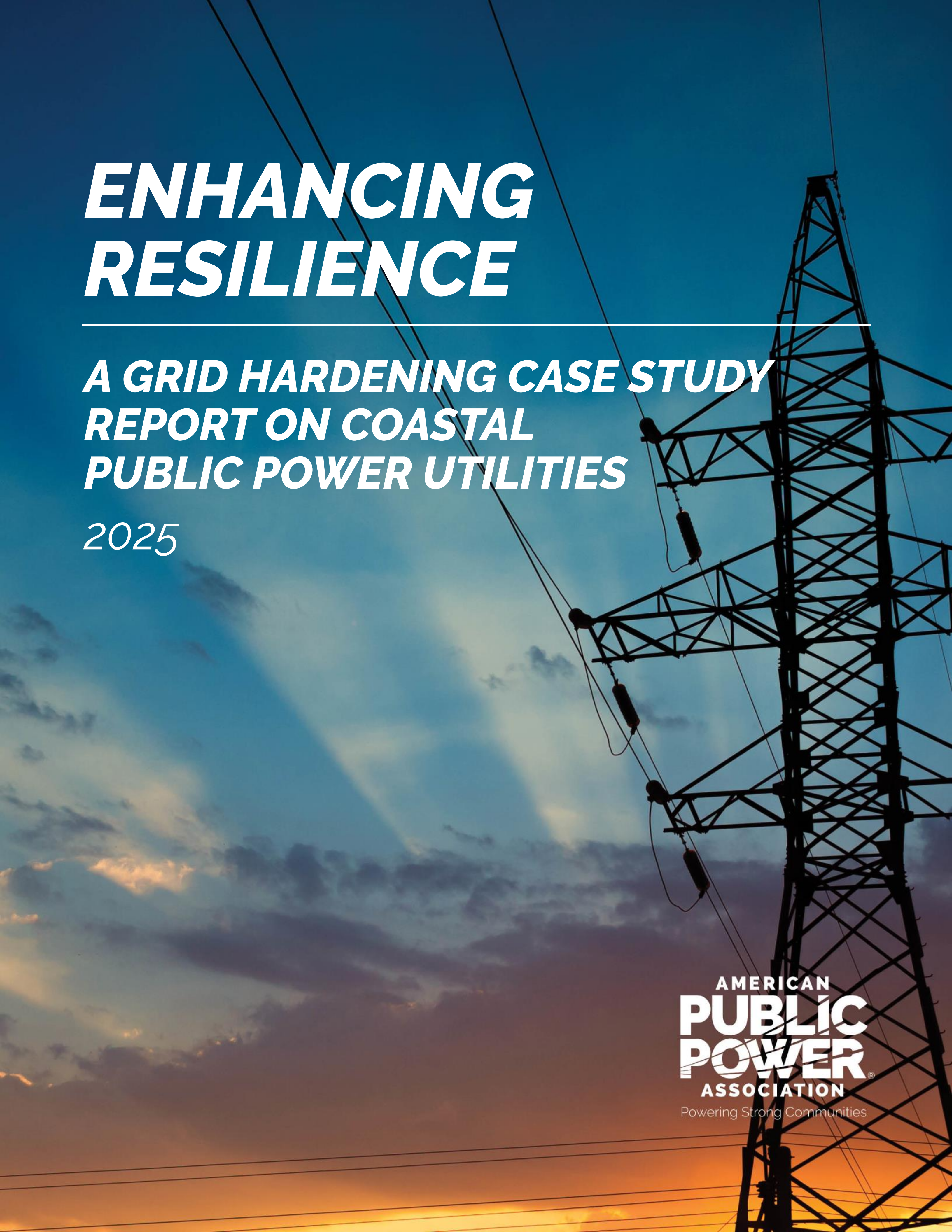

ENHANCING RESILIENCE

A GRID HARDENING CASE STUDY REPORT ON COASTAL PUBLIC POWER UTILITIES

2025

AMERICAN PUBLIC POWER ASSOCIATION
Powering Strong Communities

ABOUT THIS REPORT

The authors of this report set out with the intent to encourage contemplation of how utilities and regulators can consider grid resiliency efforts and practices to be better prepared for increasingly severe weather systems. Our research was primarily focused on how coastal utilities considered and/or implemented various grid hardening techniques. The report and its conclusions are based in part on interviews with utility personnel and best practices released by regulators and utilities.

Special thanks to:
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Beatrice Limtiaco, Assistant General Manager Administration, Guam Power Authority
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Lynn Tejada, General Manager and CEO, Keys Energy Services, FL
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INTRODUCTION

Resilience, as defined by the Federal Emergency Management Agency's (FEMA) National Resilience Guidance, is the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover rapidly from adverse conditions and disruptions. To electric utilities, it simply means how well an electric utility can lessen the impact of an incident on its infrastructure and quickly restore service to its community following that incident.

In today's era of increasingly prevalent and intense natural disasters, the importance of infrastructure resilience and utility service continuity have never been more critical. The value of strategic mitigation and grid hardening investments extends far beyond immediate cost savings. It encompasses bolstering customer trust, ensuring operational continuity, and safeguarding against financial and social repercussions of disaster-induced service disruptions. Grid hardening champions a future where utilities are not merely resilient entities, but pillars of community trust and security.

Coastal utilities face unique geographical and environmental hazards, ranging from hurricanes, tsunamis, and storm surges to threats of tidal flooding and the gradual advance of sea-level rise. Such conditions exacerbate infrastructure degradation and introduce other challenges, such as water salinity, which can further compromise utility assets and service reliability.

