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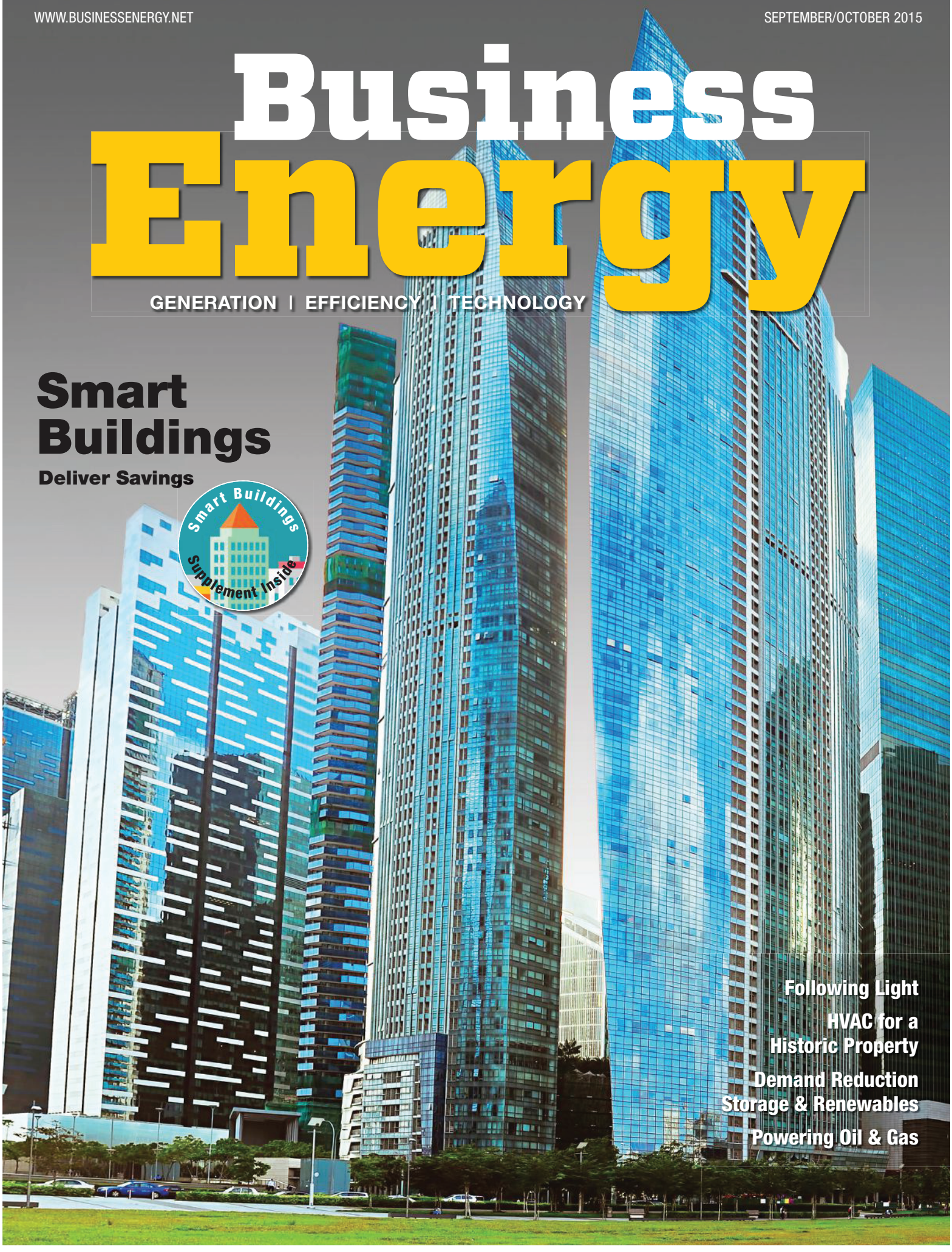

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NEW SOPHISTICATION BEHIND THE METER AND IN COMMUNITY SCALE SYSTEMS

BY LYN CORUM

The energy storage business is hot these days. It has become the most talked-about trend in the retail energy business in the past three years with large companies offering new products, and startups introducing newly designed energy storage, software, and hardware packages.

