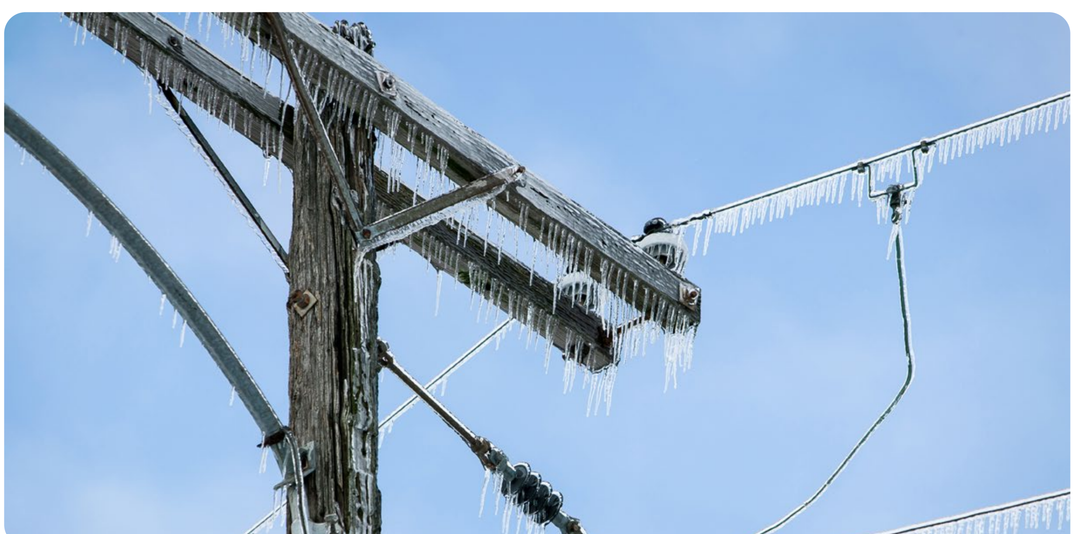
White Paper

A guide to grid resilience

The vital role of advanced overhead infrastructure management



We're IKE, the PoleOS™ Company

With climate change ramping up, utilities around the globe are facing tougher challenges in keeping power flowing reliably, especially when it comes to managing overhead infrastructure. From hurricanes to ice storms to record-breaking heatwaves, extreme weather is hitting harder and more often, making the grid more vulnerable and raising the stakes for reliable service.

Utilities are moving toward “grid hardening” to tackle these threats head on. So what does that look like? First, it’s about digging into data—analyzing asset conditions, running structural checks, and using pole loading analysis to spot weak points before they cause trouble. Then there’s predictive maintenance, which involves catching issues before they turn into full-blown outages. And, of course, there’s the physical work of storm hardening: reinforcing poles, power lines, and transformers so they’re ready for the worst, whether it’s high winds or heavy ice.

28

weather and climate disasters in 2023

RESULTING IN

$92.9 billion in damages

Surpassing the previous record of **22** in **2020**

Source: NOAA National Centers for Environmental Information (NCEI)

As the climate changes, key hazards such as high winds, ice accumulation, flooding, and extreme heat pose significant risks to the grid's resilience. High winds, expected to become more severe due to climate change, increase the likelihood of asset damage and outages from downed trees and conductor stress. For ice accumulation, the weight it adds to structures can lead to line sag and potential infrastructure failure. Flooding, particularly a threat to substations, intensifies as precipitation patterns change, stressing components highly sensitive to water exposure. Extreme heat similarly compromises system resilience by reducing equipment efficiency, accelerating aging, and necessitating worker safety protocols. A utility's preparatory measures include structural upgrades, targeted system evaluations, and rigorous safety and environmental protocols to enhance resilience across the network.

Building a resilient grid is about more than reacting to problems after they happen. Utilities are stepping up with proactive strategies, such as routine inspections and scheduled maintenance, to stay ahead of weather-driven risks. Being prepared with strong emergency response plans and well-trained teams is equally important for restoring power faster after outages.

Looking ahead, as climate change continues to reshape our energy needs, a focus on resilience will be essential. By tapping into new technologies, making decisions backed by data, and planning for worst-case scenarios, utilities can keep power systems reliable, no matter what nature throws their way.