The five case studies in this report aim to demonstrate diverse types of mitigation and hardening techniques undertaken by coastal public power utilities to increase the resilience of their infrastructure. The utilities highlighted in this report share their firsthand experiences of how they effectively navigate the challenges faced to provide safe and reliable power to the communities they serve, with each utility demonstrating varying levels of implementation. Furthermore, the case studies explore the rationale behind supporting funding for these crucial projects and programs, outline methods for approaching mitigation efforts, share engagement strategies with their communities, and identify potential partners in these endeavors. These case studies aim to provide actionable insights and guidance for enhancing the resilience of coastal public power electric utilities, safeguarding their future against extreme weather.

GRID HARDENING TECHNIQUES

EXECUTIVE SUMMARY

The action(s) taken by each of the five coastal utilities to strengthen and harden the power grid is consistent with the following techniques:

Reinforcing	Upgrading
Reinforcing infrastructure through: • Weather resistant materials; • Undergrounding utility lines; • Elevated substations and transformers; and • Redundancy through secondary lines, distributed energy, and microgrid sources	Upgrading modern technologies through: • Smart grids; • Supervisory control and data acquisition (SCADA) systems; and • New technologies

Reinforcing Coastal Utility Infrastructure

Utility pole replacement remains a prominent hardening and reinforcement technique for coastal utilities. The cost, maintenance, lifespan, and environmental impacts are all factors involved with utility pole replacement. This report highlights the risks that each utility faces, along with the historical event(s) that have influenced which materials utilities use to construct poles. Although wood utility poles remain the most widely used in grid construction, the rate of decay in wetlands and coastal areas — resulting in increased maintenance and replacement costs — have led these five utilities to invest in other materials. Some have shifted towards metal, steel, or concrete poles for added durability, while others have invested in new composite materials that provide a range of efficiencies (including cost, lighter weight, and flexibility to withstand winds up to 145mph and other adverse extreme weather and natural disaster conditions) to increase their resiliency.

The **burying of overhead electric lines** has become an equally prominent hardening technique for areas that are geographically favorable for undergrounding. The high cost of the initial investment and the long-term maintenance considerations involved with undergrounding remain the leading deterrent for most utilities and their customer base. For some coastal utilities, the option to underground is simply not available due to the limitations imposed by landscape and topography. Where possible, undergrounding is gaining momentum among federally funded mitigation projects.

As the frequency of extreme weather increases, more coastal utilities are investing in the **relocation and elevation of substations and transformers** out of areas that are prone to flooding or storm surge. To mitigate the effects of direct water exposure, many coastal utilities are also taking the opportunity to upgrade and replace components or whole substations and transformers with materials that are noncorrosive and can withstand indirect impact from prolonged humidity, rust, direct sunlight, and salt air. The five utility case studies address how they are reinforcing their grid operations through relocation and upgrading to more weather-resistant equipment.

Additionally, coastal utilities are improving their resilience by **increasing reliability**. Most of the utilities included in this report manage independent, island-based operations, or are at the end of a single service line that connects to a generation source located on a mainland or at an extended distance away. The ability to ensure reliable service depends on having a redundant generation source available. Coastal utilities are investing in distributed energy options, such as backup battery power, or the installation of secondary service lines, to build redundancy and ultimately increase the reliable delivery of services. Several utility case studies highlight the implementation of microgrids and/or local energy assets.

Upgrading Technologies for Coastal Utilities

Coastal utilities are increasingly focusing on creating a comprehensive resilience plan to modernize their electrical grids, which includes investing in smarter and cleaner capabilities and security. This approach not only allows utilities to control flow and peak loads, but also to achieve greater cost efficiencies among their customer bases. One of the leading digitally focused techniques for hardening the grid includes the **implementation and/or upgrading of SCADA systems**. These systems, along with other **smart grid technologies**, enhance real-time monitoring and operational efficiency, enabling utilities to swiftly address and mitigate system disruptions. Furthermore, the resilience plan incorporates distributed energy resources (DER), such as solar panels and battery storage, which provide additional layers of reliability and flexibility. Overall, efforts to enhance grid resiliency have been expanded to include contingency measures, preparing the grid for unexpected failures and continuous service.

Resilience and Implementation Spectrum

Each coastal utility evaluates the implementation and effectiveness of resilience and hardening activities looking at a multitude of factors that may range from cost, time, and complexity. An essential part of a grid hardening mitigation plan is engaging with customers, as well as state, local, and federal officials, to convey how the investment will provide long-term benefits to the community.

In this report, a spectrum is assigned to each utility that identifies its highest and lowest levels of resilience or implementation based on the information collected. The spectrum is intended as a quick reference to illustrate the similarities, as well as the uniqueness, among these coastal utilities that are invested and engaged in grid hardening. The activities identified in each spectrum are subject to change and may not reflect all contributing and influencing factors for each identified utility.

PRIORITIZING AND DETERMINING GRID HARDENING INVESTMENTS

Upgrading Materials During Scheduled Replacement

The integration of upgraded and modern technologies to replace aging or damaged infrastructure will improve the resiliency of the grid with little additional cost or work. Selecting stronger and more weather-resistant materials to replace older technology, like wooden utility poles during routine or planned projects, reduces potential issues in the future. Concrete, ductile iron, and composite poles are all examples of ways communities can harden their power grid.

