UT ENERGY WEEK 2018

Resilient Infrastructure and Protecting against the Worst Case Scenario

The Generators Role

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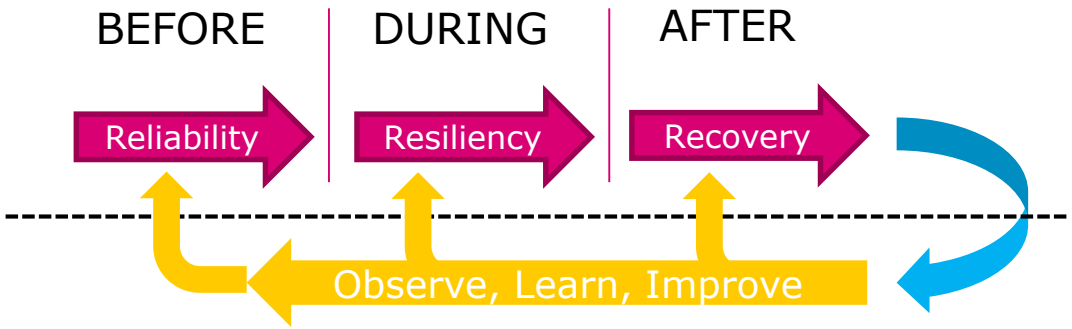
Reliability vs Resilience

Grid reliability is commonly defined as the ability of the electric power system to deliver electricity in the quantity and with the quality demanded by end-users.

Resiliency is the ability for the electric power system to withstand and recover from extreme, damaging conditions, including weather and other natural disasters, as well as cyber and physical attacks.



While the two are different, resiliency directly impacts reliability.

Being Reliable

What's it mean?

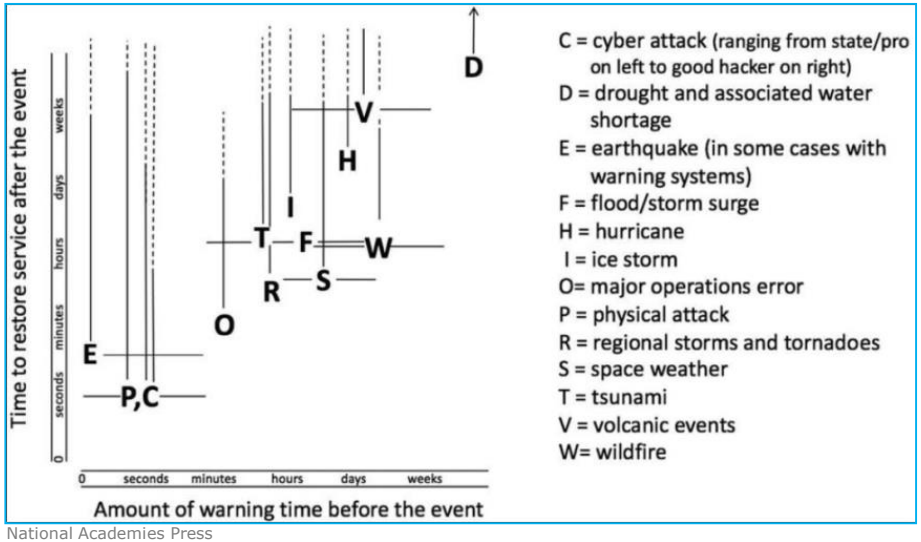
In and ideal world we like to plan and operate the electrical system so that a single contingency or multiple contingencies of sufficiently high likelihood will not cause system instability, unplanned separation, cascading outages, voltage or frequency excursions.

- Prioritizing
  1. Safety (public, workers)
  2. Protect equipment from damage
  3. Reliability of the bulk interconnected system
  4. Optimize the economical operation of the system
- Maintaining Reserve Margins
  1. Having sufficient Generation to maintain operating reserve, spinning reserve
  2. Ensuring sufficient transfer capacity on the transmission grid utilizing comprehensive planning studies
- Ensuring Redundancy
  1. Network topology
  2. Backup equipment, network, location
- Ability to Restore
  1. Short-term (e.g., uninterruptible power supplies)
  2. Long-term (e.g., diesel generators)
  3. If blackout occurs, implement restoration plans (e.g., "Black Start")

Preparing to be Reliable

Different threats have different characteristics. The amount of warning time that is available to ensure reliability differs dramatically with the type of event and different events cause different types of damage with different recovery needs.

For example:



National Academies Press

- The Hurricane
  - ✓ Wind
  - ✓ Driving rain
  - ✓ Flooding
  - ✓ Rationings
- The "hot weather" event
  - ✓ Cooling reservoir/river levels
  - ✓ Cooling towers
- The "cold weather" event
  - ✓ Piping, valves, critical component protection (heat trace)
  - ✓ Gas Supply
- Forced Outages
  - ✓ Preventative Maintenance

Safety for Personnel and Community is Top Priority

What about Resiliency?

- Resiliency aims to reduce or prevent the magnitude and/or duration of disruptive events
- The resilient infrastructure should be able to anticipate, absorb, adapt to, and/or rapidly recover from a disruptive event
- The most resilient systems require that engineers design for:
  - Naturally occurring hazards such as storms or earthquakes and disruptive human actions
  - Maintain equipment functionality, providing for rapid restoration with minimum downtime
  - Ensure coordination with emergency controls when all else fails to limit cascading failures (e.g., under frequency relays, load shedding)
  - Designing the system's cyber-physical architecture to reduce the criticality of individual components
  - Rapidly providing better information and control strategies to operators through increased deployment of sensors and advanced data analytics; and

Addition of intermittent resources and market economics will drive the need for the power system to become more resilient in the future

What's the role of Conventional Generators?

- Quick start gas turbines and unloaded baseload generators respond when wind resource output is suddenly reduced (batteries beginning to play a role)
- In cold weather events, NG is in high demand and is often instantly curtailed
  - Oil fired generation often provides the resilience needed to maintain sufficient generation resources for grid stability
  - Coal and Nuclear have built in fuel storage. Not days but weeks in the case of coal and years in the case of nuclear.
- Nuclear and Gas play key role during heavy floods when water mixed with coal turns into slurry
- Diesel generators power essential equipment while bulk system is restored after a major grid outage
- Black start resources (diesel generators used to start larger secondary resource) still needed to restore system after a major grid outage

Wind, It's a Roller Coaster

While the output of some resources change dramatically, conventional generators continue to provide bulk power, voltage support, frequency response all needed to maintain grid resiliency!