identified gaps in Reliability Standards and compliance monitoring.	• Based on the gap analyses conducted, zero gaps in Reliability Standards and compliance monitoring identified
Metric 3: Resource deficiencies are foreseen		
Measure of success	Threshold	Target
Number of unanticipated	• No firm load outages over 300 MW due to resource or essential	• No EEA-3 declarations for resource deficiencies. This excludes (1) any deficiencies or common mode failures identified as a risk in an assessment

[2] Measured on a rolling 5 year basis, including days with zero events and excluding Category 4 and 5 events, events caused by weather, flooding, earthquake, and AESO islanding. Other events that are high impact and infrequent, such as acts of war, are also excluded from the eSRI.

[3] Those events of interest that occur in the fourth quarter of the current calendar year can be included in a future year gap analysis.

<table>
<tr><td>resource deficiencies[4]</td><td>reliability services[5] deficiency, or common-mode failure.[6] This excludes deficiencies or common mode failures identified as a risk in an assessment during the past 3 years and not reported as resolved.</td><td>during the past 3 years and not reported as resolved and (2) any deficiencies that do not lead to a load shedding event</td></tr>
<tr><td colspan="3">Metric 4: No unauthorized physical or cyber security access resulting in disruption to BES facilities</td></tr>
<tr><td>Measure of success</td><td>Threshold</td><td>Target</td></tr>
<tr><td>Number of unauthorized physical or cyber security access resulting in disruption to BES facilities</td><td>• No firm load loss due to BES cyber attack
• No firm load shed more than 100 MW due to physical attack</td><td>• No disruption of the operations of the BES from cyber attack
• Flat or declining trend in physical security events affecting BES facilities over the most recent two year period reported under reported U.S.D.O.E. Emergency Incident and Disturbance Report Form QE-417 and NERC Reliability Standard EOP-004</td></tr>
<tr><td colspan="3">Metric 5: Reduced reliability risk from noncompliance</td></tr>
<tr><td>Measure of success</td><td>Threshold</td><td>Target</td></tr>
<tr><td>Number of severe violations and mitigation completion rates</td><td>• The downward trend from 2011 for the compliance severity index[7] (excluding CIP version 5) is statistically significant
• CIP compliance severity index (for all CIP standards including version 5) stays at or below 65% of the 2011 index
• 75% of all noncompliance is self-identified
• Mitigation[8] completion rates are as follows:
<table>
<tr><th>Noncompliance discovery year</th><th>Threshold</th></tr>
<tr><td>2016</td><td>70%</td></tr>
<tr><td>2015</td><td>85%</td></tr>
<tr><td>2014 and older</td><td>99%</td></tr>
</table></td><td>• Compliance severity index trend is 50% or less of the 2011 index (excluding CIP version 5)
• CIP compliance severity index (for all CIP standards including version 5) stays at or below 55% of the 2011 index
• 80% of all noncompliance is self-identified
• Reduced repeat moderate and severe risk violations
• Mitigation completion rates are as follows:
<table>
<tr><th>Noncompliance discovery year</th><th>Target</th></tr>
<tr><td>2016</td><td>75%</td></tr>
<tr><td>2015</td><td>90%</td></tr>
<tr><td>2014 and older</td><td>100%</td></tr>
<tr><td></td><td></td></tr>
</table></td></tr>
</table>

[4] Resource deficiency is defined as an operating condition that requires operators to manually shed firm load to maintain system stability due to a lack of available resources.

[5] Essential reliability service deficiency is defined as an operating condition that results in either of the following: 1) manual load shed to ensure stability of the BPS (pre-contingency) in respect to maintaining adequate voltage and voltage support or ramping capability, or 2) automatic load shed due to a lack of voltage or frequency support.

[6] Common-mode failure is defined as a disruption of infrastructure that impacts electricity supply, excluding force majeure events, e.g. weather, flooding, earthquakes, acts of god, war, etc.

