Measuring the Effectiveness of Utility Resilience Programs

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Defining Resilience

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Elements of Resilience

To determine how to measure resiliency, a good working definition is required. Several national organizations have proposed definitions, converging closer to an industry consensus.

IEEE- Anticipate the impact, resist discontinuity of service, and restore service with rapidity, to critical loads in the system.

EPRI- Damage Prevention, System Recovery, and Survivability

FERC 2018 and CIGRE- Withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event.

Sandia- The ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions

Climate Change

Climate Change Impacts

- The impacts of climate change are expected to lead to more frequent and severe weather events, increasing the probability of power outages
- A resilience plan driven by climate change must include both **mitigation** factors to reduce the impact of climate change, and **adaptation** factors to adjust to the impacts too late to change.
- While the clean energy transition will spearhead National Grid's **mitigation** efforts, we have also developed **adaptation** plans to better protect our networks from severe weather.
- Every employee knows that their top priority is to keep the lights on for our customers.
- **Adaptation** plans require a holistic approach that incorporates investments in resilient assets and work practices that maximize operation of the system.
- A resilient grid requires investments in an array of assets that focus on Damage Prevention, System Recovery, and Survivability.

Climate Change Vulnerability Study

Climate Change Mitigation vs. Adaptation

REV, CLCPA, and other initiatives focus on reducing carbon emissions and **mitigating** the effects of climate change

The Climate Change Vulnerability Study & Resilience plan are focused on identifying vulnerabilities and recommending storm hardening and resilience measures to **adapt** to the impacts of climate change

Legislation & associated PSC Order

NY Public Service Law PSL §66(29) was updated to require electric utilities to submit a climate change vulnerability study and resilience plan in the fall of 2023

NYS PSC subsequently issued an order (22-E-0222) with additional clarifications and questions which the JUs responded to.

Purpose – Be Proactive and Forward Looking

Traditionally, electric utilities have prepared for the future by making sure we are able to handle the worst events we've experienced in the past (wind, icing, etc.)

Given the latest climate projections over the next 20+ years, that won't be good enough

We need to be proactive in identifying vulnerabilities based on future climate projections and develop plans **now** to identify affordable ways to maintain electric system reliability and resilience

Climate Change Vulnerability Study Plan

Climate Information that will inform our study & plan

- **NYSERDA/Columbia** –Temperature, precipitation, & extreme weather events for 12 NY regions through 2100
- **MIT Study** – Detailed wind speed and icing data at 3x3km grid resolution through 2041
- **Climate Change Risk Tool (CCRT)** – General risk for 9 climate hazards at 7x7km grid resolution through 2070
- **EPRI Climate READi Program** – Workstream 1 on Physical Climate Data & Guidance starting late 2022
- **Climate Vulnerability Study & Plan** - ConEd filed in 2019/2020 (well received by NY DPS Staff – to be used as example)

Deep Dive Groups & Leads:

- Transmission Line
- Substations
- Substations (Civil)
- Operations
- Distribution Lines
- Forecasting
- Emergency Response
- Stakeholder Engagement

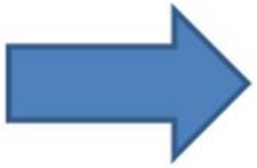
Programs

Resiliency Spending Rationale

Reliability and Resiliency

OLD

Reliability
Reliability
Costs to improve reliability performance or pocket performance, reconductor due to mechanical capacity, replace bare conductor to minimize tree interruptions, correct hazardous conditions, replace open wire secondary, replace service due to condition, install sectionalizing equipment increase pole size for spacing or clearance
-Network Transformer DGA Monitors
-Sub T Automation
-Distribution Line Sensors/Monitors
-Advanced Distribution Automation (ADA)
-Engineering Reliability Review (ERR)
-Reliability
-Secondary Network Arcflash Mitigation
-Side Tap Fusing
-Storm Hardening
-Substation Flood Mitigation
-Substation Mobile



