The Trend in ENGINEERING

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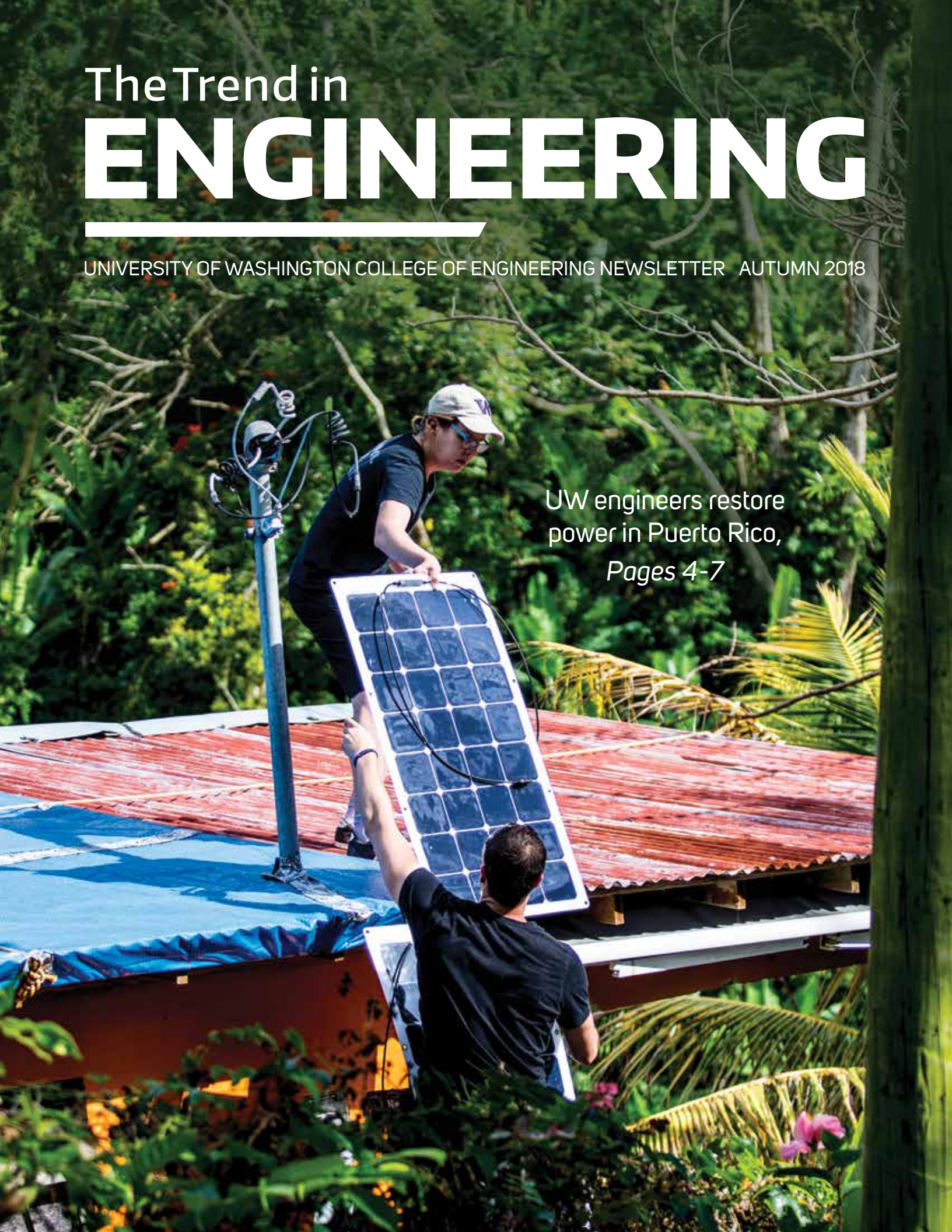

UW engineers restore power in Puerto Rico,

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GRID BY GRID

By James Urton
Photos by Dennis Wise

Even six months after Hurricane Maria, thousands in rural Puerto Rico still lacked electricity. In partnership with local communities, UW researchers worked to restore their power.

