

Reading Report 4

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Summary

In September 2017, the East coast of North America and the islands nearby in the Atlantic ocean suffered several hurricane events, notably hurricane Irma closely followed by hurricane Maria. The archipelago of Puerto Rico especially experienced extreme weather and storm conditions for several weeks that month. This left basically all aspects of Puerto Rico's infrastructure in ruins, both literally and figuratively. At the time of the event, I personally remember hearing stories in the news about hospitals on backup power, supplied solely by diesel generators. The electrical grid was obviously not exempt from this destruction.

The article "Build Back Better" describes a full assessment of the damage to the electric grid that occurred during the hurricanes. It also prescribes a new basis of design for reconstruction of the grid, and comprehensive recommendations for the reconstruction. The report was performed by large working group comprised of many East-coast American power groups that had prior experience with similar situations as well as Puerto Rican entities.

PREPA, which stands for Puerto Rico Electric Power Authority, is the vertically integrated power supplier in Puerto Rico. This means the company is its own supply chain. As such, the company owns the majority of its power generation sources (two thirds of their generation comes from six fossil fuel and seven hydroelectric power generation plants owned by PREPA). PREPA's grid also includes about 2,500 miles of transmission lines, about 31,500 miles of distribution lines, and 334 substations to service 1.4 million customers.

Due to the geography of the island, most of the population is located on the North side of the island, with high concentrations around the perimeter of the island and not many inhabitants in the middle of the island due to mountains. This means that a lot of power lines circle around the coast of the island, which is susceptible to high winds during a hurricane. After Irma came and went, about 70% of PREPA's customers came back online, but once Maria hit soon after, the system was already weakened enough that catastrophe ensued - leading to the longest power outage so far in US history. Many reports indicate that some customers did not get power back on for over 11 months.

New Basis of Design

Sadly, hurricanes aren't going anywhere. The fact is, global warming and climate change are shown to lead to higher frequency and higher impact weather events. This means that in rebuilding the PREPA infrastructure, the design must be resilient and hardened to these types of situations. Some methods of increasing resiliency and hardness to the hazards seen in Puerto Rico are detailed in the report.

This basis of design includes redesigning all transmission and distribution lines to be Storm Category 4 or even 5 survivable. Creating a design that also strategically locates lines near main roads will allow for better serviceability in the case that they still come down. Use of steel power poles instead of wood or concrete, and using underground lines when available instead may help with more system robustness.

Of course, facility upgrades are another important part of increasing the resilience of the system. Some of the suggestions are to make sure the main control center is very robust so that during an event, the control center itself is able to stay operational throughout and better control the situation and damage. General hardening tactics such as flood barriers in substations may be helpful as well.

In general, the new basis of design includes more resilience and hardness built into the system, starting with how it is designed on paper.

Recommendations

Some of the recommendations to improve resilience and hardness are to use renewable energy sources and distributed energy resources, including energy storage and microgrids; incorporate better SCADA technology into substations; use of more redundancy in system design, including having more reserves; more advanced automation; and more asset management, including a significant increase in vegetation management.

The use of renewable energy could help with resiliency because if shipments of fuel cannot make it to the island due to stormy conditions, the renewable generation will still be able to generate some amount of power. This use of renewable generation in combination with energy storage is an especially good idea, as excess generated power may be stored for emergencies later. Also, microgrids allow for larger grid systems to be more modular; if needed smaller areas can disconnect from a bigger system as it experiences difficulties, transfer onto a backup system or separate system to help reduce time customers are blacked out. This seems like it may be especially important for things like hospitals, in addition to backup generators, to increase redundancy and therefore robustness of the system.

Better SCADA (supervisory control and data acquisition) which basically means the control systems could also help to identify problem areas quicker.

Redundancy in system design is a nebulous recommendation, but the principle is that if the system has several of the same thing, if one of them is de-commissioned, the ones remaining on will be able to keep the system functional. This could mean more reserves (which could be supplied by the renewable generation) or for example multiple SCADA systems.

In regard to asset management, one thing that was mentioned specifically for this situation was vegetation control. In the climate Puerto Rico has, plants grow abundantly and quickly, so managing the vegetation surrounding grid connected equipment and lines can help keep systems fault-free in general and also help during windy times when vines or branches may blow onto lines.

Personal Opinion

Interestingly enough, a lot of the suggestions for rebuilding the system better are not related to power system protection in the sense of relays, breakers, coordination, etc. Most of the suggestions are in regards to power system robustness and reducing the likelihood of events happening in the first place. I think that a lot of the suggestions have merit and would definitely help to ensure a blackout of this scale does not happen again.

However, in the report, the estimated cost to implement all the suggestions was over 17 BILLION dollars. This is over 15% Puerto Rico's GDP. It will be extremely difficult for PREPA/Puerto Rico to rebuild the power system to the suggested standards. As detailed in the report as well, pieces of legislature such as the Stafford Act will make it even more difficult to get goods cheaply as for Federally funded projects only USA-source goods are to be used. Further economic strife such as a weak labor force and the forecasting of further storms in the near future also cause concern. So I think realistically the rebuilding of one island-wide large grid may be unattainable.

Though this may not be ideal, small private providers located around the island may be more feasible and flexible in a lot of senses, for example the Stafford Act likely would not apply, costs could be more distributed, and labor demand could be lower. I think this is generally along the same vein of thought that using microgrids has. At the time of this event, I remember reading that private entities such as Elon Musk were interesting in trying to implement their new technologies to help the situation, which would be interesting to allow - it could be an opportunity to rebuild a completely new system that is different than anything we've ever made before. It's not very often that essentially an entire power system is destroyed.