Distributed Energy Resources

Utilities and their customers are shifting from the traditional electric power paradigm to installing distributed energy resources (DER), such as distributed generation (DG) facilities that produce electricity closer to the end-use power. DER include demand-side management tools and DG resources like solar photovoltaic (PV) installations, small wind turbines, combined heat and power, fuel cells, micro-turbines, and storage devices (e.g., large lithium batteries or grid-connected EVs). The use of DER can benefit utilities and customers by reducing the need for new utility generation assets, lowering transmission costs by reducing peak demand, diminishing air pollution from fossil fuel generation, and helping utilities hedge against widespread power outages. However, DER also present challenges, including operational complexities for transmission, distribution, and generation systems, such as causing high voltage swings and other stresses on equipment when there's excess DG. Additionally, financial equity issues may arise, with utilities needing capital investments to address potential strains and designing rates for DG customers, particularly under net metering programs. These issues may also emerge with the growth of storage and EVs. More information on DER can be found in APPA's issue brief on distributed energy resources.

Community Education

Education programs inform the public of ways to make their homes more energy-efficient and ways to reduce energy consumption. School programs, community energy audits, and seminars are all ways to educate the public. By raising awareness about energy-saving techniques and providing practical guidance, these initiatives empower individuals to take actions that collectively contribute to a more resilient grid. Informed customers are more likely to understand the various programs, further supporting grid stability efforts. By integrating education as a key component of their hardening initiatives, utilities can enhance overall community resilience in a cost-effective manner.

Community Reporting

Real-time data collected from the public helps utilities pinpoint the exact locations of outages and infrastructure issues, facilitating faster and more efficient repairs. Establishing numerous ways for the public to report power outages or infrastructure issues provides real-time information. Phone applications, websites, and hotlines are all ways to enable the public to provide information, allowing timely response. These reporting channels ensure that utilities can quickly identify and address problems, minimizing downtime and improving customer satisfaction. By leveraging technology and community involvement, utilities can enhance their ability to maintain reliable service. Additionally, having multiple reporting methods makes it easier for all community members, including those with varying levels of access to technology, to contribute to grid resilience. This inclusive approach not only strengthens the utility's operational capabilities but also builds a stronger relationship with the community, fostering trust and cooperation during times of crisis.

Burying Power Lines

Burying power lines can significantly enhance the resilience of transmission and distribution systems. Though the process can vary in cost per mile depending on the environment, the investment is often worthwhile. Although this is a labor-intensive task, and especially challenging in urban areas, it results in greater resilience during storms or high winds. Underground power lines are less susceptible to weather-related disruptions, which can lead to fewer outages and improved service reliability. Additionally, buried power lines contribute to a more aesthetically pleasing environment by eliminating the visual clutter of overhead wires. This long-term infrastructure improvement can also reduce the maintenance costs associated with repairing damage from fallen trees and other storm-related issues. By investing in the hardening of transmission and distribution systems through undergrounding, utilities can provide more reliable and resilient service, ensuring better preparedness for future weather events.

Establish Microgrids

Microgrids are localized energy systems that can operate independently or in conjunction with the main power grid. The specialized work and regulatory constraints can complicate the establishment of a microgrid, and microgrids can cost between $2 and $4 million per megawatt.[1] However, despite the initial investment, the addition or supplement of microgrids reinforces the redundancy and resiliency of the power grid to disasters.

[1] Giraldez, J., Flores-Espino, F., MacAlpine, S., & Asmus, P. (2018). *Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States*. National Renewable Energy Laboratory. Retrieved from https://www.nrel.gov/docs/fy19osti/67821.pdf

Grid Resilience and Innovation Partnerships Program

Grid Resilience and Innovation Partnerships Program (GRIP) is a proactive DOE program focused on enhancing grid flexibility and improving the resilience of the power system against growing threats of extreme weather. By accelerating the deployment of transformative projects, GRIP will help to ensure the reliability of the power sector's infrastructure. The GRIP funding process takes approximately two to four years from application to delivery. The pre-application, application, and reviews can take six to 12 months. While the application process can be lengthy and complex, there is a large amount of funding available to smaller communities. See DOE's Grid Resilience and Innovation Partnerships Program page for more information.

SCADA

SCADA system costs can greatly range, depending on factors such as complexity, number of devices, hardware, and software licenses. Initial costs will focus on the hardware, consisting of sensors, communication devices, and controllers, along with software, including software licenses and configuration. Regulatory compliance, employee training, and cybersecurity are also considerations. The benefits of a SCADA system include improved reliability due to real-time monitoring, increased operational efficiency, better incident management, and scalability.

Smart Grid Modernization

The advantages of smart grid modernization include automated fault detection, real-time monitoring, and demand response systems. This involves integrating cutting-edge technologies, equipment, and control systems that enable two-way communication and real-time monitoring.[2] However, the largest obstacles are the significant physical and digital infrastructure upgrades needed, the training of personnel on modern technologies, and the high cost to implement.

[2] U.S. Department of Energy. (n.d.). Grid modernization and smart grid. Office of Electricity. Retrieved from https://www.energy.gov/oe/grid-modernization-and-smart-grid

CASE STUDY

KEYS ENERGY SERVICES (KEYS)
FLORIDA

- **Ductile iron pole construction**
- **Corrosion-resistant transformers**
- **Backup generators for substations**
- **Storm surcharge fund**

Resiliency Efforts: Highly Developed

Community Profile

KEYS serves Key West to the Seven-Mile Bridge, providing reliable service to nearly 32,000 customers and employing 133 personnel in the Lower Florida Keys. It is overseen by the Utility Board of the City of Key West and is a member of the Florida Municipal Power Agency's All Requirements Project, a collective that pools its power resources with other public power utilities in Florida. KEYS imports all its power supply and uses local generation for emergency backup and load support. Lynne E. Tejeda is the General Manager and CEO of KEYS and has led the implementation of several grid hardening projects over the past 19 years.