Weather conditions to combat

Wind and ice

Wind and ice events are among the most challenging weather conditions for overhead power infrastructure, often causing significant damage to poles, lines, and other components. Strong winds can topple power poles and cause overhead conductors to vibrate, gallop, sway, and collide. This movement can lead to electrical arcing and damaged conductors, often resulting in power outages. Fluctuating freeze-thaw cycles weaken infrastructure over time, compounding maintenance challenges. Ice storms can also impede access for repair crews, delaying restoration efforts and escalating costs while putting crews at risk. In combination with wind, assets already weakened or overloaded structurally by ice are at their weakest point.

Flooding

Weather events such as hurricanes, tropical cyclones, and subtropical cyclones, are happening with more frequency, intensity and impact. Factoring in the impacts of flooding helps inform the changes necessary to weather those issues going forward.

Flooding poses a significant threat to utility assets, particularly to substations which are highly vulnerable to water exposure. Damage from flooding and water poses serious risks to electrical infrastructure, especially for equipment located in low-lying or flood-prone areas. Heavy rainfall, storm surges, and rising water levels can damage substations, transformers, and underground systems, leading to widespread outages and safety hazards. Water infiltration can corrode equipment, short-circuit components, and make recovery efforts more challenging. Standing water from flooding can last for days or weeks after most of the water recedes, isolating equipment and delaying repairs.

To reduce these risks, utilities can leverage flood risk mapping and historical data to identify vulnerable assets and proactively relocate or elevate critical infrastructure. Asset data management, which includes precise location information, enables utilities to monitor and document asset conditions, making it easier to assess the need for flood-resistant upgrades. Additional challenges posed by flooding can include landslides that destroy assets and make access difficult, as well as add so much water to the soil that assets may be vulnerable to damage for a considerable amount of time after the waters have receded on the surface. Predictive models that incorporate rainfall, flood and soil data can help utilities predict high-risk zones, allowing them to deploy protective barriers or drainage systems before severe weather events.

Regular inspection and maintenance programs are essential to identifying early signs of water damage and preventing corrosion or other structural issues. By implementing these strategies in alignment with National Electrical Safety Code® (NESC®) guidelines, utilities can strengthen their flood resilience, minimize downtime, and ensure the safety of personnel and the public during extreme weather events.

Severe heat

Temperatures that exceed the 32°C (89.6°F) threshold can reduce the effective capacity of substation transformers and increase the rate of aging of internal components. Transmission and distribution lines are also projected to experience increasing extreme heat throughout the later part of the 21st century.

To address severe heat, measures include operational policies for worker safety and heat resilience, alongside asset reinforcement, as high temperatures can compromise equipment capacity and longevity.

Preparing for the worst

Analysis and asset health intelligence are integral to improving grid resiliency against climate-related hazards. A utility's approach should include several components:

- Data-driven vulnerability assessments, combining climate data and asset health metrics to identify high-risk areas
- Analysis of real-time temperature data and use of historical load patterns to identify high-risk components and adjust operations to prevent overheating
- Grid modernization efforts, such as upgrading transformers and other equipment to handle higher loads and help ensure reliability during peak summer months
- Load balancing strategies, including distributed energy resources (DERs) and demand response programs, to reduce strain on the grid and help maintain stability
- Identification of priority assets, determined by consequence and sensitivity ratings, to ensure that resources are allocated to the most critical infrastructure
- Collaborative efforts among subject matter experts and data analysts to enhance predictive insights and allow for targeted improvements in structural durability and operational efficiency

Assessing the vulnerability of grid infrastructure is crucial for a company to determine if the benefits of storm hardening outweigh the costs and to identify the most effective storm-hardening strategies aligned with its objectives. Thanks to modern technology, these assessments can now be completed more rapidly and yield more precise insights than ever before.

The assessment should evaluate multiple factors, such as vulnerability to wind damage, flood and storm surge risks, infrastructure age and condition, and historical data from past weather events. With a clear understanding of the specific risks to their infrastructure, utilities can prioritize preparedness initiatives and allocate resources more effectively.

Pole loading analysis is another critical component of any vulnerability assessment. For instance, one North American utility recently began leveraging advanced data collection tools for assessing whether poles can withstand additional stress from wind and ice. This data collection too has optimized back-office loading analysis to significantly reduce the time needed for structural analysis of utility poles. By evaluating each pole's load-bearing capacity, utilities can identify weak points and prioritize reinforcement in high-risk areas.

