Off-grid, battery-free solar water purifier operating in Puerto Rico

December 5 2017, by Kylie Foy

A team in the coastal town of Loíza, Puerto Rico, begins rolling out the first of 16 solar modules from MIT Lincoln Laboratory and Infinitum Humanitarian Systems (IHS). Left to right: Abdoun of the Boys and Girls Club; George Villec, president of GeoInnovation; Denisse Abdo, dietician and translator; Erik Limpaecher of Lincoln Laboratory; Alex Hatoum, IHS managing director; Eric Rasmussen, IHS CEO; Steve Birnbaum of the Federal Emergency Management Agency; and Ibrahim of the Boys and Girls Club. Credit: Lorenzo Moscia

Puerto Ricans in the coastal town of Loíza stood in a line that stretched seven blocks, waiting hours for bags of ice and bottles of water. Dirty sewer water flooded a canal in the town. At least one person had died from the bacterial disease leptospirosis, most likely from drinking contaminated water. There was no power.

That was the scene in late October, when a disaster response team consisting of staff from MIT Lincoln Laboratory and Infinitum Humanitarian Systems (IHS), supported by the Roddenberry Foundation, visited the town, which is located roughly an hour east of the capital city of San Juan. At the time, some residents had been without electricity for 45 days, since Hurricane Irma. The rest was knocked out by Hurricane Maria.

Five days later, taps outside the Boys and Girls Club in Loíza ran with clean, safe drinking water.

A water purifier, powered completely by the sun, now pumps in polluted municipal water and pours out 850 pure gallons per day for public consumption in Loíza. Rooftop rain barrels provide a backup water source if municipal water stops flowing. The system is called the Water Aid and Renewable Power (WARP) system.

WARP is a new version of a water purification system that the IHS/Roddenberry Foundation team has been installing in disaster-stricken communities around the world since 2013. The original system requires a generator to power pumps and purification equipment. A consistent fuel supply for the generator can be difficult to get after any disaster, no less so following the hurricanes in Puerto Rico. Still, without an alternative system, the IHS/Roddenberry team had prepared to deploy it on the island.

Meanwhile, at Lincoln Laboratory, Mabel Ramirez, the associate leader of the Active Optical Systems Group who was born and raised in Puerto Rico, was leading the effort to find technology at the laboratory that could help the disaster recovery effort. One idea that staff in the Energy Systems Group, led by Erik Limpaecher, proposed was a set of small, albeit expensive, direct current (DC) systems to power LEDs or cellphone charging stations.

"Mabel stopped us, and said, 'Well, this is good. But, people in Puerto Rico really need water right now,'" Limpaecher says. "We started looking at who else was doing water treatment and learned about the IHS/Roddenberry system and its generator. We thought, 'Aha! We can replace that generator.'"

The question of how they would replace it led them to reconnect with an Arizona company called GeoInnovation, with whom the laboratory had deployed a large battery and solar array system at the southern U.S. border for a homeland security project. Together, GeoInnovation and Energy Systems Group staff designed a new solar power system for the IHS/Roddenberry purifier.

The solar power system has two components. The first is a flexible solar-panel mat made of copper indium gallium diselenide (CIGS) solar cells. CIGS mats are waterproof, thin, and extremely durable, especially compared to the common glass solar panels that shatter easily. CIGS mats also work well at sunrise and sunset, and offer a high-power output even when part of the mat is in shade. "These CIGS modules will keep working even if they're penetrated by a tree branch during the next hurricane season," Limpaecher says.

The array of solar mats feeds into an inverter, the device which converts the DC energy produced by the solar array into alternating current (AC) energy for powering the system. While the inverter can eventually connect to the electric grid (when that is back up and running in Loíza), it also has a unique secure power supply (SPS) function that allows the system to work completely off-grid and without batteries.

"Traditional off-grid solar power systems are designed to be used with batteries; but batteries require maintenance, they're heavy and expensive, they don't perform well in hot temperatures, they require additional power conversion gear, and they can be dangerous," Limpaecher explains. "There are a whole bunch of issues."

At the flick of a switch, the SPS function turns on and provides up to 1,500 watts of power when the sun is out. The power is turned off at night, during which a 600-gallon food-safe storage tank continues providing clean water. "It's much more effective to use purified water as our battery," Limpaecher says.