The popularity of energy storage is driven by the rapid deployment of renewable resources, either grid connected, or connected at a customer's commercial or residential site to smooth over the intermittency of wind and solar resources. But energy storage is offering an additional benefit for commercial and industrial businesses: its integration with renewable resources dramatically reduces high-cost peak demand.

Energy management software and hardware packages accompanying an energy storage system can track a customer's daily energy use, and once a preset demand limit is reached the batteries in the storage device automatically discharge energy into the building's electricity system, displacing the grid power. No monitoring is required by the customer.

There are many energy storage technologies. Solid-state batteries include electrochemical capacitors, lithium ion batteries, nickel-cadmium batteries, and sodium sulfur batteries. Other types include flow batteries, flywheels, compressed air energy storage, thermal (usually ice) storage systems, and pumped hydro power.

The Energy Storage Association (**www.energystorage.org**) has a lot of information available on its website —including a good number of case studies. This article will look at a sampling of what is happening in the marketplace today.

Cutting Peak Demand

The Escondido, CA, headquarters of longstanding electrical contractor Baker Electric, will surely be a model for some of the businesses the company serves. Baker installed its own 90-kW roof-mounted solar photovoltaic (PV) system in early 2014, and a 30-kW Sharp energy storage system in April 2015. The major peak demand numbers that drove them to solar and energy storage are now a memory, along with a big improvement in their electric bills.

Christopher Chappell, Director of Commercial Solar at Baker Electric, now sees mini-peaks on graphs of the company's electricity use. He says starting at around noon, when workers come in for lunch, peak demand goes up and then drops down around 3:00 p.m., and when the electrical crews come in at night, a minor peak will appear.

Chappell says the solar system did

some peak shaving, and the energy storage system clipped the peak right off. The solar system feeds directly into the building where 100% of the power is used. There are no sales to the utility, he says.

The storage system balances both the solar and grid power as it comes into the building, Chappell adds. An algorithm supplied by Sharp is set up to follow utility rates and monitor the cycling of the storage system, making sure it doesn't cycle too much. The storage system can discharge for an hour or two.

"We monitor the energy storage itself and Sharp manages it," as part of the 10-year operations and maintenance contract Baker signed. Chappell says. "This is really clean and professional. If you didn't know what it was, you wouldn't notice it."

Baker Electric is in San Diego Gas & Electric's (SDG&E's) service territory, and Chappell says Baker's storage system was the first or second "behind-the-meter" project there. The utility was cooperative throughout the installation.

The company is 78 years old and family owned. It employs 600 electricians, has several facilities in southern California and has completed projects throughout California. Chappell relates that the company has approximately $130 million in annual revenues.

Baker installs solar PV systems as part of its business, and is also promoting battery storage to its customers. Chappell says the company is solar panel and technology agnostic. Different applications require different panels, he explains.

System Designed to Reduce Demand

Sharp Electronics Corporation, a US subsidiary of Osaka-based Sharp Corporation, formed Energy Systems and Services Group (ESSG), which entered the market in 2014 with the launch of the SmartStorage behind-the-meter scalable energy storage system.

Designed to reduce peak demand charges in commercial and industrial buildings, Carl Mansfield, general manager and founder of ESSG, says the SmartStorage system can be deployed as a standalone storage system or in tandem with a solar system, and it uses energy management software installed onsite. The system keeps a large amount of energy stored in reserve, which it selectively releases in order to limit a facility's electricity demands.

The lithium ion batteries are sized to store 40 kWh for just over one hour, or 80 kWh for about two and a half hours. The system can be scaled to as much as 480-kW power rating, to accommodate customers' needs.

Mansfield says Samsung SDI is currently supplying the batteries, but ESSG tracks it and can adopt the leading battery technology whichever that might be. Ideal Power (profiled further on in this article) currently supplies the inverters, but Sharp is capable of adopting alternate inverters, too. The company has selected Ideal Power to supply inverters for the storage system because of high efficiency and compact size.

Sharp offers a 10-year performance guarantee in conjunction with its 10-year operations and service agreement for all SmartStorage system installations. "We will guarantee a minimum demand reduction which is reviewed on an annual basis," says Mansfield. "If we do not meet that demand level, we will compensate for the deficit."