After completing the assessment, utilities should develop and regularly update emergency plans tailored to different weather scenarios. Predictive maintenance strategies, informed by real-time weather data and historical event patterns, enable utilities to prepare proactively before storms hit, minimizing the potential for outages. Preventive maintenance powered by advanced asset health intelligence systems can help detect signs of wear or damage that could make infrastructure vulnerable to wind and ice.

By integrating these strategies with NESC standards, utilities can strengthen their networks to withstand the most severe wind and ice events, ensuring safer, more reliable power delivery for customers.

Best Practice #1

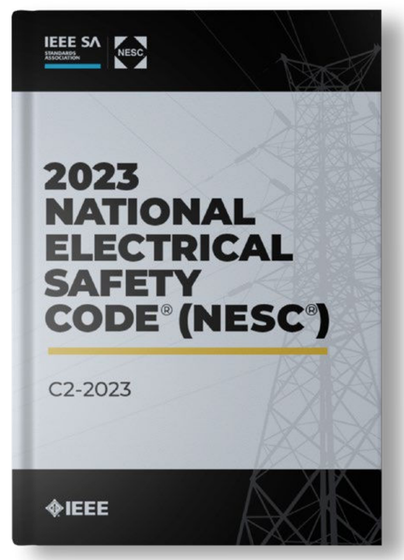
Conduct a vulnerability assessment

Identify priority vulnerabilities based on asset exposure to climate hazards: high winds, ice, flooding, and extreme heat. Assets with high consequence ratings are prioritized for resilience recommendations to improve structural reliability.

- Account for the most extreme weather conditions for wind, ice, flooding, and heat.
- Consider special conditions, such as radial icing. The added weight can cause line sag, mechanical and electrical line failure, or other consequences that result in electric infrastructure damage and outages.
- Consider historical storm data from most damaging events, such as understanding where higher wind speeds are likely to occur.

Standards as the backbone of grid reliability

Over the past two decades, technological advancements have been reshaping the utility sector, promising to revolutionize the way workers in the industry operate. But it's not just about technology. Standards like the NESC give utilities a rulebook for keeping overhead systems safe and robust. The NESC offers a set of minimum guidelines for designing and constructing electric infrastructure. These regulations are essential to keep systems resilient and reduce risks.



To further enhance resilience and reliability, utilities can design distribution systems to exceed NESC standards. By going beyond the minimum requirements, utilities can account for increasingly severe weather events, higher load demands, and evolving grid complexities. This proactive approach not only safeguards infrastructure against future challenges but also supports long-term operational efficiency and public safety.

Inspection and maintenance protocols

Inspection and maintenance protocols are central to maintaining and improving grid resiliency through regular assessments and data-driven asset management. Utilities may employ an inspection and maintenance program as a primary tool for evaluating the condition of individual poles and aging assets, aiming to proactively identify vulnerabilities.

In addition to assessing the physical condition of assets, routine inspections are an opportunity to validate or update data. Advanced tools support inspection programs by standardizing data collection and enabling the creation of digital twins, which facilitate asset monitoring and lifecycle management.

A robust inspection and maintenance program serves as a fundamental approach to managing asset health and ensuring grid reliability. This program not only addresses aging infrastructure by systematically assessing individual poles and other assets but also emphasizes continuous data refinement and accuracy improvements.

Best Practice #2

Use advanced data collection and analysis tools in inspection programs

By gaining a comprehensive view of network conditions, utilities can carry out targeted inspections and shift toward predictive maintenance and timely infrastructure upgrades. This data-driven approach supports strategic decisions like reinforcing power lines in high-wind areas, replacing aging poles, and upgrading equipment in flood-prone zones.

