Duke Energy Resiliency Philosophy Initiative

CAPER – March 2018

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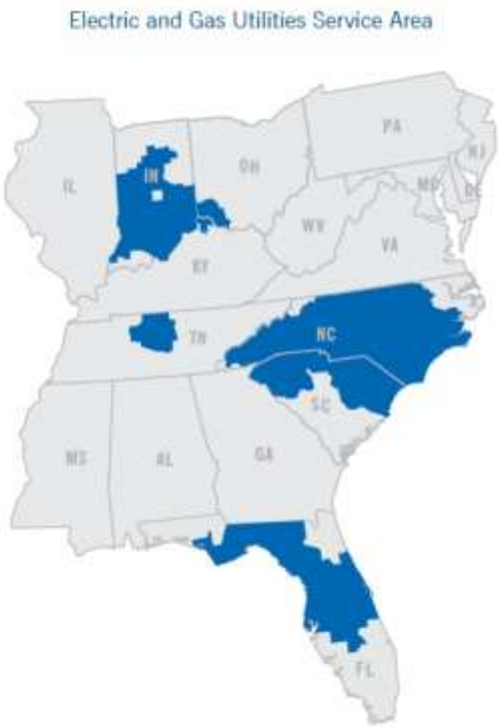
Duke Energy Fast Facts



- 7.5 Million Electric Retail Customers in 6 States
- 1.6 Million Natural Gas customers in 5 States
- 49,300 MW Generating Capacity
- ~29,000 Employees
- Service Area 95,000 Square Miles

- 32,000 Miles Transmission Lines
- 4,000 Substations

Resiliency Philosophy Direction

Problem Statement

The regional transmission systems have been built with various historical philosophies regarding reliability, redundancy, and approaches to serving retail substations . Today, resiliency is the phrase that captures these concepts as well as those of physical security, lessons learned from meteorological events, etc. We do not have a consistent vision of our resilient philosophy. Determining our Resilient Philosophy will aid in focusing our efforts.

Objectives:

- Define Resiliency and how to measure
- Identify historical/current best practices - including industry peers and organizations
- Identify current work products to be included
- Recommend what should be included in a consistent Resilient Philosophy

Scope:

The team is charged with developing a consistent Resiliency Philosophy to be used as the directional beacon for strategic investments in our transmission system. The team should leverage work already underway where available – i.e. Physical Security, Flooded Substations, etc., and should also consider historical and current "best practices".

Measures of Success

- Development of a consistent Resilient Philosophy to be used as the beacon for future transmission investment regarding resiliency.

Resiliency Definition

- ***Resilience*** - The ability of the system and/or its components to prepare for and adapt to changing conditions, withstand and rapidly recover from all types of disruptions, whether deliberate, accidental or naturally occurring.
    - While resilience is related to aspects of both reliability and security, it incorporates advanced preparation and a dynamic response capability to reduce the magnitude and duration of energy service disruptions under a range of stressful conditions.
    - *Reliability* – The ability of the system and/or its components to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components.

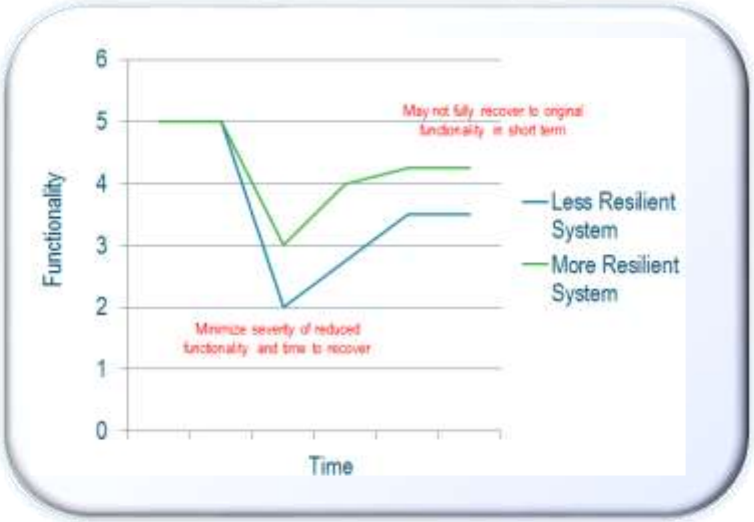


Figure 1: Measuring Resiliency

Resiliency Definition

Figure 2: Power System Resilience Cornerstones

Adaptability - the ability of the system to adjust to new conditions while maintaining its intended function and purpose (i.e. maintain firm Transmission service, serving load, maintain grid stability, etc.).

Hardening – the concept of investing in programs prior to events that limit damage and disruption during an event.

Security - The ability of the system and/or its components to detect, prevent and withstand attacks (including physical and cyber incidents) on its integrity and operations.

Recovery – the ability of the system to and/or its components to regain functionality following an event.