Sharp's operations and service agreement provides continuous whole-system remote monitoring, performance tuning, and maintenance with its own intelligent energy management software. Mansfield says, "We deploy a separate onsite controller and can run the site automatically and this is integrated into a cloud-based territory server."

If the Internet fails, the onsite system will continue to operate and forward the cached data once the Internet connection is reestablished. Mansfield notes that the system does not currently provide emergency or backup power, but development is underway to add that feature.

When Sharp's SmartStorage system is deployed alongside a solar system it can increase the return on investment on installed solar assets, he says. Each system is separately integrated into the building's Alternating Current (AC) electrical system, and the battery storage system is replenished from the grid while the solar system narrows the load peak. Operating in tandem, the battery storage system firms demand reductions and improves overall solar performance.

Mansfield adds that ESSG staff has looked into plugging batteries into a solar system's Direct Current (DC) system, thereby eliminating one AC/DC inverter, but has found that this alternative to be less flexible and oftentimes more problematic to deploy. For example, the solar system integrator may prefer to select their own inverters, rather than one compatible with our SmartStorage system.

Furthermore, much greater flexibility for system sizing and deployment location is achieved when ESSG staff uses its preferred battery inverters separately from the solar inverters. This is particularly beneficial when the storage batteries and solar panels must be installed in different locations and at lengthy distances.

By installing both a solar system and a SmartStorage system, the building owner can benefit from a combination of solar tax credits and incentives in addition to applicable storage incentives if offered. Both California and New York do offer energy storage incentives.

Integrating Emergency Supplies

The Borrego Springs microgrid is perhaps the best-known microgrid in the energy industry, and it is being expanded. The desert town of Borrego Springs is located in eastern San Diego County. It has four golf courses, no stoplights, a tourist-driven economy, and is served by a single electric transmission line at the end of SDG&E's grid system.

SDG&E built the microgrid to provide service to Borrego Springs' 3,000 electric customers because the power fails frequently due to bad weather and dust storms and it seemed the ideal place to demonstrate what a microgrid could do.

SDG&E won $8 million from the US Department of Energy (DOE) to build the initial distributed energy system to provide power to critical portions of the community, including the downtown business area and cooling zones. The community uses anywhere from 4 MW to 15 MW, depending on the time of year. The microgrid includes two 1.8-MW microgrid generators and a 1.5-MW lithium ion energy storage system, which has the capability to provide three hours' worth of power.

More recently, the California Energy Commission awarded SDG&E $5 million to allow the integration of renewable power into the microgrid. Currently,

the microgrid generators operate on diesel, since there is no natural gas in the town, according to Neal Bartek, distributed energy resources manager at SDG&E. This funding is also being used to increase the size of the microgrid to serve all of Borrego Springs.

The CEC funding will also support the development of advanced software, which, Bartek says, will allow SDG&E to integrate the software used by each system into a full control system.

In May 2015, lightning struck the transmission line cutting power to Borrego Springs. The microgrid supplied power to a portion of the community and required SDG&E crews to replace or repair three transmission poles. Normally that kind of repair would require a 10-hour outage for the whole community. Instead, at 8:45 a.m. on May 21, SDG&E switched the town's grid to the generators and energy storage system and rerouted power from NRG's 26-MW Borrego Solar Facility.

With advanced computer software and automated switching and utilizing the energy storage system, the microgrid followed the load and filled in gaps created by the intermittent solar power over the nine hours it took for the crews to repair the transmission poles. At 5:30 p.m. SDG&E, having completed the repairs on the transmission feed, switched the town back to the main grid following a 10-minute downtime. The original portion of the community the microgrid was designed for using DOE funds did not see any 10-minute outage. Improved software will prevent the downtime in the future, Bartek concludes.

Bartek says that NRG's Borrego Solar Facility is a mile north of the microgrid station and is connected to SDG&E's grid. It sells its output to the utility under a long-term contract. The May 21 use of the solar plant was a first and one-time event, according to Bartek. He says SDG&E is working with NRG to change operating procedures so that the solar plant can provide power to the community whenever the microgrid is needed. Currently, when grid power is interrupted and transmission fails, the solar system goes offline.

Bartek says engineering studies need to be done, contractual arrangements need to be signed, operations and maintenance procedures need to be written. Protection schemes need to be worked out and software installed for the solar plant to be fully integrated into the microgrid. In the future, he says, the switchover from grid power to microgrid power will be fairly automatic.