[7] The *Compliance Severity Risk Index* is calculated by multiplying an assigned weight for the risk determination of a noncompliance to an assigned weight of the discovery method of the noncompliance.

[8] Excludes mitigations involving federal entities and matters in litigation.

Metric 6: Reduced risks in targeted areas		
Measure of success	Threshold	Target
a. Events caused by generating unit forced outages due to cold weather	• No firm load shed occurs from generating unit forced outages caused by cold weather	• Using most extreme cold winter months, the Effective Forced Outage Rate (EFOR) decreases compared to a rolling previous 5 year benchmark average for each Regional Entity[9]
b. Annual Misoperations rate of performance[10]	• Annual Misoperation rate of performance is less than 9%	• Annual Misoperation rate of performance is less than 8%
c. Number of automatic AC transmission outages caused by human error	• No events with load loss greater than 300 MW caused by human error	• Number of transmission line outages per circuit caused by human error is declining by 5% and outage impacts[11] are declining • Declining number of events from transmission line outage caused by human error resulting in firm load loss based on a rolling 5-year average
d. Number of transmission outages due to AC substation equipment failures	• No events with load loss greater than 300 MW caused by AC substation equipment failures	• Number of transmission line outages per circuit caused by AC substation equipment failures declines by 5% and outages are declining • Reduce the number of events from AC substation equipment failures resulting in firm load loss based on a rolling 5-year average
e. Number of transmission line[12] outages due to vegetation	• No transmission line outages due to FAC-003 violations	• No more than 15 Sustained Outages caused by vegetation (e.g., blow-ins, fall-ins) that are not violations of FAC-003-
Metric 7: NERC's efficiency and effectiveness		
Measure of success	Threshold	Target
a. Execution of BP&B	• NERC will be at or under budget for expenses and fixed assets exclusive of the authorized use of operating reserves	• NERC will be at or under budget for expenses and fixed assets inclusive of the authorized use of operating reserves with the exception of authorized reserve expenditures resulting from a FERC directive which was not in existence at the time the final 2017 BP&B was provided to the Board for approval
b. Implementation of ERO Enterprise technology solutions		• Complete ERO Enterprise IT projects for Entity Registration, Enterprise Reporting Phase 4 (data for event analysis, misoperations, or TADS), and NERC's public-facing website on time, on budget, and with expected functionality

[9] The sample will be based on the ten most extreme cold weather months between the months of December and March over the measurement period.

[10] Lines operated at 100 kV and above. The annual Misoperations rate of performance will be calculated based on data from June 2016 to June 2017.

[11] Lines operated at 200 kV and above

[12] Lines operated at 200 kV and above

		• Develop a method to measure and track the cost benefit of ERO Enterprise IT projects
c. Implementation of the Regional Entity oversight plans and NERC adherence to Rules of Procedure		• Implement the recommendations and schedule from audit findings identified in 2016 by the Compliance and Certification Committee and NERC's internal audit department • No significant new noncompliance findings in NERC's implementation of the Regional Entity oversight plans or adherence to the Rules of Procedure
d. Implementation of action plans in response to ERO Enterprise Effectiveness Survey results		• Implement the 2017 milestones identified in the action plans as accepted by the Board of Trustees in 2016

Appendix 2: 2016 Risk Profile Recommendations

The 2016 *ERO Reliability Risk Priorities Report* sets forth the results of the RISC's continued work to define and prioritize risks for the reliable operation of the BPS and provides recommendations to enhance reliability and manage those risks. The risk profiles include a description of the risk to BPS reliability as well as recommendations in mitigating the risk.

