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INSIGHTS

EMERGING ENERGY SOLUTIONS

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Battery Storage: A Primer

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Creating Markets, Creating Opportunities

Battery technology is evolving at a breathtaking pace. As performance improves and costs fall, batteries are already critical for consumer electronics, such as mobile phones, and are paving the way for the electric vehicle market. The battery revolution doesn't end there. Battery systems are also transforming intermittent renewable energy—such as solar and wind—by making them much more financially attractive. Investors are taking notice.

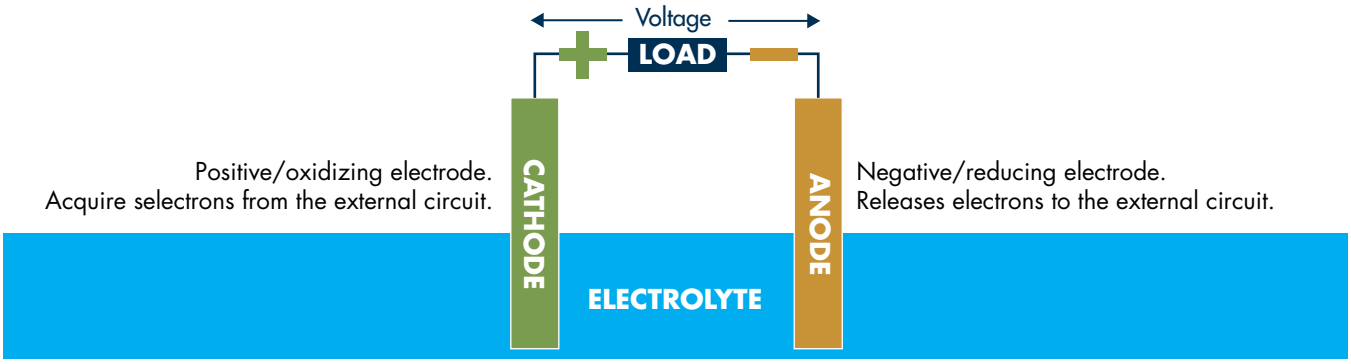
But while the versatility of batteries makes them attractive, it is difficult to determine their economic value. Understanding where and why batteries are most successful remains challenging, as each situation is different based on power-to-energy ratios, project size and complexity, the level of built-in redundancy, and local regulations. Regardless of their application, batteries have quickly become a new asset class with a multitude of uses.

BATTERY BASICS

Batteries convert electrical energy to chemical energy, store it, and then convert it back to electrical energy as needed. Benjamin Franklin invented the term "battery" in 1749 to describe a set of linked capacitors through which he conducted electricity. In 1800, Italian scientist Alessandro Volta invented the first true battery known as the voltaic pile.

Battery technology has come a long way since then: In 2019, the Royal Swedish Academy of Sciences awarded the Nobel Prize in Chemistry to three scientists for their work developing the lithium-ion battery. Today, lithium-ion batteries are ubiquitous, powering everything from smartphones to electric vehicles, and are expected to be the relevant technology for the next five years.

Regardless of its type, a battery consists of a combination of several cells, each of which comprises the following component



The medium that provides the ion transport mechanism between the cathode and anode of a cell.
Often liquids, such as water or other solvents, with dissolved slats, acids, or alkalis that are required for ionic conduction.

Lithium-ion (Li-ion): Lithium-ion batteries are the battery of choice among electrical storage applications, from electric vehicles to consumer electronics. They use lithium ions to transfer a charge between the cathode and anode. While the anode is always made of graphite, the cathode materials vary across sub-types (nickel, cobalt, or manganese). Li-ion batteries perform well as all-round batteries with good performance across all properties. The main disadvantages are their short discharge duration (less than four hours), relatively high input material cost, and safety and durability issues (especially high ambient temperature), as seen with some subtypes. Today, lithium-ion batteries represent the bulk of all deployments—more than 95 percent of all grid-scale capacity being added today.