"The idea is to use the storage and generators to bring the microgrid on line and then tie in the solar system to maximize the amount of generation produced by the microgrid," says Bartek. "It will serve the entire town during the daytime while there is sunlight, and serve only critical loads at night."

Solar + Storage

Constellation, based in Baltimore and long known as a seller of electricity, natural gas and other fuels, is owned by Chicago-based Exelon Corp. Constellation's Distributed Energy Group has 300 distributed generation projects completed or under development, including 200 MW of behind-the-meter solar projects for commercial customers. A combination of cogeneration, fuel cells, and energy storage make up the distributed generation projects.

Constellation began offering solar installations in 2007 according to Ben Chadwick, director of commercial development for the company's Distributed Energy Group. Constellation typically owns the installed solar systems and sells the output under power purchase agreements with its commercial and industrial customers. Constellation is agnostic when it comes to the technologies it recommends, and will choose the appropriate technology for each installation, Chadwick says.

Now Constellation is offering battery storage products as well, because of perceived customer demand, he explains. "Capital is holding back energy infrastructure improvements," says Chadwick, and because facility managers are experienced in managing an operating budget, they are usually not adept at selling capital projects to the company's executives.

"We come in as turnkey asset builders and project providers" and deliver the required capital, he says.

As for energy storage, the company typically focuses on standalone projects 1 MW or higher, and systems 200 kW and up for aggregate projects, as part of a 2-MW portfolio. "Economics dictate storage for larger customers, and we are focused on this size customer," he adds, noting that the economics for smaller installations are more challenging.

California and the territories covered by the Pennsylvania/New Jersey/Maryland (PJM) independent system operator are the markets Constellation is concentrating on because of the incentives available in both areas.

California has an aggressive incentive program in the Self-Generation Incentive Program (SGIP). It provides rebates for qualifying distributed energy systems installed on the customer's side of the utility meter and includes advanced energy storage systems as well as wind turbines, waste heat to power technologies, microturbines, gas turbines, and fuel cells. Solar projects receive rebates through a separate program.

The three investor-owned California utilities have extremely high demand charges and coupled with rebates the savings are great enough they can pencil out a viable project, Chadwick says.

In PG&E's territory for example, Chadwick explains there are different voltage levels and tariff classes, so a 1-MW demand charge can vary, but, on average, large customers can pay around $200,000 per megawatt of demand.

PJM's incentives come in the form of revenue created through the ancillary services market, specifically frequency regulation, Chadwick explains. To balance the grid at 60 Hz, the PJM fine-tunes the grid every second. The grid operator pays generators and energy storage owners to increase or back off their supply and demand in response to an automated signal.

"Storage devices can do this instantaneously and are paid a premium for their services," he says.

Chadwick says his group is talking to customers about energy storage, but as of June had not announced any contract signings. He says his group will install energy storage independently of solar, if the customer chooses not to install the latter.

Chadwick says the Distributed Energy Group is looking for all opportunities to improve a customer's energy

efficiency. In fact, he says, California's SGIP requires that a customer's site must improve its energy efficiency to reduce power usage first before qualifying for a solar or energy storage rebate.

Investing in Startups

Constellation Technology Ventures (CTV) is a venture capital fund located within Exelon Corp, Constellation's parent. It was created to drive innovation in the energy technology space and to support Constellation's additional services, which it offers to its customers through its Distributed Energy Group.

CTV is actively investing in startup energy companies, including Aquion energy, C3 Energy, ECurve, and Stem, all of which offer energy storage systems or controls to reduce peak demand charges.

Michael Smith is Constellation Vice President and head of CTV. He says his team works with each of the startups and coordinates with Constellation retail teams to offer these new and innovative products to customers. "When we invest, we also plan to connect the company's portfolio to our customers," he adds.

CTV invested in Aquion Energy last year. Aquion Energy, a company spun out of Carnegie Mellon University in 2010, manufactures aqueous hybrid ion (AHI) battery systems for remote power and microgrids, energy management and grid-scale energy storage for stationary long duration daily cycling applications. According to its website, AHI is made of cheap materials in a simple manufacturing approach. The smallest battery stack produces about 2 kWh, and can be stacked in ever increasing sizes even to a racked module-based system. It has installed systems in Hawaii, California, Colorado, and at a grid-tied microgrid.