Risk

KEYS has a unique operating environment involving low elevation, rising seawater through porous limestone, and erosion. The area is particularly vulnerable to tropical systems and disturbances that range from heavy rainfall to storm surge and flooding caused by hurricanes.

Historical Event(s)

In 2005, Hurricane Wilma produced one of the greatest storm surge events to impact the Florida Keys, resulting in significant damage to infrastructure. In 2006, the Florida Public Service Commission established storm hardening requirements that included inspecting utility poles every eight years and addressing inaccessible facilities. In 2017, Hurricane Irma damaged numerous wood utility poles, and affirmed that the poles replaced during the previous years of inspection with storm-hardened materials withstood the hurricane's impact. Hardened poles that survived Hurricane Irma became the benchmark for KEYS' utility pole replacement program.

Grid Resiliency Efforts

KEYS is the recipient of FEMA Pre-Disaster Mitigation funding to upgrade poles to ductile iron construction. It has replaced 119 distribution poles serving critical governmental facilities. KEYS is also the recipient of a FEMA Hazard Mitigation Grant to add cathodic protection to all water crossing concrete transmission poles along the Seven Mile Bridge and throughout its service territory in Southern Monroe County to protect the poles from corrosion. KEYS has elevated transformers manufactured using corrosion-resistant materials above flood levels and installed backup generators at five of its critical substations to maintain local generation capability during extended outages, increasing redundancy.

To manage its utility pole inspection and replacement costs, which is approximately $1 million per year for 130 poles, KEYS implemented a by-zone inspection process, which alternates on a four-year cycle. The prioritization and replacement of poles continues with connections to critical facilities, including those with telecom and fiber optic connections. KEYS uses a combination of its own trained line workers and contractor labor for utility pole replacement to avoid delays when replacing larger quantities of poles.

KEYS has strengthened three buildings, now rated to withstand a Category 5 hurricane, so personnel can shelter in place in those buildings. Additionally, KEYS continues to invest in community engagement and outreach initiatives that include:

- Acquiring buy-in from homeowners and business owners to relocate lines from backyard easements to the street for easier access and maintenance; and
- Reaching the disaster reserve and mitigation fund goal of $40 million that will fund additional storm hardening projects, which is part of a long-term community objective.

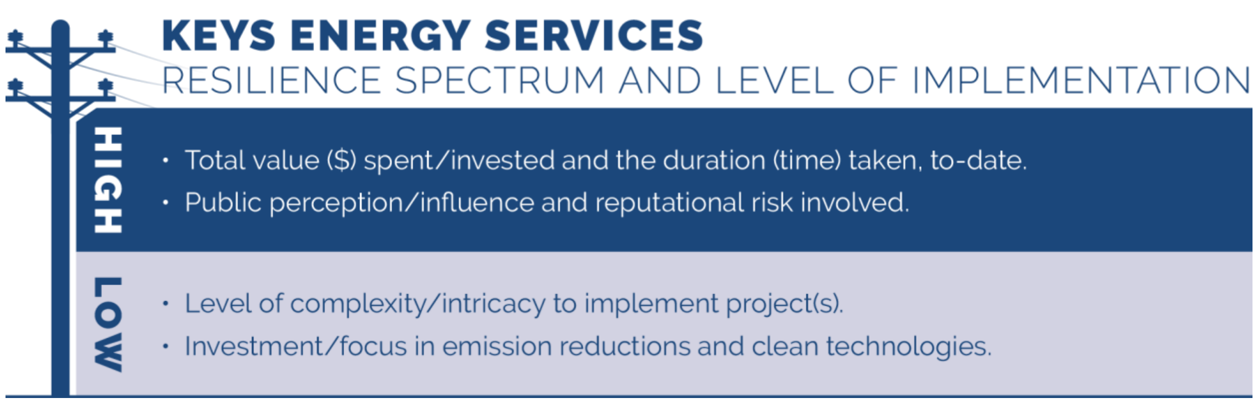
KEYS is one of the 254 public power utilities — out more than 2,000 in the United States — to earn the Reliable Public Power Provider (RP3) designation from APPA for providing consumers with the highest degree of reliable and safe electric service. The RP3 designation recognizes public power utilities that demonstrate proficiency in four key disciplines: reliability, safety, training, and system improvement. Criteria within each category are based on sound business practices and represent a utility-wide commitment to safe and reliable delivery of electricity.

Challenges and Limitations

- Imported Power: KEYS relies on imported power from the mainland through one radial transmission line. Additionally, nearly one third of KEYS' 850 transmission poles are located in the water, so KEYS depends on the use of alternate strategies like cathodic protection to mitigate the impacts of saltwater corrosion.
- Environment: The local environment is equally challenging in terms of geology, geography, and wear and tear to infrastructure (e.g., saltwater, termites, tropical heat, and moisture). The option of undergrounding distribution lines remains a challenge given the coastal environment, flooding, and compact property lines.

Resilience Spectrum and Level of Implementation

KEYS has been involved with hardening techniques for nearly two decades, so the overall duration and length for implementing its projects ranks high on the resilience spectrum, along with the total dollar value spent or invested. In contrast, the complexity and intricacy of some of the projects that KEYS has prioritized are considered low given the gains in efficiencies and the skills that have been mastered with utility pole replacement and transformer upgrades. Similarly, the focus and implementation of hardening measures in response to more extreme weather issues and DER remain limited for the KEYS, given its other project priorities, and is therefore also identified as low on this reference spectrum.