Energy storage applications are based on a system's ability to capture and store energy while it is available and then discharge it at exactly when it is needed. In a functioning battery, the anode and cathode produce a voltage capable of driving enough current to serve an electrical load. A variety of material and chemical processes can produce the necessary current.

Less understood is that batteries can act like Swiss army knives, serving different purposes simultaneously. For example, batteries can perform both transmission and distribution functions while simultaneously serving as generators when they release stored energy.

THE MARKET

Today, electric vehicles account for the lion's share of demand for batteries, followed by consumer electronics. Stationary energy storage systems represent only a small part of overall battery demand. Growth in demand for stationary storage is forecasted to grow steadily in the foreseeable future, as shown below.

Affordable battery-powered energy storage is the missing link between generating intermittent renewable energy—for example, in a solar mini-grid—and delivering it to end-users when they need it. The technology is proven, but the economics continue to evolve: As the costs of battery technology steadily fall, the focus is shifting towards services and increasing value.

Batteries are becoming necessary and mainstream components to how people and businesses generate, purchase, and consume energy. The global power and transportation sectors of the future will be fundamentally different than they are today, igniting opportunities for investment in new technologies that can bolster resilience and lower carbon emissions. The global energy storage market is showing a lower-than-exponential growth rate. By 2040, it will reach a cumulative 2,850 gigawatt-hours, over 100 times bigger than it is today, and will attract an estimated $662 billion in investment.

STORAGE INPUT ECONOMICS

Energy storage is a crucial tool that effectively integrates with renewable energy, unlocks the benefits of local generation, and enables a clean, resilient energy supply. The technology continues to prove its value to grid operators around the world who must manage the variable generation of solar and wind energy. However, the development of advanced battery energy storage systems (BESS) has been highly concentrated in select markets, primarily in regions with highly developed economies. Today, as system costs are rapidly decreasing and energy markets are being reformed, allowing the use of more distributed resources, installations of stationary battery energy storage systems are increasing dramatically around the world.

In 2019, prices for fully installed, four-hour utility-scale storage systems ranged from $300 to $446/kilowatt-hours. Roughly half of the current storage system costs are attributable to battery cells. The remaining costs derive from the process of packing the cells into battery

packs, adding cooling, software control systems, and any remaining balance of plant (BoP) costs. Several factors will continue to drive down costs, including technology improvements, manufacturing scale, competition between manufacturers, greater product integration ahead of installation, and greater overall industry expertise.

The industry is likely to continue improving on cost and discharge time—at least through the 2020s—as projects continue to increase in size. The first project exceeding 10 megawatt-hours was built at the start of the 2010s, the first 100-megawatt-hour project in 2016, and the first gigawatt-hour project is currently being built in California—signifying growth by a factor of 100 within a single decade.

Storage system costs are falling fast. The turn-key system price for battery energy storage systems is expected to fall by almost half over the new decade. Most of this decline will be due to battery cost improvements. Today, the battery accounts for less than 50 percent of system costs for a generic four-hour, megawatt-scale system. By 2030, this share is expected to fall to about 40 percent.

STORAGE OUTPUT ECONOMICS

The business case for battery storage can be built on multiple revenue streams and cost savings.

When storage is charged from renewable energy generators, the energy is discharged at the most valuable point in time: the early evening, when air conditioning usage peaks in warm climates. Most battery storage systems today store between two and four hours of energy. In practice, storage is more often combined with solar power than with wind.

