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# ENHANCING GRID RESILIENCE: THE STRATEGIC IMPORTANCE OF SYSTEM HARDENING FOR ELECTRIC UTILITIES

According to a 2022 U.S. Department of Energy (DOE) report, modernizing, hardening, and expanding the grid will enhance the resilience of the nation's entire electric system, and ensure that electricity is available to customers when it is needed most. For example, aging infrastructure leaves the grid increasingly vulnerable to attacks. In addition, according to the report, the increasing frequency of extreme weather events is leading to energy supply disruptions that threaten the economy, put public health and safety at risk, and can devastate affected communities all over the country.



## Weather Challenges

According to the highlights of a January 2024 report from the National Oceanic and Atmospheric Administration (NOAA):

- There were 28 separate billion-dollar weather and climate disaster events identified during 2023, which was the highest annual disaster count in NOAA's 44-year record.
- The Atlantic Basin saw 20 named tropical cyclones during 2023, ranking fourth for the most named tropical systems in a year since 1950.

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- The preliminary tornado count for 2023 was above average, with 1,197 tornadoes reported, and an additional 97 preliminary tornadoes still under verification for the October 1 to December 31 period.



- A wildfire broke out on the island of Maui on August 8, becoming the deadliest wildfire in the U.S. in over a century.

- Drought coverage across the contiguous U.S. ranged from a maximum extent of 46 percent occurring on January 3 and a minimum coverage of 19 percent on May 30, the lowest contiguous U.S. footprint since the drought of mid-2020.

As noted, in 2023, the U.S. experienced 28 weather and climate disasters each incurring losses that exceeded \$1 billion. The year 2023 surpassed 2020 (which had 22 events), for the highest number of billion-dollar disasters in a calendar year. These disasters included: 17 severe storms, four flooding events, two tropical cyclones, two tornado outbreaks, one winter storm, one wildfire and one drought and heat wave event.

The total U.S. disaster costs for 2023 was \$92.9 billion. “This total annual cost may rise by several billion dollars as additional costs from identified events are reported,” said the NOAA. There were at least 492 fatalities associated with these events.

Over the last seven years (2017–2023), 137 separate billion-dollar disasters have killed at least 5,500 people and cost greater than \$1 trillion in damage.

The year 2023 was also a record 13th consecutive year during which the U.S. experienced 10 or more billion-dollar disasters and the fourth consecutive year (2020–2023), when 18 or more billion-dollar disasters impacted the U.S.

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Since NOAA records began in 1980, the U.S. has sustained 376 separate weather and climate disasters where overall damages/costs reached or exceeded \$1 billion per event. The total cost of these 376 events exceeds \$2.660 trillion.

In specific:

**Tropical Cyclones:** Record-warm sea surface temperatures in the Atlantic Basin brought 20 named tropical systems during 2023, ranking fourth for the most named storms in a year since 1950. Seven of these storms were hurricanes, including three that intensified to major hurricanes, while three of these storms made landfall in the U.S. - Hurricane Idalia and tropical storms Harold and Ophelia.

**Tornadoes:** The 2023 tornado count was above the annual 1991–2020 annual average across the contiguous U.S., with 1,197 confirmed tornadoes reported, with an additional 97 preliminary tornadoes still under verification during the October 1 to December 31 period.

**Fires:** The number of wildfires in 2023 was close to the 10-year average (2013–2022) with more than 55,500 wildfires reported over the year.

**Snowfall:** A series of nine atmospheric river events from late December 2022 into mid-January 2023 dumped a record amount of rain and mountain snow across parts of the western U.S., hitting California particularly hard, causing more than 700 landslides, over 1,400 rescues plus loss of life.

## Strategies

The increasing number, intensity, and cost of weather events is a sign for electric utilities to put programs in place to reduce the damage from such events, and to help reduce the time associated with repairs after such events.

The DOE recommends two general strategies:

- Operations and Maintenance
- Grid-Hardening Measures

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## Operations and Maintenance

According to the DOE, routine maintenance can improve the ability of operators to identify and respond to disruptions, reducing outage durations by enabling faster repair and/or mitigation measures. A few examples are below.

**Vegetation Management:** During major storms, distribution lines and poles primarily fail due to fallen trees rather than the direct impact of wind. Utilities should regularly conduct vegetation management for distribution systems including clearing overhang and removing dead or dying trees. Where possible, utilities may seek to expand the existing rights-of-way (ROW) for distribution infrastructure to allow for additional vegetation management. New remote sensing technologies, such as Light Detection and Ranging (LiDAR) can be used to enable more effective vegetation management.



**Automated Distribution Management Systems:** Utilization of smart grid remote sensors and fiber-optic communication technologies enable utilities to quickly detect and pinpoint disruptions and facilitate automatic or manual corrective actions, such as isolating damaged equipment to minimize the number of customers affected, or rerouting power to undamaged circuits and feeders. New technologies such as artificial intelligence, machine learning, and predictive modeling with real-time data can be used to identify both early warning signs of potential equipment failure, and downed wires.