CASE STUDY

VIRGIN ISLANDS WATER AND POWER AUTHORITY (WAPA)
US VIRGIN ISLANDS

- Undergrounding utilities
- Composite pole construction
- Renewable energy and smart grids

Resiliency Efforts: Highly Developed

Community Profile

The Virgin Islands Water and Power Authority (WAPA) produces and distributes electricity to 13,000 customers throughout the territory and employs approximately 420 personnel. WAPA was created by the Fifth Legislature of the Virgin Islands in 1964, which was amended to add the responsibility of installing and maintaining streetlights to the utility's mission. WAPA produces electricity at plants on St. Thomas and St. Croix and distributes electrical service through smart grids to customers on St. Thomas, St. Croix, St. John, Hassel Island, and Water Island. In recent years, the responsibility for the production and distribution of drinking water has also been added to WAPA's mission.

Ashley Bryan, Interim Chief Operating Officer of WAPA, has overseen the implementation of several grid hardening projects during the past few years, especially since Hurricane Maria in 2017.

Risk

The US Virgin Islands (USVI) are located in the Caribbean Sea, including federal park lands, and are particularly vulnerable to tropical conditions that range from humidity, heavy rainfall, and flooding to storm surge and hurricanes.

Historical Event(s)

Hurricane Irma, which was followed by Hurricane Maria two weeks later, caused widespread damage across the USVI and limited the availability of scarce resources among the islands. The federal government provided close to a 100% match of federal funds to accelerate recovery and ease the financial burden on the territory from significant damage incurred during the 2017 hurricane season.

In 2024, WAPA was able to keep its generation online during Tropical Storm Ernesto due to its undergrounding of circuits as part of its mitigation activities that were undertaken since the storms of 2017.

Grid Resiliency Efforts

WAPA is the recipient of multiple federal funding sources from DOE, the US Department of Housing and Urban Development (HUD), the US Department of Interior (DOI), FEMA, and the Environmental Protection Agency, which were used to prevent or reduce damages caused by future disasters. The utility is focusing on renewable energy projects to reduce reliance on the use of fossil fuels for generation and to reduce fossil fuel emissions.

WAPA's investments in undergrounding lines were made to provide greater reliability and resilience throughout the power system. A rigorous cost-benefit analysis coupled with a competitive bid process was used to identify the third-party engineering firm to complete the projects. Where undergrounding is not feasible, composite construction is used for replacing and upgrading utility poles. WAPA is also looking to make substation improvements and changing out air-insulated switch gears and installing gas-insulated switch gears.

Three microgrid projects are underway for St Thomas, St. John, and St Croix, providing renewable-based resources to the grid and maintaining small sections of the power system when there is a loss of electricity from a thermal power plant.

Coordination and collaboration continue among federal and territorial partners, especially those involved with long-range project planning and environmental and historical preservation review and permitting. For example, WAPA works closely with several engineering and design firms regarding joint use of utility poles to support telecommunications across the islands. It also maintains a GIS database with all infrastructure modeled used for different dynamic studies. Additionally, WAPA participates in weekly collaborative meetings with its departments of public works, waste management, and water management.

Additional efforts include HUD-funded projects for new generation installed at the power plant on St. Thomas, the acquisition of two liquefied petroleum gas terminals for propane supply, and the strategic development of battery storage throughout the grid. DOI grants are also being used for skilled labor workforce training and to purchase 30 hybrid and electric vehicles, including bucket trucks and digger derricks.

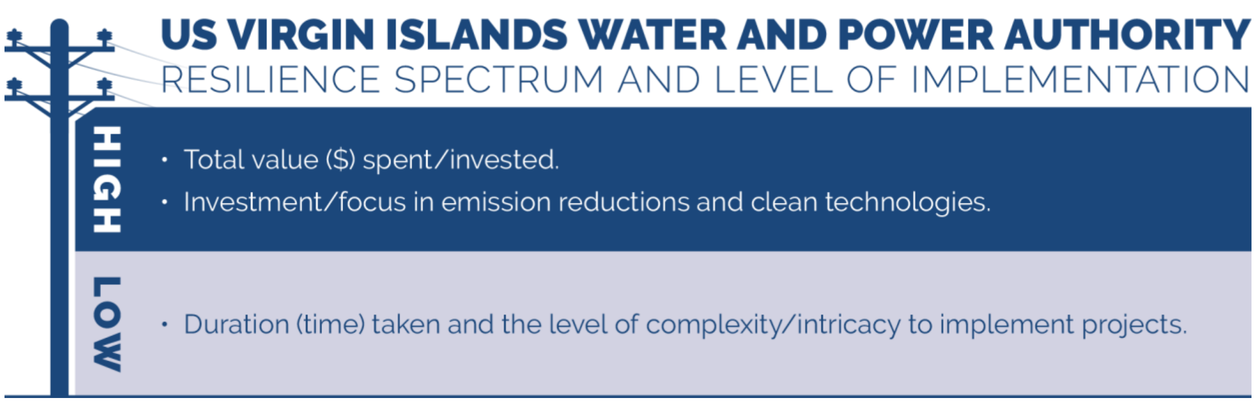
Challenges and Limitations

WAPA faces unique challenges and limitations due to its geography and political relationships. As an archipelago, it relies heavily on self-sourced power for critical infrastructure.

Operational Coordination: WAPA continues to maximize the cost-benefit analysis of projects underway, as well as those yet to commence, utilizing the various federal funding sources to mitigate as many of the critical customer bases, which are densely populated areas, as possible. It is a delicate balance collaborating with other departments and agencies to avoid impacts to utility operations across the USVI. For example, coordinating excavation efforts to minimize impact and disruption while still managing other WAPA projects to reach the reliability benefit as quickly as possible.