Resiliency Definition

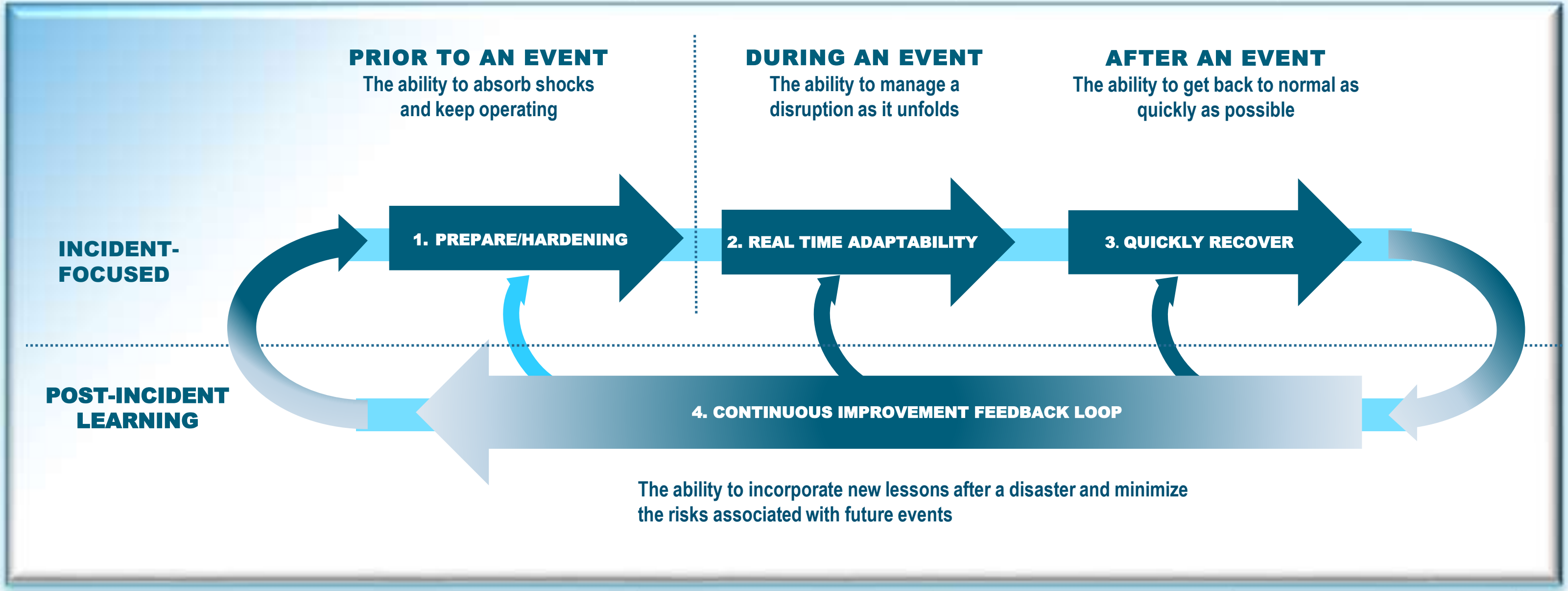


Figure 3: Framework for Infrastructure Resilience

Modified from NIAC (National Infrastructure Advisory Council), 2010

Key Attributes of a Resilient Grid

- Minimizes frequency and duration of customer outages
- Resistant to High Impact Low Frequency (HILF) events
- Able to withstand multiple events on the system or the loss of multiple components
- Improved equipment outage availability
- Utilizes intelligence to predict events and automatically recover following events

Measuring Resiliency

- No industry established metrics
- Continuing to follow work of industry organizations developing potential metrics
- Appropriate metrics to measure resiliency must differentiate from traditional reliability metrics
- Measuring performance against major events and comparing to baseline may be more important

- Potential Measurement Examples:
  - Maturity Model
  - Recovery over time
  - Ratio of performance recovery to performance loss