Risk Profile #1 – Changing Resource Mix (High Priority)

The change to the resource mix is accelerating due to fuel costs, subsidies, and federal, state, and provincial policies. Transmission planners, Balancing Authorities, and system operators of the BPS may not always have sufficient time to develop and deploy plans to mitigate reliability considerations with various resource additions and retirements.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The ERO Enterprise and industry should continue to conduct interconnection-wide technical studies, such as frequency and inertia response, voltage support, short-circuit analysis, inter-area oscillation assessments, and electric and gas dependency studies. Also, through a stakeholder outreach and input process, inform and educate policy makers and the industry of reliability effects and interconnection requirements for the changing resource mix.
2. The ERO Enterprise should develop an effective means to gather data and insights into distributed energy resources (i.e., customer, distribution, or otherwise), and formulate plans to achieve the appropriate level of transparency and control such that implications to the BPS can be better understood.
3. Expand the collaboration, through the technical committees, with the Regional Transmission Operators (RTO)/Independent System Operators (ISOs) Council, Balancing Authorities in non-RTO/ISO market areas, other registered entities, and regulators on ERS recommendations for effective implementation as they emerge.
4. The ERO Enterprise should continue to provide independent technical assessments of the reliability impacts from the changing resource mix driven by proposed state, provincial, or federal statues and transmission provider tariffs.

Mid-term (3–5 year timeframe):

5. Policy makers should engage in high-level collaboration among market operators (RTOs/ISOs), balancing authorities in non-RTO/ISO market areas, and provinces and states to establish long-term strategies for aligning policies with reliability needs.

Long-term (greater than 5-year timeframe):

6. The ERO Enterprise should continue working with industry stakeholders and policy makers on reliability attributes essential to support the long-term reliability of the BPS, including equipment controls that enable system support from variable energy resources, accommodating distributed energy resources such as small end-use customer resources, distributed energy resource performance, and synchronous generation retirements.

Risk Profile #2 – BPS Planning (High Priority)

BPS planning is transitioning from centrally planned and constructed resources based on forecasted load growth and reliability projects to more reactive, rather than proactive, planning based on the integration of new resources and technologies driven by policies and incentives. Due to the lack of visibility, certainty, and speed that these resources are being integrated in some areas, planners currently may lack the ability to update or create system models and scenarios of potential future states to identify system reliability needs. Planners may not have sufficient time to implement mitigation plans or reliability upgrades to address likely scenarios, driving the need for more real-time operating procedures.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The ERO Enterprise should coordinate and work with industry and manufacturers and developers of asynchronous resources to develop accurate dynamic models and make them available.
2. The ERO Enterprise should identify the type and frequency of information needed from distributed energy resources.
3. The ERO Enterprise should develop guidelines and best practices for developing and maintaining accurate system and electromagnetic models that include the resources, load, and controllable devices that provide ERS. This would add the benchmarking of dynamic models with Phasor Measurement Units (PMU) measurements based on actual system response to disturbance.
4. NERC should continue to collaborate with Planning Coordinators to expand development of interconnection-wide models commensurate with expected dispatches. This collaboration will support the ability to conduct more effective long-term planning assessments.

Mid-term (3–5 year timeframe):

5. Continue to assess the system performance to determine if the current body of planning Reliability Standards is sufficient to address ERS.
6. NERC should collaborate with Planning Coordinators to assess the impact on reliability from well-head, storage, and fuel delivery issues and how to assess them in long-term planning studies.
7. Improve load forecasting, generator modeling, and coordination between BPS and distribution system planners and operators.

Long-term (greater than 5-year timeframe):

8. Encourage vendors of power system simulation software to develop programs to enhance dynamic load modeling capabilities.

Risk Profile #3 – Resource Adequacy and Performance (High Priority)

