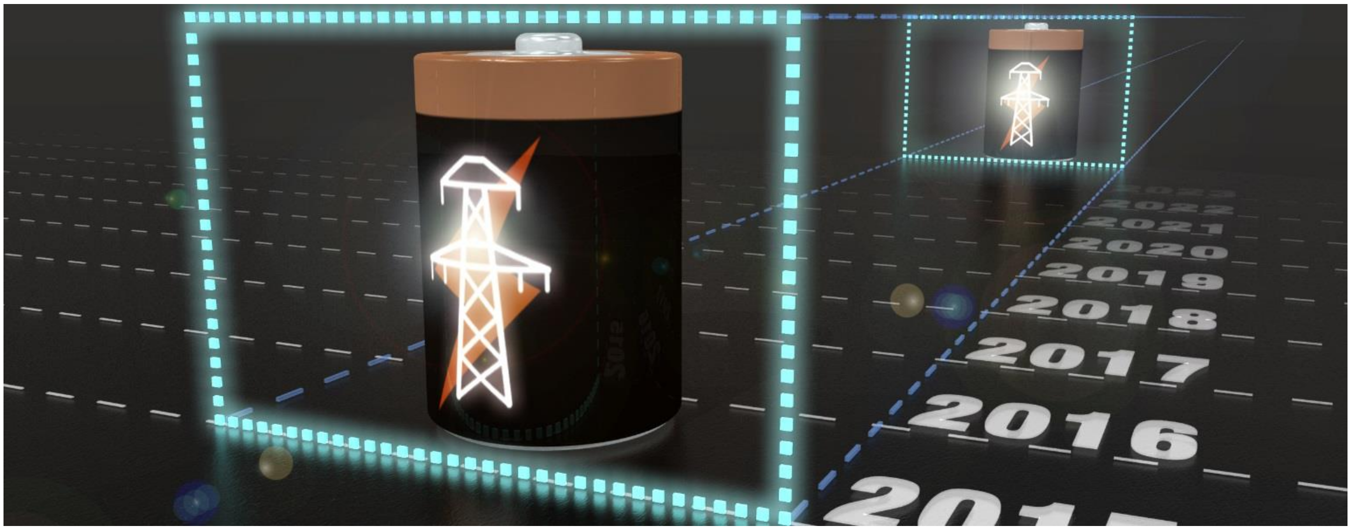
Feature—A Reality Check on Energy Storage



Widespread Grid Storage Is Coming, But Not as Fast as Many Think

By Garrett Hering

The eager anticipation at a recent solar energy trade fair in San Francisco felt familiar, reflecting an emerging technology seemingly on the verge of a major commercial breakthrough. But instead of solar photovoltaics (PV), it was electrical energy storage that stole the show at this year's Intersolar North America.

Haresh Kamath, EPRI's program manager for energy storage

The battery buzz was palpable in standing-room-only presentations featuring bullish views on market prospects, game-changing chemistries, and electricity sector disruption. Sprawled across a bustling exhibition hall, vendors showcased new products, partnerships, and investments. Ambitious technologists tantalized participants with bold predictions, often blurring the lines between hype and hope, vision and spin.

"There's going to be much faster growth of grid energy storage than most people expect," Tesla Motors Chief Technology Officer and co-founder JB Straubel told a packed auditorium in his keynote address. "Batteries are going to win the day."

Relying on the same lithium ion technology at the heart of its electric vehicles, the California electric carmaker is ramping up its new battery venture for residences and businesses. "We don't just want to make cars electric," said Straubel. "We need to link electric cars back to where energy comes from."

Straubel predicted that as most ground vehicles move "toward battery electric," the collective fleet of electric vehicles "will integrate with growing renewables on the grid to allow 100-percent non-carbon energy for electricity and transportation." Straubel said he is certain that an "amazing tipping point" will occur when battery-backed PV systems become "cheaper than fossil energy," though he did not pin a date on this prediction.

Hype Meets Reality

Not everyone agrees that such a tipping point is imminent.

"Batteries have a lot of potential, but are not yet ready in the way many people think they are," said Haresh Kamath, EPRI's program manager for energy storage. "We believe energy storage will bring vast, sweeping change, but the timeframe will be longer than the next two to three years. We will see a more subtle transition, leading to a substantially different grid in 10 to 15 years."