$$R = \sum_{1}^{n}\left(\frac{P_i}{T}\int_0^T Cr(t)_{i,t}\,dt\right)$$

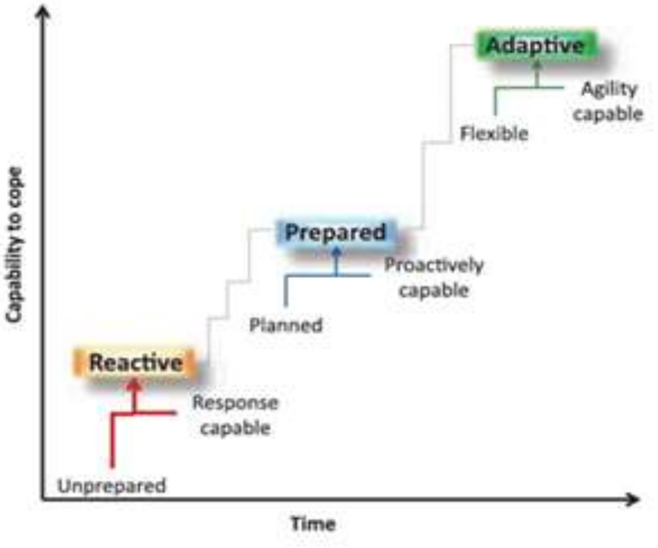
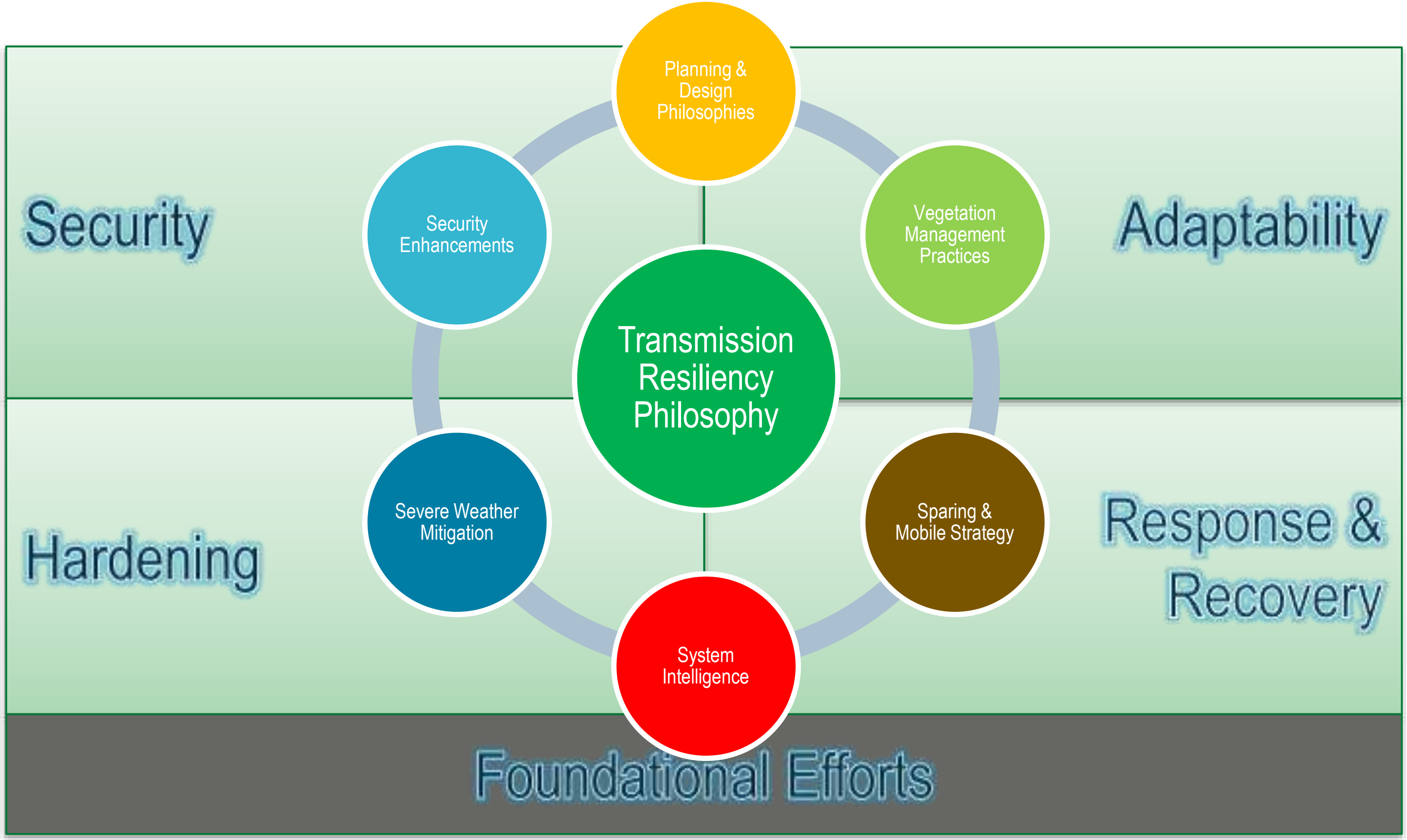


Figure 4. The progression of resilience maturity

Transmission Resiliency Philosophy



Final Recommendations

Planning & Design Philosophies

Transmission Planning Philosophy

Expand Transmission Planning criteria to include multiple

System Design

nce criteria

Transmission – Interface

Rights of Way

Final Recommendations

Planning & Design Philosophies

Line Design Standards

- Transmission line design for extreme wind and ice loading
- Implement consistent approach for installation of dead-end structures
- Improved technology for soil conditions to improve foundation design
- Criteria for underground Transmission lines

Final Recommendations

Vegetation Management Practices	Enhanced buffer zones for danger tree cutting
	Utilize advanced technology (i.e. LiDAR) to replace ground patrols
Sparing & Mobile Strategy	Participation in external sparing programs
	Implement consistent internal sparing strategy
	Mobile equipment improvement program

Final Recommendations

System
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