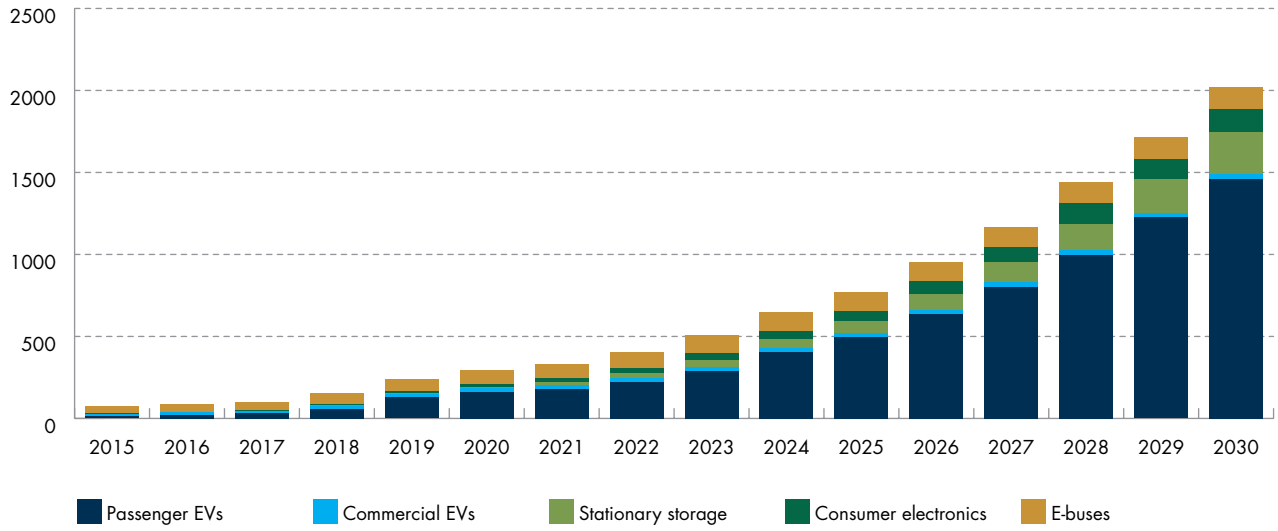
At the current trajectory of technological improvements and falling costs, battery storage, in combination with solar generation, will be highly competitive with alternatives by 2030. Today, it is already competitive with gas, and has shown potential in competing with coal. Diesel could also face pressure for remote power systems, another area where solar and storage are competitive. Gas peaker plants—thermal generators that are run only when demand is high—are also vulnerable to battery competition. Batteries can augment gas turbines' performance by letting them run at an optimal set point, which reduces operational costs.

CHALLENGES

The energy sector is globalizing. A number of challenges, however, must be addressed if investment opportunities are to bear fruit, especially in emerging markets. These include:

- ***Utilities should be at the forefront***, engaging with the private sector. Batteries would allow them to significantly defer necessary investments in their grid to accommodate more renewable energy.
- ***Regulatory time lag in emerging markets***: The main obstacle to faster adoption of front-of-the-meter storage is a lack of regulatory certainty. Some potential income streams for storage projects depend on the regulatory framework. Not a single emerging market has comprehensive regulation of storage in place as of May 2020.
- ***Market transparency***: The rapid improvement of economics has not been adequately disseminated. Some market actors use battery cost data from a few years ago, and even two years make a difference.
- ***Technology skepticism***: There is skepticism that the technology is robust enough to work in emerging markets.
- ***Financing***: The other main challenge, particularly for behind-the-meter applications, is related to financing. In the diesel replacement case, a typical payback takes four to six years. Commercial and industrial off-takers want two years or less for payback. They do not want to commit their own capital to energy solutions, and they may not be able to finance the equipment.

ANNUAL GLOBAL LITHIUM-ION BATTERY DEMAND (Gigawatts, 2016–30)



Source: BloombergNEF.

GOING FORWARD

Energy storage is a fast-evolving industry. The roles of market actors are still fluid, and the industry has not yet converged on standard roles. Some companies cover the entire value chain from cell production to system integration, while others concentrate on single stages in the value chain.

Energy storage technologies will enable this market transformation, as reflected by an impressive market growth outlook. Between 2020 and 2035, energy storage installations are forecast to grow over 27 times (see above graph), attracting close to $400 billion in investment. (BNEF, *Energy Storage Outlook 2019*).

The global power and transportation sectors of the future will be fundamentally different from today, igniting opportunities for investment in new technologies that can bolster resilience and lower carbon emissions. As costs for wind and solar continue to plummet and passenger electric vehicle fleets expand, consumer behavior is also changing, with early adopters becoming autonomous customers and detaching entirely from incumbent utilities.

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