Resilience Framework

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About NERC: Mission

To assure the effective and efficient reduction of risks to the reliability and security of the grid

- Develop and enforce reliability standards
- Assess current and future reliability
- Analyze system events and recommend improved practices
- Encourage active participation by all stakeholders
- Accountable as Electric Reliability Organization (ERO) to regulators in the United States (Federal Energy Regulatory Commission) and Canada (National Energy Board and provincial governments)
• NERC work and NERC/DOE collaboration recognized in Grid study
• NERC’s Reliability Issues Steering Committee tasked to develop framework for resilience
• Develop common framework, understanding, and definition of the key elements of bulk power system (BPS) resilience
  ▪ National Infrastructure Advisory Council’s (NIAC) resilience framework
    o Robustness, Resourcefulness, Rapid Recovery, Adaptability
  ▪ Adequate Level of Reliability definition and technical report
• Understand how key elements of bulk power system resilience fit in the existing ERO framework
• Identified current NERC activities within the NIAC framework
• Evaluate whether additional steps are needed to address key elements of bulk power system resilience within the ERO
• Discussed at NERC’s February 2018 Member Representatives Committee meeting
• Regional Transmission Organization/Independent Service Operator FERC filing
• Standing Committees (i.e. Planning, Operating, Critical Infrastructure, Standards, etc.)
• NIAC’s resilience framework with adjustments in red:
  ▪ Robustness – to absorb shocks and continue operating
  ▪ Resourcefulness – **detect and** manage a crisis as it unfolds
  ▪ Rapid Recovery – get services back as quickly as possible **in a coordinated and controlled manner**
  ▪ Adaptability – incorporate lessons learned from past events to improve resilience
Activities Supporting Framework

- Robustness
  - Risk, event, and performance monitoring
  - Reliability and emerging risk assessments
  - Technical committee work, including special projects
  - System operator training, certification, and credential maintenance
  - Reliability Standards and Reliability Guidelines
  - E-ISAC information-sharing programs

- Resourcefulness
  - Situational awareness and industry coordination
  - Government coordination
  - Cross-sector information sharing
  - Reliability Standards Functional Model and Reliability Guidelines
  - System operator training, certification, and credential maintenance
Activities Supporting Framework

- **Rapid Recovery**
  - Situational awareness and industry coordination
  - Government coordination
  - Cross-sector information sharing
  - Reliability Guidelines
  - System operator training, certification, and credential maintenance

- **Adaptability**
  - Reliability and emerging risk assessments
  - Event analysis, forensics, and lessons learned
  - Reliability Guidelines
  - System operator training, certification, and credential maintenance
  - Periodic reviews
• Revisions to standards process templates and training materials
• Increased communication of NERC’s ongoing resilience and risk mitigation efforts
• Compliance monitoring focus on standards supporting resilience
• Recommend additional focus on:
  ▪ Operational impacts of distributed energy resources
  ▪ Fuel assurance and security to promote resilience
  ▪ Quality of emergency preparedness
NERC’s view of reliability for the bulk power system consists of two fundamental and aspirational concepts:

- **Adequacy**, the ability of the electric system to supply the aggregate electric power and energy requirements of electricity consumers at all times, taking into account scheduled and reasonably expected unscheduled outages of system components.

- **Operating reliability**, the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system components.
Resilience is a Characteristic of a Reliable System

NERC Reliability Assessments and Performance Analysis
- Reliability Assessments
- System Analysis
- Events Analysis
- Performance Analysis
- Situational Awareness

Operator Training

E-ISAC

* Solely the Bulk Power System. Does not include local distribution systems.
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Operator Training

E-ISAC

NERC Reliability Assurance
- Standards
- Compliance
- Enforcement
- Registration
- Certification

Bulk Power System Reliability and Security

Bulk Power System Resilience*

Bulk Electric System Reliability

* Solely the Bulk Power System. Does not include local distribution systems.
Adequate Level of Reliability:
- No instability, uncontrolled separation, cascading, or voltage collapse
- Frequency is maintained within defined parameters
- Voltage is maintained within defined parameters
- Adverse Reliability Impacts beyond design criteria are managed
- Restoration after major system disturbances is coordinated and controlled
Disruption on BPS

Reliability

$R(t)$

$R_{100\%}$ Reliable

$R_{Target}$

$R_{ALR-Nadir}$

Disruptive Event

If Detectable, Pre-Position

Reliable Operation

Degradation Profile

Rebound Profile

Recovered Steady-State

$t$

$T_{disruption}$

$T_{rebound}$

$T_{recovered}$

Recovered Steady-State

If Detectable, Pre-Position

Reliable Operation

Degradation Profile

Rebound Profile

Recovered Steady-State
Resilience Framework

- **Disruptive Event**
- **If Detectable, Pre-Position**

**Reliability**
- \( R_{100\%} \) Reliable
- \( R_{\text{Target}} \)
- \( R_{\text{ALR-Nadir}} \)

**Recovery Period**
- Coordinated & Controlled Recovery

**Degradation Profile**

**Rebound Profile**

**Recovered Steady-State**

**Robustness**
- Disaster Prevention and Maintenance Period

**Resourcefulness**
- Resistance Period

**Adaptability**
- Lessons Learned and Implementation Period

**T_{\text{disruption}}**

**T_{\text{rebound}}**

**T_{\text{recovered}}**
Resilience Indicators

- **Disruptive Event**
- **Degradation**
- **Recovery**
- **Recovery State**
- **Amplitude**
- **Robustness**

- **$R(t)$**
- **$R_{100\%}$** Reliable
- **$R_{Target}$**
- **$R_{ALR-Nadir}$**

- **$T_{disruption}$**
- **$T_{rebound}$**
- **$T_{recovered}$**

- **If Detectable, Pre-Position**
- **Improved**
- **Stable**
- **Deteriorated**
Ensuring Adequate Level of Reliability

- **Disruptive Event**: If detectable, pre-position.
- **Reliability Components**:
  - $R_{100\%}$: Reliable
  - $R_{\text{Target}}$ (Target Reliability)
  - $R_{\text{ALR-Nadir}}$ (ALR-Nadir Reliability)

- **Reliable Operation**
- **Degradation Profile**
- **Rebound Profile**
- **Recovered Steady-State**

- **Avoid & Control** (e.g., serve critical load)

- **Key Times**:
  - $T_{\text{disruption}}$
  - $T_{\text{rebound}}$
  - $T_{\text{recovered}}$
• Await reply comments from industry on FERC’s resilience proceedings
• Monitor FERC’s response to comments
• Discuss suggested additional activities
• Present recommendations to NERC’s Board of Trustees in August and discuss additional work
Questions and Answers
• **Robustness**: the measured ability to withstand certain threats

• **Amplitude**: a measure of the impact on BPS performance

• **Degradation**: a measure of a change in system response with respect to an impact of varying amplitude

• **Recovery**: a measure of the rate at which the system returns (rebounds) to a normal or stable state after the disruptive event, including any preparation time

• **Recovery state**: the state of BPS performance following the recovery period.
  - Stable
  - Improved
  - Deteriorated
A Reliable System is a Resilient System

- The 2005 Federal Power Act requires NERC to develop and enforce Reliability Standards that:
  - Support reliable operations.
  - Provide for an adequate level of reliability.
- System with an adequate level of reliability is resilient
  - Industry has designed a reliable bulk power system that is robust, resourcefully operated, and rapidly recovers
  - Lessons learned are actively considered during and after an event