Rebuilding better electrical grids in disaster zones

By **Scott Litzelman**

Try, for a moment, to imagine having no power at your home.

After Hurricane Florence made landfall in the Carolinas on September 14, more than 800,000 people lost power, some of them for more than a week. September also marked the first anniversary of Hurricanes Irma and Maria making landfall in the US Virgin Islands and Puerto Rico, where some customers lost power for *nearly a year*.

Hurricanes Maria and Irma were responsible for nearly 3000 deaths, more than USD$100 billion in damage, and one of the worst electrical blackouts in the history of Puerto Rico; the island is still grappling with the aftermath of those storms.

The increasing frequency and severity of storms, such as Maria, Irma, and Florence, are forcing policymakers and electrical grid operators to consider how they can increase the resilience of electrical systems so they can remain online during a storm or recover from an outage more quickly. Materials-enabled technologies are playing an important role in these discussions.

Soon after Maria knocked out power to all of Puerto Rico's 3.4 million inhabitants, residents, energy experts, and policymakers started calling for the island's grids to be rebuilt with newer technologies, incorporating photovoltaics (PVs), wind turbines, and grid-scale batteries. Unfortunately, the recovery was not that simple, and reasons abound for the length of time it took to restore power.

Puerto Rico was unprepared for a storm of that magnitude, as the transmission and distribution networks had been poorly maintained. Power was generated at centralized power plants running off fuel oil and liquefied natural gas, largely on the south side of the island. Most of the load, however, was concentrated in the cities to the north, and the transmission lines that connected power supply to demand were destroyed by the storm.

Several policy factors also slowed the recovery. The agency responsible for leading the relief efforts, the Federal Emergency Management Agency (FEMA), operates under authority from the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), which specifies that funds can only be used for the immediate rebuilding of infrastructure up to the most recent codes, not for long-term improvements.

Post-Maria, some people misinterpreted the Stafford Act, thinking that an electrical system built in the 1950s would be rebuilt as an electrical system from the 1950s. In reality, the electrical system would be rebuilt according to current IEEE (Institute of Electrical and Electronics Engineers) codes and standards. However, FEMA claimed that it lacked statutory authority under the Stafford Act to undertake a broader remaking of Puerto Rico's grid with distributed generators. Although federal funds could be used to build more resilient infrastructures, such as stronger transmission and distribution poles, the rebuilt grid maintained the traditional paradigm of centralized generation connected to load by transmission and distribution networks. It was a missed opportunity to build a better grid.

Private industry, however, has provided some bright spots in the recovery. In June, Elon Musk (CEO of Tesla) claimed that Tesla, Inc. had 11,000 projects under way in Puerto Rico, including solar plus storage at a hospital, elderly community center, and a sewer treatment plant. Competitors such as sonnen GmbH have also been deploying solar plus storage projects, including a microgrid in a rural, mountainous farming community.

A more distributed grid with a greater share of renewables and energy storage could be more resilient to future storms. By displacing fuel oil and natural gas, such a grid would be cleaner. And it would also be cheaper, given the rapidly declining costs of renewables and storage compared to the traditional cost of electricity on the island,

Tesla's solar power system generates electricity for Hospital del Niño in San Juan that serves about 3000 children across the island of Puerto Rico. Before the system installation, the hospital was forced to run off generators and ration diesel fuel. Photo credit: Tesla, Inc.

Scott Litzelman served as the 2017–2018 MRS/TMS Congressional Fellow.

which was two to three times costlier than power on the US mainland.

Policy changes are required for future storm recoveries to fully harness these newer technologies; materials advances can make it easier for those policy changes to be realized. For example, decades of materials research and manufacturing innovations have already enabled some wind and PV projects to be deployed at a levelized cost of electricity less than natural-gas-combined cycle plants.

But more can be done, and it benefits both policymakers and researchers to communicate with one another. For example, a materials researcher may choose to focus on a certain area, for example, higher-efficiency solar cells, out of a personal desire to mitigate climate change. A policymaker, however, might have more immediate concerns, such as ensuring low-cost, reliable electricity for their constituents. Yet, such dialogue between disparate professions reveals that the goals of both sides are not mutually exclusive. New energy technologies enabled by advanced materials are now the lowest-cost sources of electricity; their distributed nature makes them more resilient to storms; and their lower greenhouse gas emissions help fight climate change.

A rooftop solar-panel system (left) and one of two sonnen batteries (right) installed after Hurricane Maria at S.U. Matrullas, a K–9 school that educates more than 150 students in the remote town of Orocovis, Puerto Rico. Photo credits: sonnen GmbH.

There are several bills in the US Congress to accelerate such innovation. Last year, US Senator Ron Wyden of Oregon introduced three bills (S.1874, S.1875, and S.1876) to lower the cost of energy storage and advance smart grid technologies. The materials research supported by these policies can help communities survive hurricanes and other natural disasters. Together, materials advances and sound public policy could prevent future tragedies such as the one Puerto Ricans have had to endure for the past year. □