Some technology developers share this measured view. "We are seeing a shift similar to what we saw in solar PV several years ago," said Kevin Fok, senior project manager at LG Chem Power, a subsidiary of South Korean lithium ion battery manufacturer LG Chem. "In terms of product maturity, services, bankability, and an increase in commercial contracts, batteries definitely have crossed a threshold in the past year or two. But we still need some combination of cost reduction, manufacturing expansion, higher power density, and enhanced product durability and safety."

Market data reflect the nascent stage of electrical energy storage. According to the U.S. Department of Energy's Global Energy Storage Database, only 188 grid-tied electrochemical and electromechanical storage projects were operating nationwide as of September, totaling 462 megawatts. That is equal to less than 0.04% of the country's total installed generating capacity. By comparison, pumped hydroelectric storage, by far the most established form of electricity storage, accounts for more than 20,000 megawatts.

According to Kamath, much work remains in various technical areas before substantial market growth for non-hydropower-based storage can occur. "The real issues in the near term are establishing product reliability and determining which services energy storage can provide," he said. "There are still many gaps in these and other areas right now. Until these gaps are addressed, storage is still something of a niche product."

Battery Believers

To be sure, electrochemical storage is growing quickly in a few regions. The German market for small-scale battery storage systems jumped after the Federal Ministry of Economic Affairs and development bank KfW started offering incentives in 2013. In August, German solar association BSW estimated that the country has nearly 25,000 battery-coupled, on-grid PV systems.

Numerous analysts expect the United States to emerge as one of the strongest markets, beginning this year. GTM Research forecasts 220 megawatts of battery storage additions in 2015, with utility, residential, and commercial and industrial capacity more than doubling compared to 2014. By 2019, the annual market could grow to 858 megawatts, according to GTM, fueled by high electric rates and regulations in California, New York, Hawaii, and other states.

EPRI's Kamath also expects robust growth for energy storage, but with a caveat. "Projecting exponential growth rates doesn't mean much when the market is so small right now," he said. "A significant percentage of the systems that are bought today are experimental systems purchased by early adopters, and market projections on the basis of those purchases must be taken with a grain of salt. There's still a lot of uncertainty about just how storage systems will be used in the future, and that affects our certainty about how big the market will be."

For companies making big investments, the future is now. Along with Japanese consumer electronics giant and battery supplier Panasonic, Tesla is investing $5 billion in the "Gigafactory" under construction near Reno, Nevada, with planned production capacity exceeding all current lithium ion battery factories combined. The facility's scale and integrated production of materials, cells, and battery packs are designed to do for lithium ion batteries what large-scale PV factories have done for solar: cut manufacturing costs and lower consumer prices.

"Almost no one would have predicted that photovoltaic prices would fall as far as they have, and storage is right at the cliff heading down that price curve," said Straubel. Currently, Tesla prices its residential product at $350 per kilowatt-hour (inverter and installation not included), which Straubel called "by far one of the most competitive prices out there." A larger product for industrial use is advertised at $250 per kilowatt-hour.

While Tesla's battery prices are indeed competitive, EPRI's Kamath cautioned that comparisons of energy storage prices and costs often exclude important details. "These figures can be easily misunderstood," he said. "There is a wide range of utility and customer applications, each with specific installation and operations costs and prices, and often some or all of these are not included. Metrics such as dollars per kilowatt-hour can be useful general benchmarks, but you really have to look at the cost of an entire storage system designed for a particular application."

EPRI's Energy Storage Initiatives

EPRI is working on various fronts to inform fact-based analysis of storage markets and technology. It has created the Energy Storage Cost Benchmarking Database to track the costs and benefits of selected storage systems providing services such as frequency regulation, renewable energy integration, voltage support, and demand-charge management. The database, which EPRI is updating in 2015, draws on vendor surveys and considers a range of technologies, from electrochemical and electromechanical to pumped hydro storage and compressed air.

For instance, preliminary estimates for the capital cost of lithium ion batteries in distribution applications range from about $350 to $500 per kilowatt-hour for the battery alone, while fully installed lithium ion systems (including power conversion electronics) may cost $1,000 to $1,200 per kilowatt-hour of storage.