The resource mix and its delivery is transforming from large, remotely-located coal and nuclear-fired power plants, towards gas-fired, renewable energy limited, and distributed energy resources. These changes in the generation resource mix and the integration of new technologies are altering the operational characteristics of the grid and will challenge system planners and operators to maintain reliability. Failure to take into account these characteristics and capabilities can lead to insufficient capacity, energy, and ERS (sometimes called “ancillary services”) to meet customer demands.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The ERO Enterprise and the industry should continue to develop improved modeling and probabilistic methods to evaluate resource adequacy. This includes continued sharing of emerging trends and insights from assessments for effective resource planning and operating models. Adequacy and capacity may include augmenting the measurements of ERS, coordination of controls, balancing load with generation regardless of the location of resources, and energy adequacy in light of installed and available capacity from variable generation.
2. The ERO Enterprise should assess and develop mitigation recommendations as necessary to address single points of disruption, such as fuel contingencies, that will result in large resource outages.
3. The ERO Enterprise and the industry should continue to expand the use of probabilistic approaches to develop resource adequacy measures that reflect variability and overall reliability characteristics of the resources and composite loads, including other than seasonal peak conditions.
4. The ERO Enterprise should generate scenarios for reliability assessments that focus on the location of resource retirements and the impact on ERS.
5. Improve load forecasting, generator modeling, and coordination between BPS and distribution system planners and operators.

6. The ERO Enterprise should develop new measures of reliability beyond reserve margins, including measures on the sufficiency of ERS.
7. The ERO Enterprise and industry should continue to assess vulnerabilities from fuel availability as part of evaluating adequacy and capability to deliver resources.
8. Analyze data requirements necessary to ensure there is sufficient detail on the capability and performance of the BPS as it is impacted by distributed energy resources. The industry should gather data beyond simple demand forecasts and expand to identify resource capacity, location, and ERS capability.

Risk Profile #4 – Asset Management and Maintenance (Low Priority)

As the system ages and operations are modified, asset management programs also change. Failure to properly commission, operate, maintain, prudently replace, and upgrade BPS assets, such as those nearing their end-of-life, could result in more frequent and wider-spread outages that are initiated or exacerbated by equipment failures or protection and control system failures.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. Increase the use of NERC's Alert program to provide more detail on information requests from industry on specific assets, earlier dissemination of detailed reports, and potential follow-up activities involving maintenance and management of assets.
2. The ERO Enterprise, in coordination with industry, should improve data gathering for equipment failure modes and improve the dissemination among equipment owners, manufacturers, and associated vendors.
3. Continue to conduct webinars on equipment event lessons learned, equipment maintenance, and seasonal preparedness.
4. Continue to evaluate performance trends using additional data collected by event analysis to extract insights, issues, and trends for dissemination across industry participants.
5. Industry forums and trade groups should learn from successful asset management programs, maintenance, and lessons learned to gain insights on trends in effective asset maintenance and increase dissemination of best practices.
6. The ERO Enterprise should work with industry experts to develop industry guidelines on protection and control system management to improve performance.
7. Assess system performance to determine whether the current family of protection and control standards needs to be enhanced.

Mid-term (3–5 year timeframe):

8. Coordinate with the forums, research organizations, and technical committees to establish sharing of technologies or processes that aid in condition monitoring, failure prevention, spare sharing, and recovery.
9. Coordinate with the US, Canadian, and Mexican energy agencies and industry to support power transformer reserve programs.
10. The ERO Enterprise should provide technical basis for industry to support recovery of upgrade and maintenance costs for reliability purposes.

Long-term (greater than 5-year timeframe):

11. The industry should implement best practices from the sharing of technologies or processes that aid in condition monitoring, failure prevention, spare sharing, and recovery.

Risk Profile #5 – Human Performance and Skilled Workforce (Low Priority)

