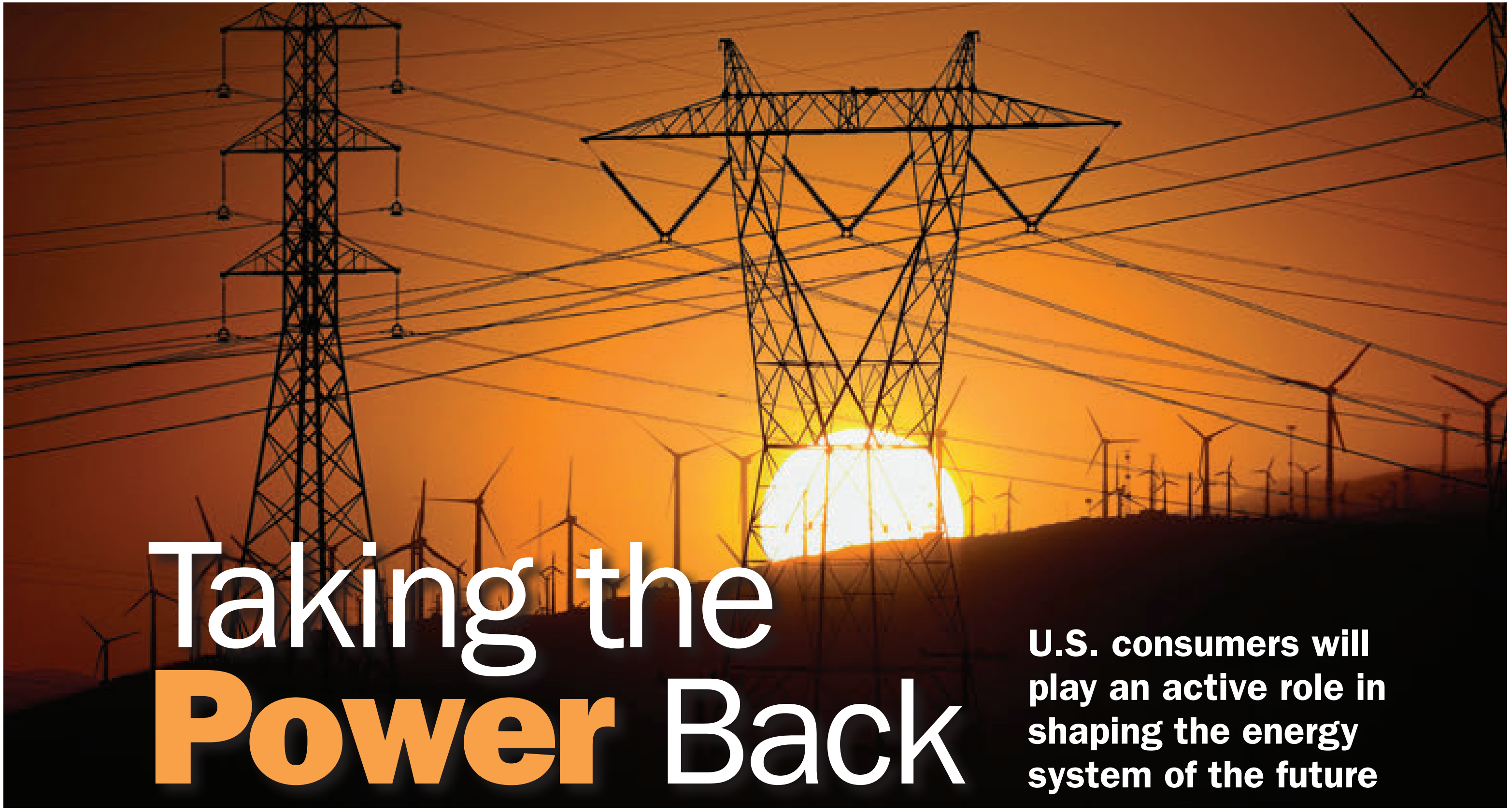
Taking the Power Back

U.S. consumers will play an active role in shaping the energy system of the future



Power lines and wind turbines in the Morongo Basin near Palm Springs, California, United States.

Mustafa Jamal

THE U.S. electrical grid is the largest machine in the world. In 2014, over 3.8 trillion kilowatt hours of electricity (nearly a fifth of the world total) flowed through its 4.3 million kilometers of power lines to reach over 315 million consumers, who paid $400 billion for it.

But this behemoth of a system has changed little except in size in the 133 years since Thomas Edison launched its earliest iteration, The Pearl Street Station in lower Manhattan. Electrical grids in most countries remain quite primitive.

Given the risks of fuel price volatility and potentially catastrophic climate change, and the availability of new technologies for mitigating these risks, consumers and regulators are demanding a greener and more efficient U.S. electrical system. Just as the telecommunications landscape was rocked when landlines gave way to cell phones, the grid infrastructure is being forced to undergo a sea change: become smarter or fade into irrelevance.

This is not the best news for U.S. utilities. In the face of pressure from their regulators to modernize, these monopolies have hesitated to assume the risk and cost of implementing changes that could cut revenue. But it's great news for consumers. Until now relatively powerless over their energy use or carbon footprint, consumers will have new tools to help them better understand and control their energy use, carbon footprint, and electricity costs.

Controlling demand

The most promising and established of these new tools is demand-side management (DSM).

DSM helps address the problem of peak load. Utilities must have sufficient generation on hand to provide the electricity needed to meet demand at its highest point—the peak of the demand curve (see chart). Otherwise, the system will crash, resulting in blackouts that incur significant economic and social losses, especially since peak load often coincides with the busiest hours for business and industry. DSM uses financial incentives to modify the demand curve by encouraging industrial, commercial, and residential consumers to use less electricity and shift discretionary use to off-peak times, such as nights and weekends.