NEW

Reliability	Resiliency
Reliability	Costs associated with resiliency projects created to provide the ability of Electric Power Systems(EPS) to recover quickly following a disaster or the ability of anticipating extraordinary and high-impact, low probability events, & rapidly recovering from these disruptive events.
Costs to improve reliability performance or pocket performance, reconductor due to mechanical capacity, replace bare conductor to minimize tree interruptions, correct hazardous conditions, replace open wire secondary, replace service due to condition, install sectionalizing equipment increase pole size for spacing or clearance	Network Transformer DGA Monitors
-Engineering Reliability Review (ERR)	-Sub T Automation
-Reliability	-Distribution Line Sensors/Monitors
-Secondary Network Arcflash Mitigation	-Advanced Distribution Automation (ADA)
-Side Tap Fusing	-FLISR
-Storm Hardening	-Targeted Feeder Tie Enhancements
-Substation Flood Mitigation	-Microgrids
-Substation Mobile	-T-Line Splitting
	-Remote Control Switches
	-Additional T-Line Sources
	Programs in black text not previously part of Reliability Spending Rationale

Damage Prevention

- National Grid's Damage Prevention programs have been highlighted by robust investments in the Inspections & Maintenance and Vegetation Management programs, spending over $1B over the last decade.

- The Company continuously reviews and refines Construction Standards, including a new series of standards for Storm Hardening.

- Addressing Asset Condition issues for aging infrastructure also provides reliability benefits, as newer assets built to modern construction standards are typically stronger than assets installed in earlier eras. In addition to planned work, the Company prioritizes restoring abnormal conditions logged in the Release Report.

- Additional Damage Prevention efforts focus on Side Tap Fusing, CSP Transformers, SubT Insulators, Flood Mitigation, and Substation Perimeter Fences.