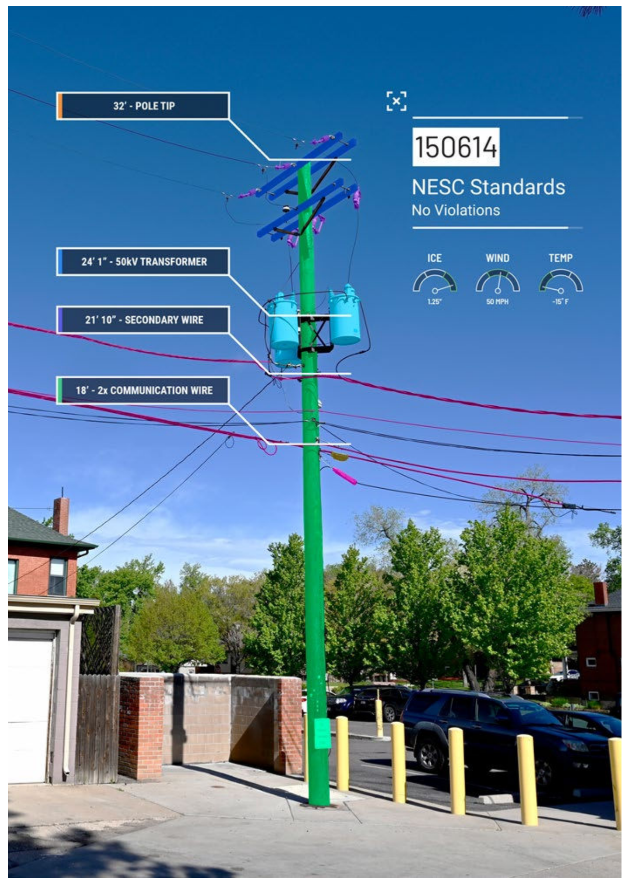
Advanced field data collection and analysis tools, such as IKE Office Pro, enhance data accuracy and consistency across all teams. By digitizing field data into a cohesive digital twin on a centralized platform, a utility can ensure a robust framework for real-time asset intelligence and informed decision-making.

Structural analysis software like IKE PoleForeman enables utilities to quickly assess and apply specific load case requirements, as well as ensures the consistent application of the utility's specific design requirements and allows for faster decision making.

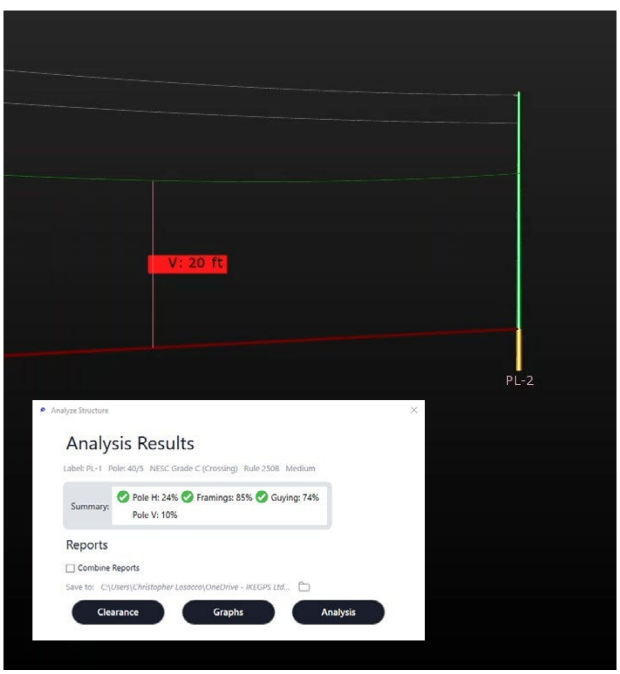
Tapping into emerging technologies

Modern technologies are transforming how utilities approach resilience. Take smart grid tech: it's giving utilities real-time visibility and control over their systems, making it easier to spot issues and respond quickly when the lights go out.

Digital twins – sophisticated models that simulate physical assets or entire systems – leverage integrated data to optimize infrastructure upgrades and simulate scenarios for better planning. For instance, utilities can identify which poles and lines require reinforcement in high-wind areas or determine the best upgrades for equipment in flood-prone regions. Properly implemented, digital twins also give utilities real-time visibility and control over their systems, making it easier to spot issues and respond quickly when the lights go out.



Digital twins, like those created in IKE Office Pro, can be shared across teams and stakeholders. This standardized approach ensures that planners, engineers, and field crews are working from the same accurate, up-to-date digital representation of the infrastructure. By linking processed data to tools like IKE PoleForeman, utilities can simulate and analyze pole loading scenarios. These simulations contribute to a digital twin that not only mirrors the physical asset but also predicts its performance under various conditions, such as extreme weather events or additional loading.



3D Model and NESC Analysis Results in IKE PoleForeman

AI and machine learning are helping predict failures before they happen. By providing precise, structured data that forms the foundation for accurate machine learning models and predictive analytics, advanced pole data acquisition and analysis tools like IKE's can enhance AI's ability to predict areas and assets vulnerable to floods and storms. Detailed measurements and imagery of utility poles, structures, and surrounding environments – including geospatial data, pole loading metrics, attachment information, and material classifications – are crucial inputs for AI models.

With IKE Office Pro, field-collected data is processed and standardized, ensuring consistency across datasets. This standardization is critical for training AI models and integrating with other data sources, such as GIS systems, weather data, and topographical maps.