ECurve is another early stage startup in which CTV invested, in May 2014. Smith says it helps customers control peak demand with power access controls to keep electrical demand equal to supply.

In November 2014, CTV invested in Stem, another startup.

New Competition

Stem Inc. was founded in 2009, but it is already working on projects at more than 150 commercial and industrial sites in California and other sites scattered across the US. Its signature product is a lithium ion-based energy storage system and proprietary power monitor with accompanying software combining historical energy use, weather forecasts and utility rates to predict energy patterns.

Stem's CEO, John Carrington, says the company installs energy storage systems separately or in partnership with solar PV systems. The company has agreements with both SunPower and Kyocera to install its storage systems alongside their solar products.

Stem's lithium ion storage systems vary in size from 18 kW to several hundred kilowatts, and are currently supplied by Panasonic and LG Chem, says Carrington. "We're agnostic about suppliers, which is the best place to be."

The power monitor, installed on site, tracks a building's energy use in

real-time and sends commands for when to store and deploy energy. The storage system draws energy when costs are low and automatically deploys that energy in time to reduce peak demand when costs are high.

Stem has created a financing plan to install its systems at no cost to its customers and charge monthly leasing fees. It has built up a $135 million fund to enable it to finance future projects.

ShoEi Foods USA, Inc. is a Stem customer and is featured in a case study on Stem's website. Located in Olivehurst, CA, ShoEi is a food processor handling nearly 1,000 acres of prunes and walnuts annually. Recognizing that its refrigerated warehouses swallow massive amounts of energy ShoEi's executive team began a search to reduce energy use. It selected Cenergy Power to install a solar system and Cenergy in turn partnered with Stem to create a combined solar storage project to trim ShoEi's peak demand profile by a projected $6,000 per month.

The 72-kW combined system was installed in September 2013 and is saving the company $72,000 a year. When software detects a spike in energy usage that would cause ShoEi to exceed its 500-kW demand threshold, facility managers are alerted. They can then reconfigure operations to reduce demand. But concurrently, the energy storage unit automatically releases stored energy, which buys more time for the team to make necessary adjustments.

Stem's software analytics allowed ShoEi to understand the energy impacts of specific equipment, identify patterns, and make adjustments to smooth usage peaks throughout the day. The software uses an algorithm developed by collecting data from over 200 customers representing a variety of different types—office buildings, restaurants, hospitals, etc. The "dashboard" displays the current day's energy use and utility costs and then predicts the customer's unique energy patterns.

"This allows the customer to see power usage in real time," adds Carrington. "It informs, predicts, and optimizes."

In consultation with Stem, ShoEi switched to a more cost-effective utility rate. Dwight Davis, ShoEi's facility and plant manager, says real time is key. "If you have one 15-minute interval in a month that exceeds maximum demand for your current rate, it's a strike against you. If you get three strikes in consecutive months, you back up to the higher rate immediately."

Stem was awarded a contract with Southern California Edison (SCE) in November 2014 to install 85 MW of energy storage packages at customers' facilities, behind the meter. Stem will do the marketing, offering lease agreements to customers in the West Los Angeles basin. "This is an exceptional opportunity, and is the most cost effective, efficient way to manage the grid," says Carrington. SCE will signal Stem and ask for the energy storage systems to take over supplying power to customers when the grid is congested and needs power reductions.

This, and several other contracts awarded at the same time, are awaiting California Public Utilities Commission approval, which is expected sometime in late September or October, according to an SCE spokesman.

A Disruptive Technology

Ideal Power focuses not on energy storage, but the inverters or power conversion technology which solar or energy storage systems need to tie the grid and an installation together. Ryan O'Keefe, senior vice president of business development at Ideal Power describes its technology as "disruptive." Why? Its patented Power Packet Switching Architecture eliminates the transformer, O'Keefe says. And it can integrate PV systems with energy storage up to 1 MW.

In general, inverters or power conversion technology, which converts DC power to AC, hasn't changed in 50 years, O'Keefe says. "If we bought the traditional AC/DC battery inverter, it would be six times heavier than ours", and would require a crane to lift it off a flatbed and move it to its permanent location.