If the peak of the demand curve is flattened or shaved, fewer new power plants will be needed, requiring less additional infrastructure investment, reducing the environmental harm associated with construction of new power facilities, and the emissions that would come from them. The emission savings are especially significant because "peaker" power plants—used to meet additional demand during peak periods—are more expensive and less efficient than baseload plants, which run constantly to meet continuous base demand. Peaker plants are also almost always powered by carbon-emitting fossil fuels, whereas baseload plants often run on nuclear or hydroelectric power.

DSM's financial incentives are time-of-use tariffs that charge more for energy during peak hours and less during off-peak hours, prompting consumers to shift their use to off-peak hours, when baseload plants can meet demand. This requires a new class of meters called smart meters, which measure not only how much electricity is used, but also when, and then communicate this information to the utility at regular intervals. Customers can log in to a secure website to view their energy use in close to real time and analyze their consumption patterns. Understanding these patterns helps consumers decide how to modify their behavior to cut their bills and help reduce peak load for the system overall.

Environmentally conscious customers can use this information to understand and reduce their carbon footprint.

In addition to encouraging energy efficiency and conservation, smart meters promote growth in distributed renewable generation—solar panels and wind turbines on top of factories, offices, and homes. Many smart meters are net energy meters, measuring electricity flow in both directions, so utility customers with solar panels installed on their roofs can sell power back to the grid, reducing their electricity bill and even earning money from the utility if they produce more than they use. About a third of all meters in the United States today are smart meters, up from fewer than 5 percent in 2008.

In the United States, DSM reduced peak loads by over 28.8 gigawatts in 2013, a 7.2 percent increase over 2012 and enough to power Austria. The latest reductions came increasingly from residential customers.

Storing it up

While still at a nascent stage, new and advanced electricity storage solutions hold great promise. At their core, these new energy storage solutions are simply large rechargeable batteries, able to store and discharge electricity. And while rechargeable batteries are nothing new, they've never been cheaper, safer, longer lasting, or more capacious.

A key limitation of energy systems has been that electricity had to be consumed when it was generated. There was no effective way to store it, which has been a major stumbling block for renewable energy technologies in particular. No matter how much sunshine there is and how efficient solar cells are at converting it to electricity, it will not contribute to meeting nighttime peak demand. Likewise, efficient wind turbines can be deployed in an area with strong wind, but that won't help meet daytime peak demand if the wind blows mostly at night. By balancing the intermittent generation from wind and solar plants, where the timing and magnitude of electricity generation supplied often don't coincide with peak demand periods, new energy storage technologies will help facilitate adoption of renewable energy.

A home battery like the Tesla Powerwall can capture solar power during the day for homes equipped with solar panels and power the home in the evening. It can also store electricity from the utility during off-peak hours, when it's cheap, and discharge it to the home or business during peak hours, when it's expensive. Given their high cost, home batteries today appeal primarily to affluent early adopters, but with rapid advances in battery technology, they could become as ubiquitous as refrigerators in a decade.

Since plug-in hybrid and electric vehicles already contain large batteries and are parked 95 percent of the time, in the future they could become significant providers of demand response when tied to the grid. A car in a vehicle-to-grid (V2G) system would help meet peak demand through its batteries, recharging them during off-peak hours. For now, though, V2G remains experimental.

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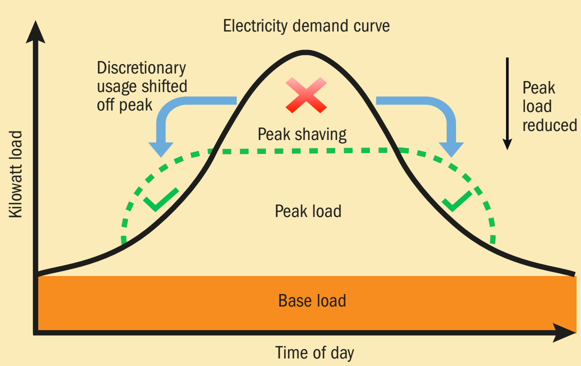
Energy storage systems don't have to be based on traditional battery designs. Several newer buildings in New York City, including the headquarters of U.S. investment firm Goldman Sachs at 200 West Street (constructed in 2009), are cooled by what are essentially giant ice makers in their basements. In Goldman's case, 770,000 kilograms of ice are frozen during the night, when electricity from baseload power plants is cheaper and 35 percent less carbon intensive. In the daytime, instead of energy-intensive air-conditioning, fans circulate air over the ice to cool the building, saving Goldman $50,000 a month during the summer. Commercial air-conditioning is responsible for over 5 percent of U.S. electricity demand. Although not much on an absolute basis, it represents a major component of peak demand, especially on hot summer days when the electrical grid is most stretched. Buildings incorporating peak-flattening technologies like those of 200 West Street help New York City avoid building additional peaker power plants, whose environmental footprint surpasses their carbon emissions alone.

Flatter demand

Demand-side management can reduce peak loads by shifting discretionary electricity use to off-peak times.



More problems to solve

There remain a few unanswered questions. For instance, who will pay for the future grid? Utilities already complain that increased adoption of homegrown green energy such as solar is draining their revenue without helping pay for maintenance and the infrastructure upgrades used to sell that power back to them. As meters and grids become "smart," they also become vulnerable to cyberattacks. How will the security of something as important as the electrical grid be ensured? And do large-scale grids make sense in a future of decentralized microgrids that offer more ownership and control to communities and corporations and greater resilience to severe weather?

In any case, in the near to medium term, end users of electricity stand to gain significantly more knowledge and choice than at any other point in the history of electricity. ■

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