The BPS is becoming more complex, and as the industry faces turnover in technical expertise, it will have difficulty staffing and maintaining necessary skilled workers. In addition, inadequate human performance (HP) makes the grid more susceptible to both active and latent errors, negatively affecting reliability. HP weaknesses may hamper an organization's ability to identify and address precursor conditions to promote effective mitigation and behavior management.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The HP groups at the ERO Enterprise and industry forums should expand their communication of insights throughout the industry regarding best practices for increasing HP effectiveness (publishing lessons learned/best practices and supporting the NERC HP conference and other related workshops).
2. NERC should encourage industry and key trade associations to determine the extent of expected skill gaps and develop recommendations to address the skill gaps (e.g., curricula, programs, industry support).
3. The ERO Enterprise, trade associations, and industry should promote expanding training and education programs to include HP and recruitment of the next generation of skilled workers.
4. The ERO Enterprise and the industry should promote the use of NERC cause codes to establish a common understanding of HP triggers, collect and evaluate trends in data, and develop metrics as needed.
5. Explore the development and widespread use of a near-miss database which will leverage data sources such as event analysis, near miss databases, Transmission Availability Data System (TADS), Generating Availability Data System (GADS), Demand Response Availability Data System (DADS), relay misoperations, EOP-004/OE-417 Reports, and AC equipment failures to identify patterns and risk.

Mid-term (3–5 year timeframe):

6. Consider and implement high value recommendations developed to address skills gaps identified in the short-term mitigation mentioned in the 1–2 year timeframe.

Long-term (greater than 5-year timeframe):

7. Industry should develop and implement a sustainable process to analyze and disseminate best practices for HP.

Risk Profile #6 – Loss of Situational Awareness (Moderate Priority)

Information sharing will be vital for visibility and a complete understanding of the impacts and contributions of distributed energy resources to the BPS. Inadequate situational awareness can be a precursor or contributor to BPS events. Loss of situational awareness can also occur when control rooms are not staffed properly or operators do not have sufficient information and visibility to manage the grid in real-time. Additionally, insufficient communication and data regarding neighboring entity's operations is a risk as operators may act on incomplete information.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The ERO Enterprise should develop new measures of reliability beyond reserve margins, including sufficiency of ERS.
2. The ERO Enterprise should develop real-time notification of interconnection anomalies and outliers (e.g., large load or resource losses, large oscillations, large angle changes, low inertia).
3. The ERO Enterprise should continue to perform a root cause or common mode failure analysis of partial and full loss of key EMS capability using events analysis information and provide lessons learned and recommendations to reduce the likelihood of failure.
4. The ERO Enterprise should evaluate whether certain important applications are over reliant on a single service provider and identify mitigating actions to reduce the risk.
5. Work with the forums on an approach for ongoing identification, cataloging, and sharing of good practices related to operating tools.

6. The ERO Enterprise should develop a guideline on situational awareness for the industry to address data modeling and information sharing.
7. The ERO Enterprise should identify the type and frequency of information needed from distributed energy resources for real-time situational awareness.

Mid-term (3–5 year timeframe):

8. Develop and implement a set of real-time indicators of interconnection health.
9. The ERO Enterprise should engage industry and trade organizations to develop a list of key tasks and learning objectives for wide-area monitoring as well as assessing status following system events.
10. The ERO Enterprise should engage EPRI to develop a supplement or companion to the Interconnected Power System Dynamics Tutorial that deals with wide-area monitoring under a changing resource mix based on the near-term deliverables above.

Long-term (Greater than 5-year timeframe):

11. The ERO Enterprise should engage industry and trade organization and the North American Synchrophasor Initiative (NASPI) to develop a suite of supplemental and back-up tools that use synchrophasor data.
12. Establish a forum with EMS vendors to leverage the near-term and mid-term suggestions for improvement of situational awareness tools.

Risk Profile #7 – Extreme Natural Events (Moderate Priority)