The stout house built into a hillside in Jayuya, a rural municipality in the mountains of central Puerto Rico, hasn't been connected to the electrical grid for six months. Someone inside suffers from sleep apnea, and his family has relied on a noisy generator — and the gas it consumes — to power the machine he needs each night.

Outside, under the thin smile of a crescent moon, four University of Washington engineers complete their work. Soon a new solar/battery nanogrid will power the sleep-aid machine: no gas, no fumes, no cacophony.

Mareldi Ahumada Parás and Wesley Tatum, doctoral students in electrical engineering and materials science and engineering, secure four flexible solar panels to the roof using yellow rope. Aeronautics and astronautics alumna Anya Raj, '17, feeds wires from the panels through a hole in the roof, while chemical engineering sophomore Hugo Pontes illuminates Raj's efforts with his smartphone.

The team connects the panels to a battery inside the house that will be charged by tomorrow's sun. They finish just as the mosquitoes emerge.

Getting to the heart of the damage

Ahumada, Tatum, Raj and Pontes are part of a team of UW engineers and scientists who are assessing the long-term impact of Puerto Rico's power loss on the health of rural residents.

Over three trips, the researchers crisscrossed this 39-square-mile region on single-lane switchbacks, some of which have narrowed sharply since Hurricane Maria struck the U.S. territory in September 2017. Jayuya is home to the highest peaks in Puerto Rico — and 17,000 people.

The team visited homes and community centers, interviewing dozens of caregivers and residents who use electronic medical devices, as part of a long-term field study on the impact of power loss on public health. They also donated and installed 17 solar/battery nanogrid systems — prototypes of a sustainable, clean energy infrastructure that can buoy public health in rural areas when power grids fail.

> "You adapt because you have to, but you never achieve the normal life you had back when you had power."
>
> **- Lilo Pozzo, associate professor of chemical engineering**

Like many natural disasters, Hurricane Maria had a disproportionate effect on those with the fewest resources: low- and fixed-income families, the elderly, the sick and rural residents in places like Jayuya. Thousands have remained disconnected from the electrical grid since Maria sliced through. The UW team hopes that the storm's lessons will help engineers develop better nanogrids — like the prototypes they've installed — for an infrastructure that meets the needs of the most vulnerable communities.

As the team has learned in their trips here, the current infrastructure's shortcomings have left deeper scars than downed utility poles and darkened homes. "It is invisible suffering," says Lilo Pozzo, associate professor of chemical engineering, who has led the trips. "You don't know what the situation is until you go into homes and see exactly how people are getting by."

Opposite page: Lilo Pozzo, Chanaka Keerthisinghe and Wesley Tatum connect a solar panel.

This page: Mareldi Ahumada Parás and a local resident position solar panels for installation.

Uncovering the hidden harm

Blue FEMA tarps are still common, but many overt signs of storm damage have been repaired: People have cleared debris, replaced windows and patched roofs. But the UW researchers have documented myriad "hidden" adjustments that residents have made since losing power. These include eating canned and preserved food, despite the lower nutritional value, or making daily trips to a doctor's office for refrigerated medicine.

"You adapt because you have to," says Pozzo. "But you never achieve the normal life you had back when you had power."

Pozzo chose Jayuya for this study because her spouse, Marvi Matos, a chemical engineer, grew up there. Like many with family ties to Puerto Rico, the couple sent supplies to the island after the hurricane. But a month after Maria, barely 20 percent of the electricity grid had been restored, according to FEMA.

Pozzo and Matos envisioned using their expertise to unearth the storm's impact on health and energy infrastructure. Pozzo recruited partners from the School of Public Health and the College of Engineering. They received funding for the study from the Clean Energy Institute and the Global Innovation Fund, while private donations covered the cost of the nanogrids. Contacts in Jayuya connected them with community organizers and needy families.

Top: Due in part to steep topography, Jayuya remained largely disconnected to Puerto Rico's power grid even six months after the storm.

Bottom: Team members assembled what they could before leaving Seattle. Some parts, like batteries, were purchased on the island.

"This storm's lasting impact is that it uncovered the vulnerable places of Jayuya," says Maria Pérez, a local community organizer. "It showed us the people in our midst who didn't have help, who were living in inhumane conditions."