Breaking down data silos

Today, data is potentially the single most important and valuable asset that a utility owns. The exponential growth in data volumes, rising customer expectations, the proliferation of distributed generation, and the need for improved automation and distributed intelligence make it paramount for electric utilities to manage data as an asset. Data—the integration, management, and use of it—sets the bar that either creates or limits opportunities. It impacts everything from storm hardening to customer engagement and even how well each employee and every physical asset performs.

With accelerating climate change, the need to leverage data to the fullest for enhanced resilience has never been more pressing. A major challenge utilities face in optimizing data is the prevalence of data silos. A silo forms when a solution is implemented to address an immediate problem without considering broader organizational needs or future integration. These silos—whether created by operational, IT, or business-focused teams—often lead to redundancies, inconsistent data practices, and limited integration with downstream enterprise systems. Over time, this "siloed" approach results in a patchwork of disconnected systems, creating heterogeneous environments that are inflexible, costly to maintain, and risky in terms of data misalignment or incomplete usage. These challenges inhibit utilities from fully leveraging data as a strategic asset.

Breaking down these silos is crucial to unlocking the potential of data across utility operations. Integrating diverse data sources—such as distributed energy resources (DERs), historical storm patterns, asset imagery, pole loading assessments, meter data, and geographic information—enables utilities to adopt a more comprehensive, enterprise-wide perspective. For example, when these datasets are seamlessly combined, machine learning algorithms can assess risk levels and pinpoint regions vulnerable to weather-related outages. This holistic view empowers utilities to transition from reactive to predictive maintenance, reinforcing infrastructure in high-risk areas before failures occur and optimizing resource deployment for greater operational efficiency.

Best Practice #3

Maximize data across workstreams with integrations

Embedding data integration into resilience efforts and overall strategy requires a comprehensive approach. Implementing intentional data governance practices, fostering cross-departmental collaboration, and building robust infrastructure to support enterprise-wide data sharing are essential steps.

Integrating data across workstreams delivers enterprise-wide benefits. It ensures that insights derived from one function—such as inspections or maintenance—are accessible to others, facilitating coordinated action. This approach also enhances operational efficiency and supports customer trust and satisfaction. Addressing vulnerable areas proactively minimizes service disruptions, ensuring reliable power delivery even under challenging conditions.

Solutions like IKE's suite of tools exemplify the power of seamless data integration. These tools ensure that field-collected data is utilized across teams and functions and enables cohesive, data-driven operations. This shift allows utilities to maximize the value of their data, driving innovation and improving efficiency across the organization. As the utility landscape continues to evolve, prioritizing data integration will be essential for meeting future challenges and opportunities head-on.

In closing

As we face increasingly extreme weather events, such as hurricanes and ice storms to heat waves and wildfires, the electric grid's role as the backbone of modern society has never been clearer. Driving toward a future of greater resilience, preparedness, and reliability in these times is possible with the right strategies and the right tools. It is increasingly vital to anticipate, mitigate, and recover from the impact of these events. By taking a comprehensive look at assets, targeted upgrades like installing poles and pole support structures better suited to withstand harsh weather conditions.

Top-performing utilities are taking a comprehensive approach to resilience, which balances physical hardening and digital modernization, aligns the utility's grid infrastructure to withstand evolving climate impacts, and emphasizes adaptability alongside strength. Creating a more resilient grid by the modernization of aging assets with advanced materials and using smarter technologies greatly contribute to grid hardening initiatives. Meeting or exceeding NESC standards and having traceability from your asset selection and health to those standards mitigates risk.

The path forward requires unified action from utilities, regulators, innovators, and customers. By investing today in resilience, we ensure tomorrow's reliability. Together, we can drive toward an electric grid that stands as a symbol of human ingenuity and preparedness, even in the face of nature's most formidable challenges.

About ikeGPS

We're ikeGPS, the PoleOS™ Company. We help electric utilities, communications companies, and their engineering providers gain actionable insights on overhead infrastructure. Our data acquisition and analysis solutions transform how to design, construct, and inspect overhead assets.

With two decades of industry expertise, IKE has become the standard for eight of the 10 largest investor-owned electric utilities in North America.

Driven by our commitment to essential infrastructure and to the success and well-being of those who manage it, IKE innovates for the next generation of power networks.

To learn more, visit www.ikegps.com and follow us on LinkedIn

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