Hardening Solar Photovoltaics against Climate Change Threats for Resilience

Eliza Hotchkiss (eliza.hotchkiss@nrel.gov), Donald Jenket (donald.jenket@nrel.gov) and James Elsworth (james.elsworth@nrel.gov) (NREL, Golden, Colorado, USA)

Overview. As climate change exacerbates the frequency and impact of extreme storms, the resilience of renewable energy systems is more important than ever before. Research was conducted, based on disaster recovery technical assistance after hurricanes in the Caribbean, to increase the survivability of solar photovoltaics (PV) systems after a storm. Increasing survivability leads to more power available to users immediately after storms. Larger-scale PV systems can be used for essential services such as regional health care centers, emergency shelters, and water and wastewater treatment plants. Smaller-scale systems can provide local services such as refrigeration, communications, or mobile phone charging. Additionally, systems designed to withstand extreme conditions result in cost savings, lower repair and waste costs, lower power production revenue losses for utilities, and less waste to landfills. Cumulatively, operational post-storm PV systems reduce the grid demand, allowing more customers to be served with limited post-storm grid generation sources.

Background/Objectives. In September 2017, Hurricane Irma passed north of Puerto Rico, bringing high sustained winds and leaving over 1 million residents without power. Two weeks later, Hurricane Maria hit Puerto Rico at Category 4 strength, further damaging the power grid. The damage to the island's infrastructure limited humanitarian relief efforts, as well as repairs to the power grid. Two weeks after the hurricanes, the conditions for many residents had not changed, with 95% of the gird nonoperational, 95% of cell service out, half of the population without potable water, and 11,000 people in shelters. Some locations were without power and water for nearly 11 months, making it the longest blackout in U.S. history. In some cases, solar photovoltaic (PV) systems can offer advantages as resilient power sources in the aftermath of disasters, including hurricanes.

Approach/Activities. PV systems can produce power close to the end user, can provide diurnal power during a grid outage, as distributed systems are typically less likely to be damaged across a broad geographic region during an extreme event. When paired with battery storage systems and islanding controls, these systems can provide power 24/7. For PV systems to provide power, the system itself must survive the catastrophic event. While many PV systems in Puerto Rico did survive the 2017 hurricanes, many did not. Post event reports and site assessments indicate that much of the damage to PV systems could have been avoided by taking relatively simple pre-storm preventative measures, as well as incorporating resilient design and installation practices. Increasing the survivability of PV systems also has local safety benefits by maintaining power, reducing flying debris, and electrical hazards related to damaged systems. During high wind conditions, PV systems can be subjected to wind loading forces that can cause structural damage at the PV system anchoring points. When mounted to a rooftop, these forces can cause cracks or holes in the building envelope, allowing rain into the structure. Indoor flooding can result, potentially triggering a cascade of safety issues, including electric shock hazards, loss of shelter space, loss of access to food and drinking water, and increased risk of hypothermia. This presentation will provide an overview of technical and operational solutions to avoid or limit damage to existing and planned PV systems and support local post-storm power.

Results/Lessons Learned. Results and lessons learned will include an overview of the major components of a PV system from PV modules, cable connectors, DC cables, wire ties or clips, conduit, inverters, disconnects and system shutdown switches, grounding systems, racking, and fasteners to provide a glimpse into potential points of failure. Solutions will address points of failure within each component, as well as siting, mechanical solutions, electrical solutions, pre-storm event preparation, and re-energizing post-storm. Where possible, data from Hurricane Fiona and the survivability of hardened PV systems will be provided.