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Modernizing the Puerto Rico Power Grid

Power Technology | Issue 130 | June 2019

When Hurricanes Irma and Maria battered Puerto Rico, in September 2017, the island lost all power.

The consequences were deadly. Hospitals couldn't operate crucial equipment, including respirators, and drugs that require refrigeration, such as insulin, were ruined. An estimated 135,000 people fled to the mainland, and the Puerto Rico Electric Power Authority (PREPA) needed 11 months to fully restore service. Death toll estimates reached 2,975.

As Puerto Rico grappled with the difficulty of running a country without power, energy companies, including Sunrun and Sonnen, set up solar microgrids and battery storage to deliver electricity. Elon Musk pledged to do the same, and Tesla batteries are now powering parts of the island. These small-scale systems helped bring rural community centers and schools back online. Other utilities, including Consolidated Edison (Con Ed) and the New York Power Authority (NYPA), rushed to the aid of PREPA voluntarily providing resources vital to restoring power on the island, coordinated by Federal Emergency Management Agency (FEMA), the U.S. Army Core of Engineers and the U.S. Department of Energy.

Figure 1: PREPA, Puerto Rico - Utility Size 2,800 MW peak load island utility

Puerto Rico needed a broader strategy for the future, so the U.S. Department of Energy and PREPA engaged the German company Siemens, an expert in resilient infrastructure. Siemens proposed replacing Puerto Rico's single grid with eight subgrids, each powered by smaller generators that would tap existing coal-powered plants as well as new solar and battery storage units. The island's existing distribution infrastructure would carry energy out from these facilities.

"What's innovative—and durable—about this mini-grid model is its flexibility," says Matthew Martinez, technical director at Siemens Government Technologies. "Each of the smaller grids will encompass distinct geographical regions, governed by their own management systems. The mini-grids will operate in concert as an island-wide grid. But they can also operate independently: If an event caused a disruption in the southwest, for instance the other mini-grids, such as the one serving the San Juan area, could detach and continue to operate. The small size of the individual grids means that power outages will be easier to repair; Siemens estimates that no asset would remain offline for longer than a few weeks. And if an area loses power, an adjacent mini-grid can help supply some electricity to compensate for the outage."

Siemens's plan represents a shift "away from large, centralized energy-generation assets and distribution," Martinez says, "and toward a more decentralized and localized system. Out of the tragedy of Hurricane Maria, [Puerto Rico] can take a white-sheet approach with its grid and do something innovative. And it can serve as a model for the rest of the United States."

Siemens had originally presented the mini-grid architecture in a conceptual whitepaper prepared by Dr. Nelson Bacalao, Senior Consulting Manager, Siemens Power Technologies International (Siemens PTI). Subsequently, PREPA awarded Siemens the contract to develop the new energy plan for Puerto Rico. The mini-grid design and analysis is detailed in the PREPA Integrated Resource Plan (IRP). At the time of this publication, the IRP work continues under the direction of the Puerto Rico Energy Board (PREB). The IRP includes an action plan for generation, transmission and distribution projects. Once the projects are completed, over the next decade plus, Puerto Rico will have a more resilient power grid that could model solutions for other climate vulnerable parts of the world.

Additionally, the IRP report details ground-breaking analytics for future high penetration of renewables and energy storage systems. Siemens PTI modeled battery energy storage using an hourly chronological production cost model in order to assess integration with high levels of renewables. The storage minimizes the need for peaking thermal generation that would otherwise be required for local support and resiliency. PSS®E dynamic simulations evaluated the impact of storage on frequency response, quantifying the storage required to reduce load shedding when PV generation supplies 50% of demand.

A preliminary copy of the report is publicly available for download here http://energia.pr.gov/wp-content/uploads/2019/02/PREPA-Ex.-1.0-IRP-2019-PREPA-IRP-Report.pdf.

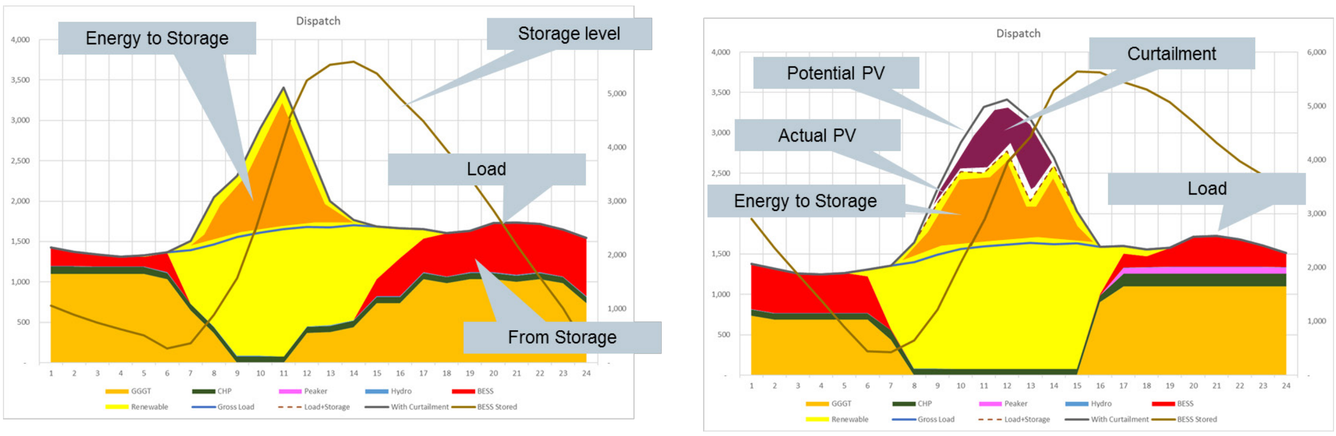

Figure 2: Timing of energy storage charging curtailment impacts

Published by
Siemens AG

Digital Grid
Humboldtstrasse 59
90459 Nuremberg, Germany

For the U.S. published by
Siemens Industry Inc.

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