Severe weather or other natural events (e.g., hurricanes, tornadoes, protracted extreme temperatures, GMDs, floods, earthquakes, etc.) are one of the leading causes of outages. Severe weather can cause BPS equipment damage, fuel limitations, and disruptions of voice and data communications, which can cause loss of load for an extended period.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. Complete the GMD Reliability Standards and start geomagnetic induced currents (GIC) data gathering and analysis.
2. E-ISAC and industry should expand communications among information sharing analysis centers (ISACs), including the Telecommunications, Water, and Natural Gas ISACs.
3. Study multiple simultaneous limitations on natural gas deliveries during extreme weather.
4. Participate in exercises that incorporate extreme physical events and implement recommendations from exercise or drills such as GridEx.
5. Incorporate E-ISAC and Electricity Subsector Coordinating Council (ESCC) communications protocols into industry disaster preparedness processes.
6. The industry, trades, and forums should evaluate inventories of critical spare transmission equipment and increase as required.
7. The Department of Energy, the industry, trades, and forums should identify appropriate mitigations to prevent spare equipment gaps and improve transportation logistics.
8. The ERO Enterprise and the industry should leverage best practices and the sharing of lessons learned to expand coordination during extreme weather events among Reliability Coordinators, Balancing Authorities, and Transmission Operators.
9. NERC and industry should plan a workshop that is coordinated with U.S. federal agencies, Canadian, and Mexican governmental authorities to address high-impact low-frequency event response, recovery, and communications vulnerabilities.

Mid-term (3–5 year timeframe):

10. Identify and promote specific resiliency best practices to plan for extreme events.
11. The ERO Enterprise should conduct more detailed special assessments that integrate:
    a. Natural gas availability, pipeline capacity, and storage facility impacts on reliability under severe scenarios.
    b. Other interdependencies, such as long-haul communications and water supply.
    c. Analytic data trend insights regarding resiliency under severe weather conditions, identifying preventable aspects for BPS reliability.
12. The ERO Enterprise should apply the severity risk index (SRI), on a more granular regional level to measure system resilience and restoration performance for loss of generation, transmission, and load. These efforts should consider or develop new comparative and descriptive metrics.
13. The ERO Enterprise should perform trend analysis on historical impacts on the BPS of extreme natural events.

Long-term (Greater than 5-year timeframe):

14. Analyze data from GMD events to further the understanding of GIC effects on Bulk Electric System facilities to support enhancements to models and standards.
15. Institutionalize relationships among ESCC, government, and industry partners to enhance the culture of recognizing and addressing extreme physical event preparedness across industry.
16. Develop a plan to review and improve the trend of SRI as indicative measure of system resilience and restoration performance for loss of generation, transmission, and load.
17. To facilitate preparedness, consider preparing sensitivity analyses to simulate the impacts from the most extreme natural events experienced to date in a planning area.

Risk Profile #8 – Physical Security Vulnerabilities (Moderate Priority)

Intentional damage, destruction, or disruption to facilities can cause localized to extensive interconnection-wide BPS disruption potentially for an extended period.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. The ERO Enterprise should continue to oversee the implementation of NERC's Physical Security Reliability Standard entitled Critical Infrastructure Protection (CIP-014-2).
2. E-ISAC and industry should expand communications among information sharing analysis centers (ISACs), including the Telecommunications, Water, and Natural Gas ISACs.
3. The ERO Enterprise should develop effective metrics formulated to understand the trend of physical attacks and potential threats.
4. Assess the risks of physical attack scenarios on midstream or interstate natural gas pipelines, particularly where natural gas availability will impact generation and the reliability of the BPS in NERC's long-term reliability assessments and planning activities.
5. Promote existing and new efforts to improve a spare equipment strategy and prioritization.
6. Develop a catalog of regional/national exercises that incorporate extreme physical events and share with industry, thus supporting increased participation across industry. Whenever possible, expand exercises to include more facilities and industries.
7. The forums and trades should perform the following activities:
    a. Identify and promote specific resiliency and vulnerability assessment best practices with planning for extreme events, including good physical security assessment practices.
    b. Develop an event guideline outlining prevention strategies and event response and recovery protocols for sabotage scenarios.

8. In collaboration with the Critical Infrastructure Protection Committee and industry stakeholders, develop a risk process to address the potential impacts of physical security threats and vulnerabilities.