Resilience Spectrum and Implementation Summary

WAPA has invested significantly in funding its hardening projects, which include a concentrated focus on reducing fossil fuels and increasing the use of DER in response to more extreme weather conditions. These initiatives rank high for the value of project implementation on this resilience spectrum. However, many of these hardening initiatives are relatively recent, undertaken in the aftermath of the 2017 hurricane season, and are considered low for the overall time, duration, and complexity to implement to date.



CASE STUDY

GUAM POWER AUTHORITY (GPA)
GUAM

- Undergrounding utilities
- Concrete pole construction
- Community engagement

Resiliency Efforts: Highly Developed

Community Profile

GPA was established by the Guam Power Authority Act of 1968 and is a public corporation that is managed by a governing board made up of five elected commissioners. GPA serves more than 50,000 customers. In addition to the residents of Guam, GPA also supports base operations and communities for the U.S. Navy, Air Force, Marines, and Army. Beatrice "Tricee" Limtiaco, Assistant General Manager for GPA, has led the implementation of several grid hardening projects throughout the past few years.

Risk

Guam is the largest and southernmost island in the Mariana Islands chain. GPA operates in an environment that is particularly vulnerable to tropical conditions, ranging from humidity and heavy rainfall to typhoons, storm surge, and earthquake-induced tsunamis from neighboring Japan. Although Guam is protected by coral reefs, the island remains susceptible to erosion.

Historical Event(s)

Typhoon Mawar (2023) was the most devastating storm Guam faced in 20 years. The aquifer in northern Guam and other well water systems lost power and relied on emergency generators, which were fuel dependent.

The U.S. Navy and Air Force bases lost power due to sustained impacts to the wooden transmission and distribution poles that are maintained by the Department of Defense and are not part of GPA's pole replacement and hardening efforts. GPA is responsible for and provides power until it reaches the infrastructure on the bases. Additionally, in the aftermath of Typhoon Mawar, GPA's indoor substations eventually lost power due to the buildup of accumulated humidity.

Grid Resiliency Efforts

Based on the lessons learned from Typhoon Mawar and the efficiencies gained through its hardening initiatives, GPA has a new goal for restoring power to its customer base within two weeks following another typhoon-induced outage. To meet this goal, GPA is proactively investing in undergrounding transmission lines prioritized by areas with critical infrastructure and high demand for businesses and services. This includes focusing on undergrounding throughout Tuman Bay (Guam's tourism district), followed by secondary side streets and other less populated areas. Additionally, GPA is hardening indoor substations that service critical assets (e.g., well water, sewer/sanitation, and military facilities).

GPA was able to use its own crews when it replaced poles for concrete construction. Additionally, GPA manages an apprentice program for transmission and distribution services and undertakes various community engagement efforts to inform the community and key stakeholders of how base rate revenue funds are being used to increase resilience. This public messaging covers information on standby generators to assist with keeping substations climate controlled, energy storage batteries for well water systems, hardening communications and the SCADA system, and moving all substations indoors and away from the coast.

Guam received an award from the DOI's Office of Insular Affairs to conduct a study called "Guam 100," which aims to achieve 100% renewable energy and eliminate fossil fuel plants by 2045. Solar energy is the most viable renewable option on the island, and GPA maintains supply-and-needs contracts with two private PV farms, but it still currently relies on traditional power plants. It is the intent of Guam 100 to provide tools to ensure energy system resilience that will allow the island to no longer rely on the power plants.

Challenges and Limitations

Guam faces several unique challenges and limitations due to its geography and political context. As an island, it relies heavily on self-sourced power for critical infrastructure, including communications and public water sources.

- Approval and Permitting: The process for approving and permitting new projects is often lengthy. This is due to Guam's historic preservation restrictions, complex military relationships (such as sharing property easements with the Department of Defense), and the ever-present risk of encountering munitions and explosives. These factors, combined with contracting constraints and limited availability, often result in Guam not receiving the best value or rates, leading to premium market prices and long lead times for contracted support and services.
- Public-Private Partnerships: There is a need for more robust public-private partnerships, particularly with telecom companies, to enhance emergency response capabilities and identify critical infrastructure ahead of disruptions. Conducting informed gap analyses can help in understanding and addressing these needs.
- Supply Chain Management: Following Typhoon Mawar, there was a significant need for large transformers, bucket trucks, fuses, and other critical components that were not readily available. National supply and demand dynamics impact how territories and islands like Guam receive products and services, threatening overall resiliency.
- Training Needs: Distribution and transmission teams require more training in underground repair to improve their response capabilities and ensure the reliability of the power grid.

Resilience Spectrum and Implementation Summary

GPA has invested a significant amount in funding complex and intricate projects shared with the U.S. Department of Defense, which results in a high ranking on this spectrum for resilience and implementation. Several recent projects are based on lessons learned from Typhoon Mawar that rank the overall duration or time for implementation as low, with the pursuit of hardening measures and the use of DER in response to more extreme weather conditions, to date.

GUAM POWER AUTHORITY
RESILIENCE SPECTRUM AND LEVEL OF IMPLEMENTATION

HIGH
- Total value ($) spent/invested and the level of complexity/intricacy to implement projects.

LOW
- Duration (time) taken to implement projects.
- Investment/focus in emission reductions and clean technologies.