EPRI's regularly updated Energy Storage Valuation Tool helps regulators and utilities to understand when and where grid-connected storage systems make economic sense. In 2013, California regulators used the tool to help set the state's energy storage targets. Since then, EPRI has worked with more than a dozen utilities using the tool to assess the value of storage in their service territories.

The EPRI-led Energy Storage Integration Council (ESIC) provides a technical forum for utilities, energy storage vendors, government organizations, and other stakeholders to advance safe, reliable, and cost-effective energy storage. Activities include:

- Identifying technical grid challenges that energy storage could solve and communicating requirements to vendors
- Defining common performance metrics and verification methods for products
- Performing cost-benefit analyses
- Providing guidelines for the safe operation of products and projects
- Documenting and disseminating best practices for installation, integration, and operation

"We are trying to understand how storage fits into our portfolio, what the multiple value streams are, and how to price those values," said Thomas Golden, Technology Development Manager for Duke Energy, who chairs an ESIC working group on grid integration.

In addition to its participation in ESIC, Duke Energy, the largest U.S. utility, is exploring energy storage through numerous projects across the country, including a 2-megawatt project at a retired coal plant in Ohio and a 36-megawatt project at a Texas wind farm.

Golden isn't bothered by the exuberance about batteries. "Young, immature industries need a certain amount of hype," he said. "There is this big swell of excitement when a new technology takes off, followed by a shakeout separating winners from losers, and then it matures. It's part of how the market gets built. We are excited about storage and its potential to make the grid more flexible and reliable."

For EPRI's Kamath, energy storage today is reminiscent of computers 30 years ago. "In the early 1980s, people knew personal computers would be a big deal, but they had no idea how they would use them," he said. "Now most personal computers are handheld devices used for things people never imagined they would do but are nonetheless considered essential. In the same way, we are still figuring out what storage will become."

Energy Storage: Past, Present, and Future

Although energy storage is considered one of the most exciting new technologies in electric power today, it is nothing new. Alessandro Volta invented the voltaic cell, the basis for the modern electric battery, at the dawn of the 19th century. Lead-acid batteries, the first rechargeable batteries, made their commercial debut in telegraph systems of the 1830s and were used in New York's direct-current grid of the 1880s before entering global automobile markets in the 20th century.

Connecticut Light & Power completed the first large-scale energy storage system in 1929, a 31-megawatt pumped hydroelectric storage installation. Today, pumped storage makes up the majority of energy storage capacity, with approximately 130 gigawatts in operation worldwide—including more than 20 gigawatts in the United States. Pumped storage can provide bulk energy services, with storage discharge times in the tens of hours and generating capacities larger than 1 gigawatt at individual facilities. Another form of bulk energy storage is compressed air.

In contrast with compressed air and pumped storage, various electrochemical batteries have emerged that provide shorter periods of storage, with discharge times ranging from approximately one to six hours. In addition to lead-acid, commercial energy storage chemistries include sodium-sulfur, sodium-nickel-chloride, nickel-metal-hydride, vanadium redox flow batteries, and lithium ion.

Each has advantages and disadvantages when it comes to costs and performance factors, such as cycle life, service life, charge rate, discharge duration, round-trip efficiency, and operations in different temperatures.

Among electrochemical technologies, lithium ion batteries dominate the market for grid-scale battery storage in the United States—partially because of their ability to ramp quickly in applications, such as frequency regulation, requiring less than four hours of storage. Other technologies, notably sodium-sulfur and certain types of flow batteries, have an advantage for grid services requiring longer discharge.

"We don't believe that a single battery will ever address all the energy storage applications or that battery innovations will end any time soon," said John Jung, CEO of Greensmith, one of the largest integrators of grid-scale storage in the United States. "That is why our technology and business model have been and always will be battery-agnostic."

No one has invented a super-battery yet, but many are trying. The mission of the U.S. Department of Energy–funded Joint Center for Energy Storage Research—led by Argonne National Laboratory and including EPRI as an affiliate member—is to "develop new technologies that move beyond today's best lithium ion systems to provide five times the energy storage at one-fifth the cost within five years." Tesla's mission is similar, focusing on commercially available lithium ion batteries from Panasonic. While it remains to be seen which group gets there first, it's a competition worth watching.

Key EPRI Technical Experts

Haresh Kamath