Connecting solutions for grid resilience

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Credit: Northwestern University

Imagine Alexander Graham Bell's reaction if someone handed him an iPhone and told him that the device in his hand was the same as the large, cone-mounted transmitter he invented and used to call Thomas Watson in 1876.

He'd probably say, "What the hell is this?" according to Kevin Self, senior vice president of strategy, business development, and government relations for Schneider Electric North America, and a member of ISEN's executive council.

Conversely, Self notes, if Thomas Edison, the father of the modern-day grid, were to look outside in 2017 and see all the wires and poles, he'd say, "Yep, nothing has changed in 100 years."

Nonetheless, after decades of stagnation, power grids are modernizing. Utilities are using consumer data to optimize usage. "Prosumers"—consumers who also produce electricity—are emerging, with a greater interest in managing their own usage. Energy storage is a priority. Still, many wonder if these changes will bring the sweeping effects that many envision.

Fuel, Renewables, and the Decline of Coal

Electricity demand has stabilized in the United States and production is plentiful, with natural gas sustaining much of the country's requirements. "From an industry standpoint, people have been [thinking] that gas in the United States will remain cheap and plentiful for many years to come," says Tom O'Flynn, executive vice president and chief financial officer of AES, a multinational energy distributor based in Arlington, Virginia, and a member of ISEN's executive council.

Meanwhile, non-hydroelectric sources of renewable energy—most notably wind power and solar—have begun to gain market share. In just seven short years from 2009 to 2016, wind power tripled as improvements to turbine technology saw gains in efficiency and a reduction in costs.

Solar generation quadrupled between 2013 and 2016, topping off at 33.3

billion kilowatt-hours in that final year as more people and businesses installed rooftop solar panels.

Another reason for the increase in renewables has been the rise of battery storage. As part of a grid storage system, batteries can retain electricity from these intermittent resources when production outpaces consumption, and use it later when needed. "We're using batteries to store power for when the wind isn't blowing or the sun isn't shining," O'Flynn says.

As the use of renewables has grown, the use of coal has begun to shrink. Both wind and solar are cheaper than coal on average, with wind costing $0.05 per kilowatt-hour and solar coming in at $0.06 per kilowatt-hour. Coal on average costs between $0.09 and $0.27 per kilowatt-hour, once you factor in health and environmental costs.

"A coal plant's life expectancy is being jeopardized by the rising cost of operations, maintenance, and capital improvements," O'Flynn says. "These are being replaced with cost-effective gas and an increasing amount of solar and wind as costs per hour continue to decline."

Trends aside, coal will still have its place for some time, O'Flynn says, especially in fast-growing economies with an immediate need for electricity generation, and where local gas is not available. "The energy puzzle going forward is about balancing capacity resources," he says, "because what you need are resources that are available 24/7."

Power Grid 2.0

Changing how we produce electricity also means changing how that power is delivered. In other words, says Adilson Motter, Charles E. and Emma H. Morrison Professor of Physics and Astronomy at Northwestern, "the power grid needs a reboot."

Over time, consumption has grown, and the grid hasn't expanded fast enough to catch up. The result is a strained system that suffers from outages and other interruptions that cost Americans $150 billion annually, according to a US Department of Energy (DOE) report.

"Which is why we need to rethink the system to prevent this type of loss," Motter says.

Currently, the grid system is being overhauled, from replacing physical components to installing modern outage and distribution management systems. An ISEN team led by Motter and Takashi Nishikawa, research associate professor of physics and astronomy at Northwestern, secured a $3.2 million DOE grant to examine ways to avoid outages and help increase stability.

"We need some way to compensate for the loss of stability due to the intermittent nature and other salient properties of renewables," says Nishikawa, who, with his colleagues, is working on a new control architecture for the grid that can address the problem. Their project builds on the prospect that the power grid will soon evolve to include two-way communication between utility companies and consumers, including realtime pricing—a defining characteristic of smart grids.

"This opens the possibility of creating incentives to control consumption to match intermittent production through the use of smart appliances," Motter says. He notes that a smart washing machine, for example, would turn on at a time when price is low, which is precisely when there is excess energy production.

It's a Smart, Smart World

So, how does a smart grid actually work? Smart grids use information and communications technology to track electricity usage within the system. That data is collected by energy companies and analyzed to help optimize usage. Interest is high. Many companies—startups and multinationals alike—see this as an opportunity to enter an emerging technology field adjacent to an industry known for its strong, asset-based growth.

"No one wants to be left behind," says Self of Schneider Electric. "There are thousands of experiments going on right now in cities. It's definitely a state of learning."

But of greater interest (and concern) to energy companies is the emergence of the microgrid, a self-contained system that can connect and disconnect from the larger electrical grid. Microgrids are common within medical facilities; in case of a power outage, onsite generators keep respirators and other life-sustaining devices operational.

The concept gained greater attention after Hurricane Sandy hit in 2012. While major portions of New York and New Jersey were without power, Princeton University kept the lights on, thanks to its on-campus microgrid.

Solving for EV

This trend toward modularity could help solve a challenge facing another emerging trend in electricity: the electric vehicle (EV). Thanks to companies like Tesla and the growing prominence of electric-gas motor hybrids, EVs are at a tipping point, poised to become commonplace.

But power usage, the EV's internal battery length, and mileage range are still pain points for consumers. Charging stations for EVs are nowhere near as prolific as gas stations.

"Right now, you can only get 200 to 250 miles per charge, and then you have to wait a few hours to charge," says Ermin Wei, assistant professor of electrical engineering and computer science at Northwestern.

That's where modularity comes in, Wei says. Similar to using batteries to solve the intermittence problem with renewable energy generation, building storage capacity into EVs in the form of "swappable batteries" would help lengthen mileage range, making the automobiles more practical.

The extra capacity would also help keep EVs off the grid during peak demand hours, allowing owners to charge at night when pricing is lower. Wei suggests that these "swappables" could be sold to EV owners or discharged into the grid during the day.

So why aren't we doing this already? "Right now, it's still very expensive and batteries are big and heavy," Wei says. "We're looking for a breakthrough."

Not Too Small for Big Data

Amid all this change in production and transportation of electricity on the grid, more questions arise. What about residential customers? How will things change for them?

"We have a lot more data coming in now, and if you know how to use that data, you can turn it around into something that's valuable to the customer," says Ty Benefiel, a 2014 graduate of the Kellogg School of Management and CEO of MeterGenius.

Based in Indianapolis, MeterGenius works with utilities to provide analytics services to its customers. Benefiel's company employs the same information and communications technology used in smart devices to retrieve electricity usage data, then merges that with additional customer information to recommend ways to cut down on costs.

"It's not enough to tell a customer what they spent. We also tell them why they spent and how they can make changes to reduce that in the future," Benefiel says. "We give the customers the answers rather than the homework."

Many utilities offer similar services. And smart devices have been around for a while (think Nest thermostats and Bluetooth-enabled light bulbs). But it's the connectivity that Benefiel says will have lasting effects in the future.

"As these devices gain the ability to receive signals from the utilities and make smart choices, that's going to be our first real crack at what the future's going to look like," he says. "It could be within the next few years if utilities and energy companies are smart about this."

Provided by Northwestern University

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