CASE STUDY

NEW BERN UTILITIES
NORTH CAROLINA

- Undergrounding utilities
- Redundancy and expanded capacity of operating systems
- Resiliency and Hazard Mitigation Plan
- Power cost adjustment charge

Resiliency Efforts: Intermediate

Community Profile

New Bern Utilities, a member of ElectriCities of North Carolina, provides power to more than 25,000 customers throughout New Bern, Trent Woods, and points along Highway 70 East to Havelock. Charles Bauschard, Director of Public Utilities, has been involved in several grid hardening projects during the last few years.

Risk

New Bern is positioned near the North Carolina coastline and is vulnerable to tropical systems and disturbances that range from heavy rainfall, flooding, and storm surge to hurricanes. The city has also experienced wildfires with respect to its proximity to Croatan National Forest.

Historical Event(s)

In 2018, Hurricane Florence produced a 10-foot storm surge, resulting in record flooding in New Bern that caused $100 million in residential and commercial damages. The city lost its distribution service and spent weeks restoring service and collecting and clearing debris. The rebuilding process continues today as many of the temporary/quick repairs were made to aging infrastructure and now need to be replaced and upgraded appropriately to meet load growth (capacity).

Grid Resiliency Efforts

New Bern Utilities is focused on assessing system capacity, keeping reserves available to ensure redundancy of operating systems, and establishing the infrastructure necessary to support emergency operations. New Bern Utilities intends to seek DOE funding for a new 50 MVA substation, retirement of three 50 MVA transformers, extending distribution lines to reroute power to distressed area, undergrounding and right sizing exiting distribution lines to ensure rerouting powering, daily peak and reliability through design, repairs, and to conduct predictive testing. Pending funding approval, New Bern Utilities has made the following considerations should they receive funding.

The City of New Bern developed a multi-phase, long-term Resiliency and Hazard Mitigation Plan in 2022 that includes utility inputs, provides an overview of New Bern's hydrologic conditions that influence stormwater runoff, and details strategies and recommendations for mitigating impacts.

In alignment with the city's mitigation plan, New Bern Utilities is seeking additional funding to meet current and future capacity requirements, rerouting power to distressed areas, operations and control center to modernization to include operator workstations, training and testing workstations, as well as upgrades that meet the accessibility requirements of the Americans with Disabilities Act.

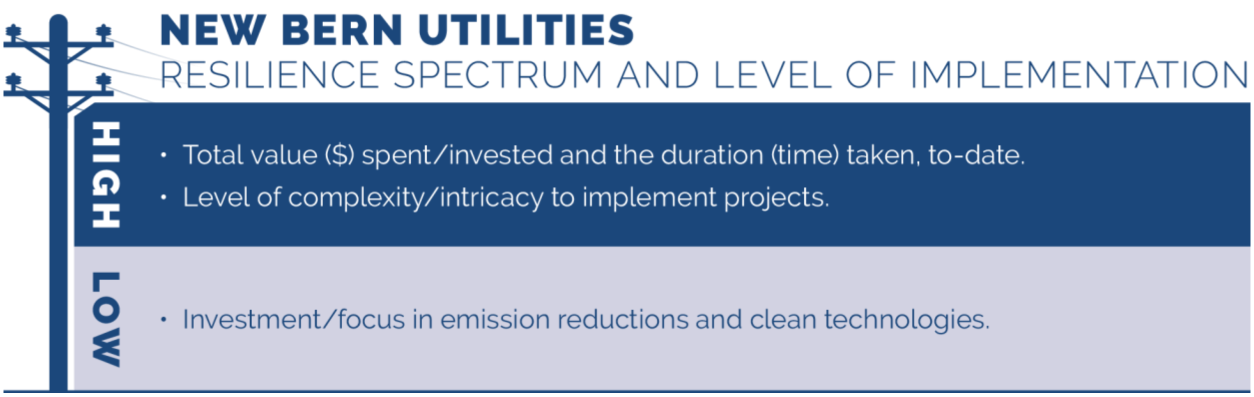
Additionally, New Bern Utilities leads a community engagement and outreach effort to inform customers of a Power Cost Adjustment Charge to offset the rising cost of fuel. Additionally, New Bern Utilities desires to participates in scholarship programs with the local community college to encourage careers in the electric utility industry. They also participate in a variety of community education and safety awareness events throughout the year.

Challenges and Limitations

- Varying Levels of Investment Interest from Community: Some members of New Bern's population are more willing than others to invest in mitigation projects (via raising consumer rates) to achieve greater resiliency.
- Availability of Resources: New Bern Utilities is faced with day-to-day maintenance of feeders to include the undergrounding of an aerial feeder crossing that continually makes it difficult to re-route power as needed. There is a market shortage of distribution transformers and renewables are not a primary focus for assisting infrastructure generation at this point.
- System depreciation is approaching 70%.

Resilience Spectrum and Implementation Summary

New Bern Utilities' hardening techniques have been focused on system maintenance and responding to line extensions for ongoing large scale residential developments which rank their overall duration and length for implementing projects high on the resilience spectrum along with the total dollar value spent or invested to date. The complexity and intricacy of some of its projects, such as undergrounding and incorporation into a city-wide mitigation strategy, are also considered high on the implementation spectrum. The focus and implementation of hardening measures in response to more extreme weather issues and distributed energy resources remain limited and rank low on this reference spectrum, given the demand to meet other hardening project priorities.