Ideal Power's power conversion technology is unique in that it can be delivered by parcel services such as UPS or FedEx and brought up in an elevator to the equipment room, O'Keefe says. The product's footprint and efficiency is what makes the product stand out in the market place, he argues. The company is targeting commercial and industrial markets.

Each power converter has either two or three ports. The first power converter the company introduced to the market

Intelligent, Behind-the-Meter Storage

Whether to reduce high-cost demand charges to optimize energy efficiency investments, or to ensure critical operations receive uninterrupted power in case of a blackout—or both—energy storage and management are critical for businesses of all sizes. In states like California and New York, commercial and industrial (C&I) energy users pay high demand charges that can represent up to 50% of their monthly electric bill. Intelligent behind the meter energy storage helps manage the distribution of the energy by balancing out peak demand times, while also providing customers with access to real-time energy usage data. Overall, energy storage solutions help businesses better manage and optimize their facility operations to minimize economic and operational risks every day.

Many companies are facing growing challenges with existing power plants being retired, renewable energy deployments increasing, ongoing power outages, and growing customer demand. In lieu of investing in costly infrastructure upgrades, California and New York, for example, are promoting the adoption of distributed energy resources (DER), including energy storage and renewable energy generation, with subsidies and mandates. With financial incentives that cover a variety of energy projects, including incentives for 30–60% of energy storage deployment costs, commercial customers are implementing energy efficiency measures, renewable energy generation, and onsite energy storage in growing numbers. The resulting growth of energy storage deployments is designed to help avoid costly upgrades and develop a more resilient grid using local generation and storage.

While many behind-the-meter energy storage systems are primarily being used for commercial demand reduction, the technology is capable of a broader array of energy applications—EV charging, UPS/critical backup power, renewable microgrids, bidding into demand response programs, and ancillary services for the grid. One of the earliest companies in the market, CODA Energy (**http://bit.ly/1MPJexu**) provides advanced, UL-certified energy storage systems to C&I customers that reduce demand and energy costs in the short term, and is also helping states meet state DER goals and mitigate utility infrastructure investments in the long term. Newer market entrants, like Tesla, are exploring residential energy storage solutions to provide similar benefits in the home.

is designed for a 30-kW system to be installed in a small business. The two-port version offers a plug to connect a battery storage system to the Grid-tied DC system and a plug into the AC building electrical system. The power can then flow in either direction.

The three-port version provides for AC/DC/DC connections in which a battery storage unit connects not only to the grid, but also to a PV solar system and the building electrical system.

Ideal Power's latest product is designed for a 125-kW system for large businesses. It also comes in two-port or three-port versions. The Power Packet switching architecture software is designed so that the AC/DC link switches open and closed very fast, O'Keefe says—8,000 to 14,000 times per second—to allow bidirectional power to maintain a steady flow of power.

The company's first commercial installation was at the University of Texas San Antonio where a 173-kW solar system was installed. It was split into six sub arrays spread across several buildings on the main campus. Ideal Power's four inverters were mounted inside one large building, and another was located in the Engineering building inside penthouse utility rooms. According to Ideal Power, this would not have been possible with conventional 480-V AC inverter systems.

The university had aesthetics concerns about using large conventional ground-mounted PV inverters that would look unattractive on campus. The design and installation company reported that Ideal Power's lightweight inverters lowered their installation costs by about $0.17 per watt (DC) and allowed short wiring runs.

Ideal Power received its initial order in October 2014 from CODA Energy, a California-based manufacturer and installer of commercial and industrial energy storage products.

Since then it has signed deals with Sharp Electronics Corporation's Energy Systems and Services and Powin Energy, a China-based company owned by Chun Fung.

Ideal Power has recently signed a distribution agreement with Gexpro, the subsidiary of Rexel, a French company that bought GE Supply. It is the largest distributor of electronics in North America, according to O'Keefe. Gexpro packages Ideal Power's inverter with LG Chem's lithium ion batteries along with a wiring kit, an installation manual, and software to run the power converters.

"This will make it simple for commercial installers, builders, and solar companies to purchase the package," says O'Keefe, and increase the value of the packages in the marketplace.

Ideal Power will continue to sell their power converters to key accounts such as Sharp and Powin, he says. **BE**

Lyn Corum *is a technical writer specializing in energy topics.*

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