Resiliency & Redundancy in the Electricity Sector *— At What Cost?*

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Resiliency & Redundancy in the Electricity Sector — At What Cost?

Given the devastating and costly impacts of severe weather events and recovery from last year's hurricanes Irma and Maria still ongoing, there's been significant discussion about the best path forward for Caribbean electric utilities to achieve greater resiliency and redundancy in the electricity sector.

Strategic efforts are also being made in coupling resiliency measures with climate change mitigation such as installation of microgrids, energy storage, and the diversification of resources, specifically the addition of more renewables.

But what does resiliency mean, how is it defined? And, what is the role and value of redundancy and duplication of critical components in the electric system to help ensure reliability and security cost-effectively?

Definition of Resilience

The National Academy of Sciences defines "resilience" as the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. **In this article, resiliency is considered in the context of Caribbean and other small island states, looking at both physical measures that could be taken to harden the electric system to lessen the risk of power outages during storms and hurricanes, and the adoption of processes for rapid recovery when outages do occur. Ultimately, whatever measures are taken to improve resiliency must be appropriate and cost-effective for the small systems involved.**

Weighing Costs

There are a variety of options for strengthening and hardening an electric system and implementing resiliency measures for faster response to storm outages. However, the cost impacts can be great. Options for greater resiliency and redundancy can be expensive investments that need to be carefully evaluated over the long term.

When evaluating resiliency and redundancy measures, it is important to quantify the physical outcomes, economic effects and social impacts of severe weather disasters on the system. Balancing the likelihood of an event against the severity and cost of the consequence on the local economy is an essential exercise to help prioritize resiliency investments and contain costs.

Ultimately, the feasibility of any improvement in resiliency or redundancy has to be balanced against the cost that the customer base can realistically be expected to bear. While it might seem logical that improving resiliency through physical hardening of the systems and adding more redundancy is a beneficial step, it is important to assess the overall cost in the context of each small-island state and the customer's ability to afford the resultant price of electricity.

Grenada, after Hurricane Ivan in 2004

Learning from Experience

In 2004, Hurricane Ivan devastated the nation of Grenada. Grenlec, the island's sole electic utility, suffered unprecedented damage to its distribution system. However, because of good planning and sound design in prior years, the generation assets were largely untouched by the storm and were made operational within 24 hours of the "all-clear" status. Guided by its Disaster Recovery Plan, Grenlec restored power rapidly to critical locations for medical, water and public safety services. Full restoration was completed within a year.

"Resiliency and redundancy were designed into the restoration plan and processes as Grenlec rebuilt the electrical system in Grenada," says Murray Skeete, WRB Energy Vice President of Engineering & Regulation and Director of Grenlec. The flexible nature of the generating assets allowed Grenlec to segment the system into multiple "islanded" power systems, essentially creating ad hoc microgrids. The distribution system was then rebuilt radiating from these "hubs."

Assistance with this rebuilding effort was afforded by several crews from neighboring island utilities. A disaster relief program, organized by the Caribbean Electric Utility Services Corporation (CARILEC), ensures that sister utilities are available to support each other in recovery and restoration efforts. Lastly, and very significantly, Grenlec also maintains a self-insurance "Hurricane Fund" which allowed the utility to promptly pay for restoration materials and efforts.

Grenlec solar photovoltaic (PV) rooftop installation in Grenada.

Methods of Improving Resiliency

Undergrounding transmission and distribution lines is one of the most common measures proposed for mitigating storm damage. However, in many cases, the costs associated with converting overhead systems is extremely high. According to a report by Edison Electric Institute for U.S. utilities, *Before and After the Storm*, not one study included in the report recommended a complete conversion of overhead distribution infrastructure to underground, given that the estimated costs would be in the billions of dollars. The studies found that undergrounding would not be economically feasible and would negatively impact customer rates.

Additionally, although undergrounding lines can reduce the frequency of outages, studies also showed that restoration time can increase due to the complexities of the systems and the inability to visually identify the cause of the fault. However, while costs are currently prohibitive for total system undergrounding, utilities and regulators should review the metrics for selective undergrounding as a potentially viable solution for vulnerable areas and for locations serving critical facilities such as police, fire, hospitals, water utilities, and telecommunications. It's also important to note that undergrounding does not totally protect the system from storm surges and flood damage.