Dedicated to a sustainable future

The UW team first visited Jayuya in November 2017, gathering data and donating four solar/battery systems. They expanded their goals for their March and July trips, buying and assembling three types of solar/battery systems. The smallest can power a miniature refrigerator for storing medical supplies like insulin, while the largest can power more complex devices, such as an oxygen concentrator or a full-size refrigerator.

"We want these systems to be simple for the patients and their caregivers," Ahumada says. "There's no point in donating something that they're unable to use easily."

The researchers also installed 11 data loggers into some of the nanogrids to record information on energy use, which they are currently analyzing.

"We're combining the information that the data loggers have recorded with information from the interviews to design even more effective nanogrids," says Chanaka Keerthisinghe, a post-doctoral researcher in electrical engineering.

After installing their final nanogrid, the UW team passed a boy playing in front of his powerless house. He was wearing a Captain America costume and saluting passing cars. A nearby house sported the island's flag with a handwritten message: *Puerto Rico se levanta.*

Puerto Rico rises.

WHAT YOU CARE ABOUT CAN CHANGE THE WORLD.

Support Lilo Pozzo's research team in their effort to improve community health by contributing to the Puerto Rico Energy Recovery Fund:

uw.edu/boundless/puerto-rico-solar

HOW THE NANOGRID SYSTEMS WERE INSTALLED

Pozzo and her team purchased and assembled three different types of solar/battery systems — small, medium and large, based on the amount of power they can generate. All three work essentially the same way. Solar panels soak up the sun, delivering charge to a battery that can then power a medical device. Depending on the system, there may be additional equipment such as a power inverter to govern the power inflow and outflow from the battery.

They are small-scale counterparts to the types of clean-energy solar/battery grids that have become more popular in Puerto Rico since Hurricane Maria. According to Jesus Martes with Borintek, a solar-energy construction and installation firm in Jayuya, homes and businesses have hired firms like Borintek to install solar panels with battery systems that can provide an electricity lifeline when the power grid fails.

For the solar/battery systems supplied by the UW researchers, Pozzo and Matos ordered most parts before leaving Seattle, and team members brought those components with them in their luggage to Puerto Rico. Some parts, like batteries, were purchased on the island. Solar panels for the medium nanogrids were ordered from Borintek. Team members then painstakingly assembled each system, including repairing damaged parts since they didn't have funds for backups, before loading them into rented vans for delivery. Each installation took several hours.

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2018 Engineering Lecture Series

Engineering for Social Good: Assistive Robots, Environmental Equity and Disaster Relief

Building a Robot Butler: Towards Fluent Human Robot Interaction
Siddhartha Srinivasa, *Boeing Endowed Professor, Paul G. Allen School of Computer Science & Engineering*
Thursday, October 11
Human collaboration is a delicate dance of prediction, inference and action. Building robots with the capability to interact with humans as equals has potential to improve the daily lives of those who require assistive care, such as the elderly or mobility impaired. Learn how researchers are developing these robots using mathematical models and physics-based manipulation.

Clearing the Air: Environmental Justice and Air Quality
Julian Marshall, *John R. Kiely Endowed Professor of Civil & Environmental Engineering*
Tuesday, October 30
Air pollution is the leading environmental health risk in the United States, causing thousands of deaths each year. Research has revealed that, on average, people of color are exposed to more air pollution. By modeling changes in specific sources, Julian Marshall is examining how air pollution impacts groups differently, and testing solutions to reduce the exposure disparity.

Meeting Our Global Obligations: The Hurricane Maria Energy & Health Project
Lilo Pozzo, *Weyerhaeuser Associate Professor of Chemical Engineering*
Tuesday, November 13
In September 2017, Hurricane Maria devastated the island of Puerto Rico and left its residents without power, water and sanitation systems. A group led by associate professor Lilo Pozzo initiated a combined research and service project to assess the disaster's impact on the health of rural residents. Learn more about this project to provide emergency clean energy to help vulnerable people when power grids fail.

All lectures are at 7:30 p.m., Kane Hall, UW Campus – FREE! Registration required at events.uw.edu/Lecture2018.
Presented by the College of Engineering in partnership with UW Alumni Association.