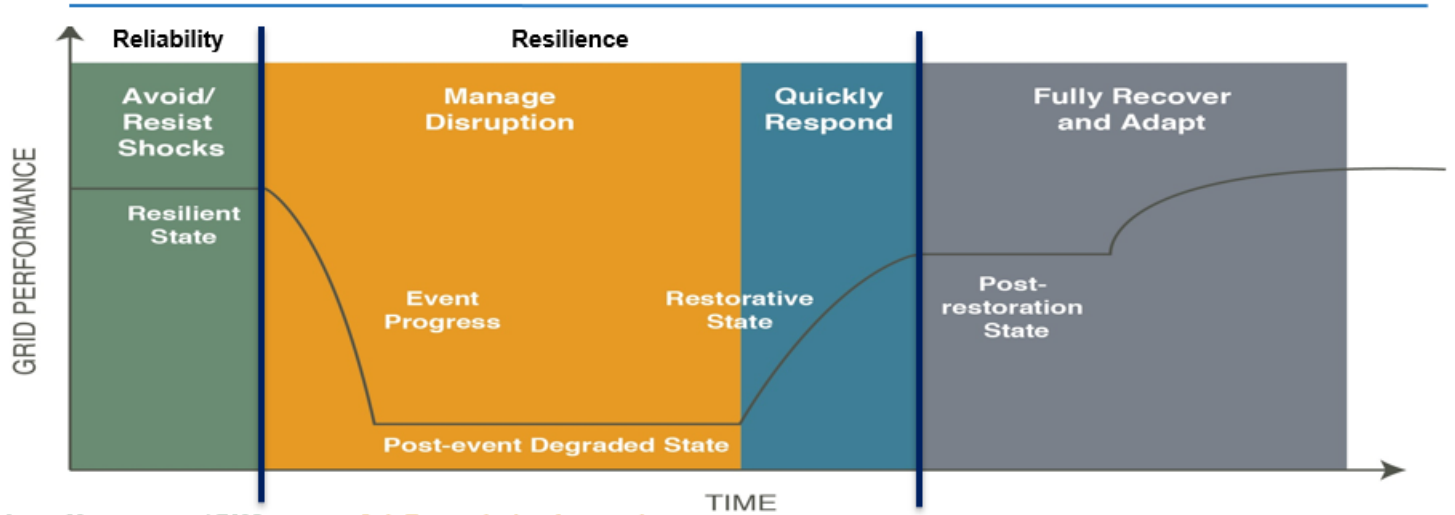
System Recovery

- System Recovery starts with keeping a fleet of trained line and forestry crews on standby when inclement weather is forecasted.
- Strict adherence to a comprehensive Emergency Response Plan allows for clear lines of communication and decision-making at the lowest appropriate level. Mutual Aid Agreements allow staffing to scale according to the event.
- The Company is investing heavily in automated devices that can create a self-healing grid that can isolate damage and reduce outages to momentary events. Programs include FLISR (Fault Location, Isolation, and Restoration), SubT Automation, three-phase Reclosers, and single-phase Cutout Mounted Reclosers.
- Storm Hardening projects include creation of Feeder Ties, which allow crews to isolate outages and restore customers faster. Mobile Transformer Fleets and critical spare inventory bypass supply chain delays to allow for recovery during major events.
- Transmission resiliency programs include Remote Control Line Switches, Additional Sources, and Line Split Breakers.

Survivability

- Survivability refers to enhanced system planning or use of innovative technologies to aid consumers, communities, and institutions in continuing some level of normal function without complete access to the grid.
- During a severe event, the Damage Appraisal team uses iPads to assess damage, including automated abilities to log GPS coordinates of damage, along with the ability to take pictures of damage and upload to a centralized database.
- Various monitoring devices, ranging from RTUs to feeder monitors to line sensors, provide operations and planning with data to better restore outages in real-time (and to inform how to avoid them in the future)
- New energy storage products enhance resiliency and may pave the way for Microgrids, whether through company-owned assets or third-party Non-Wires Alternatives.

Phases of Electric System Reliability/Resiliency



- Asset Management / BMS
- Advanced Planning Process
- Vegetation Management & EAB Focused Tree Trimming
- Distribution Standards Including Storm Hardening
- Inspection & Maintenance Program
- Targeted Minor Storm Hardening
- Flood Mitigation
- Side Tap Fusing
- Substation Perimeter Fence
- Intrusion Detection
- Cyber Security
- Steel poles

- Sub-Transmission Automation
- FLISR
- Recloser Loops Scheme Programs
- Remote Terminal Units
- Line Sensors/ Feeder Monitors
- Targeted Feeder Tie Enhancements
- Microgrids
- T-Line Splitting
- Remote control switches
- Additional T-line sources
- Distance to Fault relays

- Mobile Transformer Fleet
- Critical Spares
- Damage Appraisal & iPads
- Emergency Response Plan
- Outage Management System
- Mutual Aid agreements

- Reliability and Emerging Risk Assessments
- Event Analysis
- Event Forensics
- Reliability Guidelines and technical reference documents
- System Operator Certification and Credential Maintenance
- System Operator Training
- Periodic Review

Adapted from: Mathaios Panteli & P Mancarella, *The Grid: Stronger, Bigger, Smarter?*, IEEE Power Energy Mag., 59 (2015)

Measuring Resilience

Considerations

General Considerations

- Need to define before determining what to measure
  - Ex, measure Damage Prevention, Survivability, and System Recovery
- Attribute-Based vs Performance-Based
- Manageable volume

Utility Performance

- Effectiveness of resilience programs (ex, Avoided Outage metric)
- Ability to deliver on programs
- Restoration overperforms/underperforms expected performance
  - Weather normalization key to determining expected performance
  - Storm restoration curves
- Momentary and Sustained outages

Measuring Customer Experience

- CAIDI
  - Ex, events over 72 hours
  - Include normally excludable events
- CEMI
- Critical Customers

Questions?