Other hardening measures for poles and lines can be incorporated as part of routine maintenance schedules as new designs become available and older equipment is retired and replaced.

Overall, utilities need to weigh the size of the system, critical loads, relative costs, environmental factors, causes of outages, and weather-related risks to provide the appropriate level of resiliency.

Distributed generation and microgrids. Solar photovoltaic (PV), wind, fuel cells, and fossil fuels, can provide additional capacity to enhance resilience during major outages. In some cases, systems can disconnect from the main power system and serve as backup power.

While many small island systems could already be called microgrids, even smaller microgrids consisting of distributed generation, energy storage, and energy management systems can be configured to operate in parallel with the grid but also to operate independently as a complete "islanded" electricity system during outages. Microgrids are typically end-user, customer driven and funded, however, in some cases, utilities are involved, specifically in the case of two-way systems (interoperable systems) and security. Microgrids can reduce peak demand and load growth, as well as help utilities defer additional power capacity investments.

The caution here is that where these microgrids or distributed generation systems are utility owned, they are, in essence, redundant systems and therefore will lead to corresponding increases in overall cost, both capital and operational.

Restoration efforts in Grenada after Hurricane Ivan 2004

Methods of Improving Resiliency, Cont'd.

Remote monitoring & control. Utilities can combine information technology and automated monitoring to limit customers affected by outages. Reclosers, switches, and sectionalizers limit the spread of outages and allow faster service restoration.

Smart grid technologies can detect outages and remotely reroute electricity to undamaged circuits and feeders. Automated distribution technologies allow faults to be isolated and power to be rerouted in order to minimize the number of impacted customers.

As utilities implement resiliency plans, monitoring implementation progress and costs will be critical to assess impacts and effectiveness for reliability, sustainability, and affordability.

Restoration Planning

Many utilities have instituted formal processes involving multiple regions for responding to major outage events and restoring power quickly. Sufficient utility crews, equipment, and fuel are critical to restoration efforts. According to a recent EEI study,

"Utilities must measure the costs of having available crews compared with the costs of extended outages due to insufficient numbers of prepared crews."

In the Caribbean, the Disaster Assistance Program implemented by the Caribbean Electric Utility Services Corporation (CARILEC) ensures that crews from regional sister utilities are available to support each other in disaster relief efforts.

In addition, standby equipment can be used, including mobile transformers, mobile substations, and mobile generators that can enable quicker temporary restoration of electricity service while more extensive repairs are conducted.

Financial Considerations

Cost-benefit Analysis

An important element in making wise investment decisions is to evaluate resiliency strategies and solutions against the costs and benefits to customers over the long-term.

Reviewing vulnerabilities to the system and the potential solutions with related costs is the first step. According to the U.S. Department of Energy Outline for Climate-Resilience Assessment Framework, utilities can develop resilience plans that identify system threats and assess a variety of resilience solutions based on the costs and impacts of each option using both a cost-effectiveness and risk management perspective.

Strong Financials

It's equally important for a utility to maintain a healthy financial position including profitability and a strong balance sheet. Demonstrating sound financial performance allows a utility to access capital more readily for restoration efforts.

Self-insurance

While commercially viable insurance of the transmission and distribution systems is unobtainable in the Caribbean, utilities can maintain a fund for disaster recovery costs to help mitigate financial constraints after a catastrophic weather event. Securing sufficient hurricane reserves in advance through electricity rate mechanisms acts as a self-insurance measure, and will avoid the need for sudden rate increases to recover restoration costs and prevent post-event financial trauma to customers. **Being prepared to pay for restoration efforts ahead of time helps to speed recovery activities while minimizing customer rate impacts.**

Prudent Pacing of Service Restoration

Rebuilding of an electric system needs to be done commensurate with the reconstruction of the local communities, homes, and businesses. If the island's residents have not recovered and rebuilt, then **it's prudent to pace the restoration efforts to meet the actual customer demand.** The utility's disaster management plan needs to balance restoring full operations and service as quickly as possible against the associated costs and the actual customer demand for electricity. Otherwise, the utility can face shortfalls in revenue at the same time as incurring significant expenses which will negatively impact the utility's financial health. Strategic restoration plans that coincide with the actual recovery activity in the service territory may help to better facilitate efficient restoration efforts.