Laboratory staff quickly built a surrogate system and tested it at Lincoln Laboratory. Limpaecher and the equipment then flew to San Juan to join up with staff from GeoInnovation and the IHS/Roddenberry disaster team. Their first challenge was to choose a town best suited for installing the WARP system.

The winding roads leaving San Juan, once surrounded by lush trees, looked more like an apocalyptic scene of broken, branchless stumps and tangled power lines. The team first made their way to a community in the mountains of Utuado. A bridge to town had been washed away, so citizens were using a pulley to transport a shopping cart back and forth over the river. While there was a need for water in that community, it is made up of only about 100 people. The WARP system can serve many more than that, so its services would be underutilized there. There was also news that more help was on its way to the town. The team decided to move on.

Next, the group flew to the island of Culebra, where the hospital was in dire need of basic supplies. Cisterns had run dry. Cockroaches scurried out of them when the team lifted the cistern lids. But, there was a strong Federal Emergency Management Agency presence in the town and an organized effort to bring more supplies in.

Then the team went to Loíza.

"Loíza's water didn't meet [Environmental Protection Agency] standards even before the hurricanes hit," Limpaecher says. The town was in bad shape. "I saw solid concrete power poles snapped like toothpicks, with their lines tangled and lying across the road. This destruction was repeated the entire 10-mile stretch into town. Many of the houses' roofs were completely torn off."

Most important to the team's WARP installment criteria: Loíza had an organization to partner with. The local director of the Boys and Girls Club offered its building as a location, and staff for installing and maintaining it. "We need to train locals on how to use our system, because we leave the system behind when we go home," says Alex Hatoum, IHS managing director. The team got to work.

The first task was to lay out strings of CIGS solar mats on the roof and run cables down to the inverter inside the building. The team came to its first road bump when the off-the-shelf photovoltaic extension cables turned out to have been built incorrectly and didn't fit into each other. They had to tear the cables apart and jerry-rig them together to work.

Fixing the cables wouldn't be the only challenge they faced. Soon into the setup, one of the system's ultraviolet (UV) lights failed. The UV light ensures all biological organisms in the water are removed.

"I thought, 'Oh no, game over. The system is down,'" Limpaecher says. "But it turns out the IHS team had built redundancies into the system in the case that something didn't work, to make sure they provide safe water. The system's filters were reconfigured to account for the loss of the UV light."

The biggest issue involved one of the system's most crucial components—the Puralytics Shield. The shield removes fuel residues, pathogens, and toxic metals from the water. Every few seconds, the Shield would draw a power spike. The inverter was mostly able to handle these spikes, but would shut down about every 15 minutes.

"The inverter couldn't reliably handle these blips, and we needed a reliable power source. We were getting really worried because when we tested the integration between the shield and the inverter at the laboratory it worked fine," Limpaecher says. The team figured out that air bubbles in the pipe feeding water to the shield were causing it to draw the power spikes. The team simply ran the piping straight and removed a flow restrictor. After extensive testing, the water running through the purifier was deemed clean, safe, and good-tasting.

The taps were opened on Oct. 25. First to enjoy the water were children, who gathered around the faucets, taking turns filling cups and thanking the staff again and again. The Boys and Girls Club will now run the system and in 90 days will receive a resupply of materials from IHS. Two Boys and Girls Club staff members, Abdoun and Ibrahim, helped install each component of the system and will be able to do it again on their own. Abdoun and Ibrahim plan to install another WARP at the Boys and Girls Club in Las Margaritas, a low-income housing project in San Juan.

Now back at the laboratory, Limpaecher and fellow staff are focusing on longer-term research and development for disaster response systems. They hope to continue this new partnership and eventually develop a system that could serve 4,000 people a day. More immediately, the

IHS/Roddenberry team is raising funds to deploy the solar-powered WARP system to the remaining 12 Boys and Girls Clubs in Puerto Rico.

Ramirez, who says it has been difficult personally to process the devastation, has found it uplifting to see staff members' tireless efforts the past few weeks.

"Seeing the positive result of our hard work was a testament to the immediate impact that we can all have when our community comes together and our teams are committed to a mission," she says.

This story is republished courtesy of MIT News (web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

Provided by Massachusetts Institute of Technology

Citation: Off-grid, battery-free solar water purifier operating in Puerto Rico (2017, December 5) retrieved 26 April 2024 from https://techxplore.com/news/2017-12-off-grid-battery-free-solar-purifier-puerto.html