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**Drones for Asset Inspection:** The use of drones to inspect transmission and distribution infrastructure allows for safer and more frequent inspections, enhanced asset information, reduced operational costs and failure rates, and extended asset lifetimes. The use of drones to inspect infrastructure after storms and other disruptive events can speed up damage assessments and resource deployments, reducing restoration timelines.

**Advanced Metering Infrastructure (AMI):** AMI is an integrated system of smart meters, communications networks, and data management systems that enables bi-directional communication between utilities and customers. Smart meters can provide near-real-time visibility into customer outages and help utilities allocate resources and restoration activities more efficiently.

## Grid Hardening Measures

Grid and system hardening refers to making transmission and distribution infrastructure less susceptible to damage or failure from hazards. Common hardening measures include:

**Undergrounding:** Burying power lines protects lines from exposure to external threats including high winds and falling branches, wildfires, extreme heat or cold, icing, dirt/dust/salt accumulation, and animals; but may increase exposure to flooding, depending on location. Although undergrounding reduces outage frequency, when there is a disruption, outage duration may increase due to the additional time needed to identify problems, dig up, and then re-bury damaged equipment. Although widespread undergrounding of transmission and distribution infrastructure is costly, some utilities may bury lines serving critical infrastructure and select backbone circuits located in areas at high risk for high winds or wildfires.

**Structural Upgrading:** Upgrading poles and other structures to stronger materials may help them withstand storm impacts. Distribution poles can be upgraded from wood to steel, and transmission structures can be upgraded from aluminum to galvanized steel lattice or concrete. Less expensive options include upgrading crossarm materials or adding guy wires, trusses, or other structural supports. Securing structures with guy wires may be required for transmission and distribution structures in flood-prone areas.

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**Dead-End Transmission Towers:** High-voltage transmission lines are supported by structures, known as transmission towers. Suspension towers are typically used when the transmission line continues along a straight path. Dead-end towers (also called anchor towers or anchor pylons) are self-supporting structures made with heavier material than suspension towers. Dead-end towers are used at the end of a transmission line; where the transmission line turns at a large angle; on each side of a major crossing such as a large river, valley, or highway; and at intervals along straight segments to provide additional support. When weaker suspension towers are compromised or topple, the stronger dead-end structures can stop a domino effect that takes down multiple towers. Reducing the spacing between dead-end structures can limit the impacts of domino effect failures.

**Breakaway Service Connectors:** A breakaway service connector is designed to disconnect when the power line it is attached to is pulled by a falling limb or other debris. This avoids damage caused when a service wire is pulled down in a way that damages the meter receptacle. Although the electric meter is typically owned by the utility, the meter receptacles that attach the meter to the house are not owned by the utility, and a private electrician is needed to first make repairs, delaying service restoration.

**Flood Protection:** Water damage from flooding can have severe and long-term effects on electrical equipment, particularly electric substations. Saltwater damage can cause corrosion with prolonged exposure, and clean-up is particularly lengthy and labor-intensive. Flood protection at substations in low-lying or flood-prone areas can be enhanced by elevating substations on a raised platform, installing sheet pile floodwalls or other barriers to prevent water incursion, managing the environment to preserve natural barriers to flooding, installing storm-water pumps, installing submersible equipment, or simply re-locating assets outside of flood-prone areas.

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**Fire Protection:** In some areas of the country, utilities are making investments to both protect grid equipment from wildfire damage and to prevent equipment from starting wildfires. Fire-protection measures may include installing fire-resistant steel poles, composite crossarms, and covered conductors, or pre-treating assets near a wildfire with fire-retardant coatings or wrapping assets in fire-retardant sheaths. To protect assets from starting a fire, utilities may install line-break protection systems to automatically de-energize broken power lines or reconductor wires to increase transmission capacity, thus reducing the propensity for high loads and line sag.

**Physical Security:** Protection against human threats (e.g., trespassing, vandalism, sabotage, etc.) at substations can be strengthened through a layered security strategy and physical security protective measures, such as upgrading fencing from typical chain-link to engineered perimeter barriers; installing cameras, intrusion detection systems, and other security equipment; and by installing ballistic shielding or obscuring sightlines into substations, making it more difficult to target critical substation components with gunfire.

For assistance in improving your Operations and Maintenance, as well as your Grid-Hardening Measures, contact Finley Engineering.

## About Finley Engineering & Consulting

Finley Engineering is a full-service engineering consultancy with a successful history of providing expertise in communications technology and energy engineering services for a wide variety of clients such as independent telecom providers, electric cooperatives, municipalities, competitive providers and government entities.

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