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Enterprising Electricity: Putting Theory into Practice

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Electricity is so integral to our lives, but humanity's ever-growing need for it is defacing the planet. There are many ideas on how to stop this, but to have an effect, those ideas need to take root in the real world.
By Matt Baker

Four years ago, the Illinois Institute of Technology transformed into an island. The 50+ buildings that make up the Bronzeville campus were put on a microgrid—a network of buildings, batteries and energy sources that can be detached, or "islanded," from the power grid.

The benefits of a microgrid are numerous. They can function independently when necessary, such as during a power outage. Energy efficiency is another advantage; through the use of solar and wind generation, the IIT microgrid reduces the university's power consumption by $1 million annually and carbon dioxide emissions are trimmed by 7%. On-site batteries store excess electricity while sensors in and around the campus buildings track energy use for optimal deployment.

"Everything we do at IIT is somehow related to the microgrid," said Dr. Mohammad Shahidehpour, IIT professor of Electrical and Computer Engineering and Director of the Galvin Center for Electricity Innovation. According to him, the IIT microgrid has two main functions: "Educate the next generation of students, and create prototypes that get the message out about what modernizing the grid looks like."

A key partner in bringing the IIT microgrid to life has been the local chapters of the International Brotherhood of Electrical Workers #134 and the Electrical Contractors Association of Chicago. IBEW/NECA helped to install LED streetlights on the campus, a solar-powered farm and other projects. "We are committed to the present and future of renewable energy," said Harry Ohde, Assistant Director and Renewable Energy Coordinator at IBEW/NECA Technical Institute. "To stay on top of this, we need to have a good partnership with IIT, because they are the institution as far as I am concerned."

The IBEW/NECA Technical Institute opened a renewable energy training field at their Alsip school back in 2015, the country's largest outdoor campus of its type. "When we built this new training center," Ohde said, "our intent was to train not just installers, but also train AHJs [authorities having jurisdiction], code officials, building officials and even people without a clue what solar is." The facility offers training, simulations and hands-on experience in many different electrical and renewable energy processes. For example, students can remove and reinstall solar panels, make adjustments to a wind

generator based on given site requirements and learn battery storage techniques and energy transfer systems. IBEW/NECA also recently started a supplemental online class teaching photovoltaic theory.

"I've had a few former IBEW students in my classes," Shahidehpour said. "These guys have practiced these ideas and installed devices. They have an additional dimension that other students are missing in the classroom."

More than a hundred years ago, Thomas Edison lost the War of the Currents, the battle between his direct current technology and the alternating current ballyhooed by Nikola Tesla and George Westinghouse. Direct current failed because the electricity attenuated over long distances, limiting the reach of DC power plants. But thanks to renewable energy and microgrids, Edison may finally see redemption. "Now that we are moving to the point where loads are very close to generation, long distances are not of interest," said Shahidehpour.

A wind turbine or solar panels, such as the ones on the IIT campus, create DC power which can be served to the end use without the costly equipment of switching current type. "We can reduce a lot of this conversion loss, and reduce cost because you don't need a lot of the intermediary devices," Shahidehpour said.

The idea of a microgrid can be refined down to individual buildings, too. Last year, IIT celebrated their new nanogrid, serving the Keating Sports Center. Energy storage and power control systems manage the building's energy usage on a smaller scale than even the microgrid. This concept can be ported to mission-critical uses like hospitals or police stations.

 The project is further evidence that even at a higher education institution, theory is best served when put into practice. "I like to look at our university as not just a place where we have great thoughts, but a place where we actually take our thoughts and implement them and do something meaningful, not just for the university but for the community," said Alan Cramb, IIT President, at the nanogrid's ribbon cutting.

The IIT nanogrid is a hybrid system, able to support both AC and DC loads. The roof-mounted solar array directly powers the LED lighting systems and charges the batteries during the day; excess power can be sent to the grid. But the Keating Center is just the first foray; there are plans to convert the university's data center and other buildings into a nanogrid.

IIT and IBEW/NECA also collaborated on a solar farm. While the sight of agriculture in an urban environment has surged recently, the 5,000 square-foot UFarmIIT is notable for what you can't see. Sensors embedded in the soil direct the automated irrigation system, giving the plants water only when they need it. The goal is to prototype an intelligent farm that solves the inefficiencies that farmers face, especially those in developing parts of world.

"But to make all that work, you need electricity," said Jimmy Shah, Project Manager at IIT's CSMART Lab. "This is a low power application, so why not use solar? Let's not emit any emissions. If anything, we can create a carbon sink." Small-scale solar panels power everything on the farm, including water pumps and the soil sensors.

CSMART is a research and development operation created in partnership with ComEd, Silver Spring Networks and West Monroe Partners, dedicated to adapting smart grid technology innovations to a real-world environment. The CSMART Lab is an interdisciplinary space, bringing engineering, architecture, civil and other majors together. Computer science students, for example, wrote algorithms for the farm's soil sensors based on data gathered by biology students (literally) in the field.

The whole IIT campus, in effect, has been turned into a lab. The streetlights that IBEW/NECA helped to install are more efficient than their predecessors simply because they are LED instead of high pressure sodium; but by using smart sensors installed into the lights, they can be controlled automatically to shave off even more energy usage.

Other applications can enhance student safety. A smartphone app, developed by an IIT student, features a panic button; if activated, the app will send a text message to the public safety department and cause all of the streetlights within five to ten meters of a user to start blinking. If the campus ever needs to be evacuated, the lights can be manipulated to create a path guiding students to safety.

This enterprising thinking can have an effect in unexpected places. For instance, sensors placed around campus can measure the ground temperature and track maintenance crews during a winter storm to optimize snow plow routes, reducing both the amount of fuel and salt they expend.

The main thrust of CSMART is that the research be tied to real-world applications. Retrofitting LED and smart sensors into streetlights is a lot cheaper on the drawing board than on the curbside where an installer has an existing pole and infrastructure to wrangle with. "That's what makes CSMART a little different than normal research institutes," Shah said, "because you're really talking to the facility manager or electrician. And those experiences make you a more well-rounded engineer."

Last year, ComEd received federal funding as part of the Department of Energy's SunShot Initiative to turn all of Bronzeville into a microgrid. Building on what they've learned with their own microgrid, IIT will assist in bringing the technology to the surrounding community.

Moving from the scope of a university campus to an entire neighborhood is a natural progression for Chicago in its goal to be a Smart City. The Smart City initiative uses big data to create a resilient and symbiotic urban environment for residents and the environment

"When you talk about smart—smart grid, Smart City, smart phone, anything smart—what makes it smart is the data," said Shahidehpour. "There is no 'smartness' in the grid. The fact that you make the data available to the users or the operators, that allows them to come up with smart decisions. That makes people who are attached to the system to be smart."