Mid-term (3–5 year timeframe):

9. The industry should review and update restoration plans while accounting for physical security scenarios.
10. Develop performance and metrics reporting on joint E-ISAC and Telecommunications ISAC assessments of potential physical attack disruptions while differentiating from vandalism or theft incidents.
11. Conduct a special regional assessment that addresses natural gas availability and pipeline impacts under physical attack scenarios.
12. The Department of Energy, the industry, trades, and forums should identify appropriate mitigations to spare equipment gaps and transportation logistics.
13. The ERO Enterprise, the industry, trades, and forums should evaluate inventories of critical spare transmission equipment as necessary based on a spare equipment strategy and prioritization.
14. The industry should evaluate mechanisms for cost recovery of implementing specific resiliency strategies by the industry.
15. Industry should work with the technical committees and forums to develop mitigation strategies and physical security assessment best practices.
16. Expand participation in security exercises other than GridEx in order to reflect extreme physical events.
17. Facilitate planning considerations to reduce the number/exposure of critical facilities.

Long-term (Greater than 5-year timeframe):

18. Institutionalize relationships among ESCC, government, and industry partners to enhance the culture of recognizing and addressing extreme physical event preparedness across industry.
19. Foster the development of methods, models, and tools to simulate system reliability impacts for the planning and operational planning time horizons.

Risk Profile #9 – Cybersecurity Vulnerabilities (High Priority)

Exploitation of cybersecurity vulnerabilities can potentially result in loss of control or damage to BPS-related voice communications, data, monitoring, protection and control systems, or tools. Successful exploitation can damage equipment, causing loss of situational awareness and, in extreme cases, can result in degradation of reliable operations to the BPS, including loss of load.

Recommendations for Mitigating the Risk

Near-term (1–2 year timeframe):

1. Address FERC critical infrastructure protection (CIP) directives in *Revised Critical Infrastructure Protection Reliability Standards*, 154 FERC ¶ 61,037 (2016).
2. Address FERC directives in *Revised Critical Infrastructure Protection Reliability Standards*, 156 FERC ¶ 61,050 (2016) on supply chain risk management.
3. In collaboration with the Critical Infrastructure Protection Committee (CIPC) and industry stakeholders, develop a risk process to address the potential impacts of cyber security threats and vulnerabilities.
4. NERC should continue information sharing protocols among interdependent information sharing analysis centers (ISACs).
5. The E-ISAC should continue outreach to industry to increase registration and utilization of E-ISAC portal.
6. The E-ISAC should mature the cybersecurity risk information sharing program (CRISP) and encourage expanded participation.
7. NERC and the CIPC should prioritize lessons learned from regional and national exercises (*e.g.*, GridEx) and publish lessons learned and guidelines as needed.

8. Facilitate planning considerations to reduce the number/exposure of critical facilities.
9. The industry should encourage the development of a peer review process for emerging risks.
10. The industry should create and foster an internal culture of cyber awareness and safety.
11. NERC should develop effective metrics formulated to understand the trend of cyber-attacks and potential threats.

Mid-term (3–5 year timeframe):

12. The ERO Enterprise should develop a feedback mechanism from CIP standards implementation to evaluate the standard and lessons learned from technology deployment.
13. The ESCC should operationalize the cyber mutual assistance framework to address issues with recovery after a cyber-attack.
    a. Cross-industry sharing of best practice incident response plans.
    b. Creation and/or expansion of security operations centers that incorporate the BPS (IT/OT convergence areas).
14. Assist industry efforts to address supply chain vulnerability.
15. The ERO Enterprise with industry should develop agreed-upon levels of cyber-resilience suitable for BPS planning and operations.

Long-term (Greater than 5-year timeframe):

16. The ERO Enterprise and industry should develop methods, models, and tools to simulate cyber impacts on system reliability, enabling BPS planning to withstand an agreed-upon level of cyber resiliency.
17. The ERO Enterprise and industry should develop industry operating guidelines that incorporate an agreed-upon level of cyber resilience.
18. The ERO Enterprise should create and document pathways that enable the integration of new technologies while maintaining or enhancing the agreed-upon level of cyber resilience.