Conclusion

An Integrated, Right-sized Approach to Resiliency

Given the changes in the electricity sector with new asset types, new technologies, greater distributed generation and renewables, utilities need to assess how this impacts resilience. Resilience plans should outline the costs and consequences of options and act as a guide for prioritizing and spending limited resources efficiently.

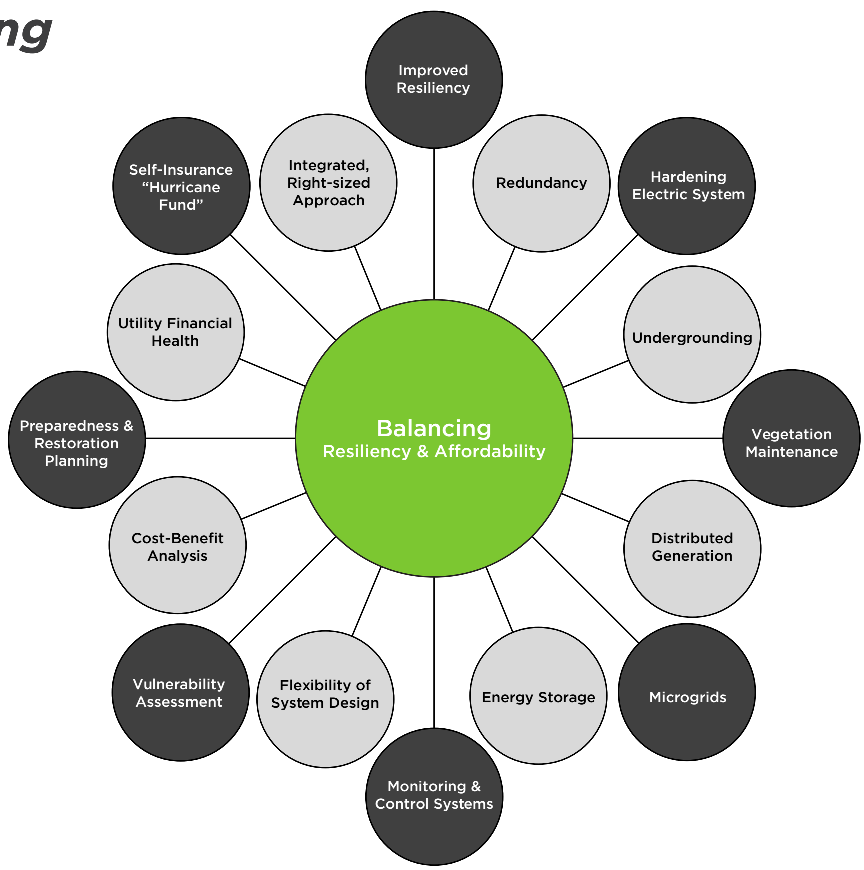
Just as many utilities implement a strategic integrated resource plan (IRP) to accommodate anticipated changes over the next 5 to 20 years, the same process can be applied to incorporate greater resiliency. The exercise allows utilities to alter their planning process and asset management to build in resiliency based on their system specifications, requirements, size, and needs.

According to a recent California Public Utilities Commission report, *Climate Adaptation in the Electric Sector, Vulnerability Assessments & Resiliency Plans,*

"The utility, along with regulators and stakeholders must establish priorities according to its goals and objectives as electricity providers. They must establish a set of guiding principles much like is done within the safety realm to help guide limited resources."

Regionally, utilities and regulators need to determine what level of cost is appropriate and prudent for greater system resiliency and reliability because ultimately it is the customer who will pay.

Balancing



Author: Murray Skeete, B.Sc.CEng.
Vice President of Engineering and Regulation with WRB Energy and Director of Grenada Electricity Services Ltd. (Grenlec)

About WRB Energy

WRB Energy develops renewable energy projects to help stabilize electricity prices and reduce dependence on imported fuels to drive economic growth and sustainability in Latin America and the Caribbean. WRB Energy manages the entire project lifecycle including site selection, design, permitting, financing, construction and operation. WRB Energy's parent company, WRB Enterprises, has more than a half-century of operational experience in the energy, utilities, and financial sectors. For more information, visit wrbenergy.com

WRB ENERGY

1414 Swann Avenue, Suite 201
Tampa, FL 33606

Town Centre Mall, PO Box 625
Providenciales, Turks & Caicos Island BWI

T: +1-813-251-3737 | F: +1-813-251-3788 | info@wrbenergy.com | wrbenergy.com

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