CASE STUDY

LEWES BOARD OF PUBLIC WORKS (BPW)
DELAWARE

- **Undergrounding utilities**
- **Steel pole construction**
- **Repositioning pump stations**
- **Corrosion-resistant upgrades**
- **Readiness to serve/commodity charge**
- **Mitigation committee**

Resiliency Effort: Developing

Community Profile

Lewes BPW is a locally owned and operated utility for the City of Lewes, proudly known as "The First Town in The First State." Located in Delaware's rapidly growing Cape Region, it serves nearly 3,500 customers and employs approximately 50 personnel. Lewes BPW, which is governed by a customer-elected body, provides the city's electric, water, wastewater, and storm water utilities and is part of Delaware Municipal Electric Corporation, or DEMEC. Austin Calaman is the General Manager of Lewes BPW and Thomas Panetta, its President, managed the implementation of several grid hardening projects over the past few years.

Risk

Lewes BPW operates in a historical district (structures date back to the 1700s) with a coastal climate that is subject to corrosive conditions, with an increased vulnerability of storm surge and flooding. The area is also subject to extreme temperatures ranging over 100 °F during the summer months to as low as -11 °F. It can have several inches of snow during the winter months.

Historical Event(s)

During the past few years, Lewes BPW conducted two planned outages to improve grid interconnectedness with Delmarva Power and Light. The outages resulted in disruption to the entire single line system, lasting more than four hours in duration for consecutive days. With the lack of a redundant line, the risk of an unplanned outage remains high. Additionally, the City of Lewes is predominately a retirement community comprised of part-time residents who support undergrounding utilities for aesthetic purposes, but whose buy-in is often influenced by convenience and overall cost.

Grid Resiliency Efforts

Lewes BPW is in the initial scoping phase with multiple attempts applying for FEMA Hazard Mitigation Grant Program funds to support several hardening projects that include the undergrounding of lines in areas that are not deemed historical or have tribal artifacts; repositioning 16 pump stations; upgrading transformers and pads near coastal areas to noncorrosive materials; replacing wood poles for steel; and relocating the wastewater treatment plant from a flood plain.

Due to the number of part-time residents, Lewes BPW maintains a Readiness to Serve Charge and a Commodity Charge based upon consumption to cover the cost of infrastructure maintenance.

Lewes BPW previously had a Mitigation Committee, which was sunsetted, but proactively benchmarked many of these projects based on limiting risk and reducing costs. A resolution was passed that requires new or rehabilitated construction projects to include underground lines. Lewes

BPW's strategic planning is sustained through annual reviews. Priorities include building redundancy and reliability in critical service areas (e.g., hospitals) and automating the grid.

Lewes BPW is one of the 254 public power utilities — out of more than 2,000 public power utilities — to be nationally recognized as a Reliable Public Power Provider (RP3) and is a recipient of the Excellence in Reliability Award from APPA for providing consumers with the highest degree of reliable and safe electric service. The RP3 designation recognizes public power utilities that demonstrate proficiency in four key disciplines: reliability, safety, training, and system improvement. Criteria within each category are based on sound business practices and represent a utility-wide commitment to safe and reliable delivery of electricity.

Challenges and Limitations

- Historic Preservation: As a historical district where tribal artifacts have been discovered, Lewes BPW continues to operate under unique planning and preservation constraints, which prevent full undergrounding of utilities. A hybrid approach includes connecting to transformers above ground in areas where undergrounding is not feasible or permissible. Where undergrounding is an available option, it has been difficult for Lewes BPW to meet current demands and stay on schedule since contracted support and specialized equipment have high seasonal demand and long lead times to procure.
- Flooding: Challenges exist in coastal areas where there is a low water table on the beaches but a higher water collection among canal areas, leading to flooding at times. The City of Lewes is located at the end of a single servicing line, with no redundancy, and is subject to congestion at peak conditions.
- Technology: Lewes BPW continues to make manual entries while pursuing opportunities to automate the grid through SCADA systems. There are limited land use options for pursuing alternative energy options such as solar, and vegetative maintenance remains an added cost.

Resilience Spectrum and Implementation Summary

Lewes BPW's unique customer base influences the implementation of its hardening projects and, therefore, ranks high on the resilience spectrum along with the duration or time it takes to implement complex and intricate projects, such as undergrounding. In contrast, the total dollar value that has been awarded or invested is considered relatively low, to date, until the time when projects commence and spending increases. Additionally, the focus and implementation of hardening measures in response to more extreme weather issues and DER remain limited for the BPW and is therefore identified as low on this reference spectrum.

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RESILIENCE SPECTRUM AND LEVEL OF IMPLEMENTATION

HIGH

- Public perception/influence and reputational risk involved.
- Duration (time) taken and the level of complexity/intricacy to implement projects.

LOW

- Total value ($) spent/invested.
- Investment/focus in emission reductions and clean technologies.

CONCLUSION

The goal of these case studies is to demonstrate the various methods utilities can employ to harden their grid systems. This was achieved by analyzing the actions taken by five coastal utilities, each at different stages of grid hardening through various techniques. Although all the utilities involved are coastal, they each have unique motivations, influences, and historical factors that have shaped their decision-making processes regarding implementation. These factors include the socio-economic makeup of their communities, environmental and historic preservation laws and policies, and their financial capacity to support such initiatives.

Understanding that many of these grid hardening actions require a thorough analysis of time, scope, and budget, it is crucial to recognize that this effort is an investment. The immediate benefits of the cost may not always be apparent; however, this should not diminish the importance of hardening efforts. Conducting a cost-benefit analysis is important to determine the positive outcomes of pursuing such measures.

In conclusion, while the path to grid hardening is complex and multifaceted, the long-term benefits of increased resilience and reliability far outweigh the initial investments. By learning from the diverse experiences of these coastal utilities, other regions can better prepare for and mitigate the impacts of disasters, ultimately ensuring a more robust and secure energy infrastructure for the future.

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