Pile on the payoff: When battery energy storage supports multiple uses, ROI soars

A Honeywell White Paper

> **"Energy storage is such a big deal that in the electric utility business we called it the holy grail. We knew that if we tried to get higher amounts of wind and solar on the grid, eventually it would break unless we had energy storage."**
>
> *Jim Kelly, Senior Vice President*
> *Southern California Edison*
> *Speaking at the 2015 VerdeXchange conference*

Utility executives may be calling battery energy storage (BES) systems the holy grail of renewables integration and other industry challenges, but here's an ironic reality: Most organizations keep that holy grail half full or even close to empty.

That's because most organizations target one, two or – if they're ambitious – three value streams from battery systems. But, when you're only trying to recoup an investment based on one or two value streams, the profitability of the investment suffers.

When researchers at the Rocky Mountain Institute, a cleantech think tank, studied this issue, they concluded that, "The prevailing behind-the-meter energy-storage business model creates value for customers and the grid, but leaves significant value on the table. Currently, most systems are deployed for one of three single applications: demand charge reduction, backup power, or increasing solar self-consumption. This results in batteries sitting unused or underutilized for well over half of the system's lifetime."[1]

According to the RMI scholars, a BES system used only for demand reduction could be leveraging as little as 5 percent of its useful life. It's unlikely it will be used for more than 50 percent of its potential benefit.

"Dispatching batteries for a primary application and then re-dispatching them to provide multiple, stacked services creates additional value for all electricity system stakeholders," the RMI team concluded. [2]

How can storage investments provide value along a broader continuum of market-based earning (MBE) opportunities? They can't do it alone. They need to be controlled using advanced algorithms that can balance a variety of factors to deliver the right service at the right time.

1. The Economics of Battery Energy Storage published by the Rocky Mountain Institute. https://rmi.org/insights/reports/economics-battery-energy-storage/

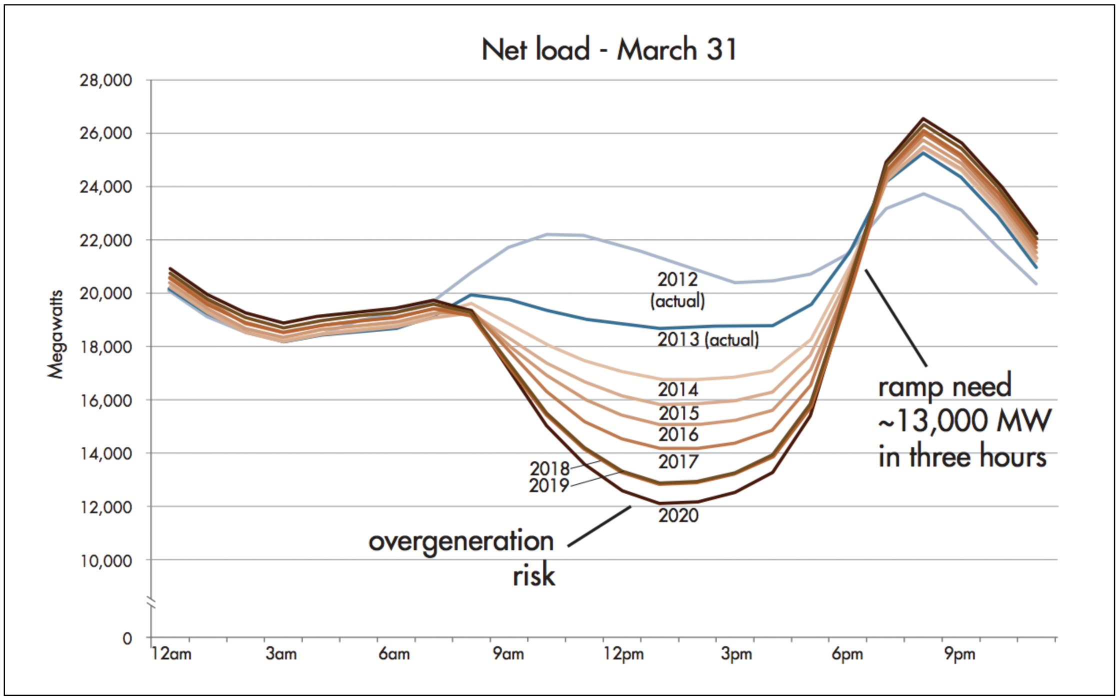
2. Ibid.

Why storage supports diverse value streams

Before explaining how BES systems can deliver multiple market-based earnings, it's important to understand why this is so. Storage isn't a generation asset. The bulk of its value stems from its fast-acting response to grid conditions. In fact, studies cited by the Energy Storage Association show that battery energy storage systems easily compete in power-system markets for ancillary services.[3] A storage system can respond to grid operator signals in near real time.

That rapid response makes storage a perfect choice for provision of grid services that can be of value to three different stakeholder groups: utilities, end-use C&I or government customers and independent system operators.

What kind of problems can storage address?



Duck-curve issues

Net load is a term that represents the imbalance of demand and generation. When California's independent system operator forecasted net load with increasing penetration of customer-sited solar energy coming online, the result was a graph that showed over generation during the day and dramatic ramping curves at day-end when peak occurred and solar power was no longer available. This graph earned the moniker "duck curve" because the dip in load during high-PV-production hours created a line that resembled the belly of a duck, while the steep ramping needs at day-end resembled a duck's neck.[4]

Storage solutions can serve that steep ramp at day-end. They also can flatten out that duck belly, which likely represent overproduction due to the relatively slow ramp rates of traditional generation.

3. http://energystorage.org/energy-storage/facts-figures, 2016.

4. California Independent System Operator, https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf, 2016.

Renewables firming

End-use customers aren't going to switch off their air conditioners, stop production in a manufacturing plant or send office workers home just because the wind quits blowing or clouds dampen PV output for a while. Battery energy storage has been proven to effectively smooth intermittent renewable generation.

One early example was a research project conducted by PNM, New Mexico's largest electricity provider. There, the utility used a battery system to lessen output variations in an adjacent 500-kW PV plant. A control system algorithm instructed batteries to discharge a percentage of their energy to compensate for generation declines and recharge during sharp increases in PV output.[5]

T&D infrastructure deferral

The battery system at PNM actually encompassed two battery systems: one to smooth energy flows from the intermittent generation of the PV system and another one-quarter-megawatt battery for energy shifting.

To leverage the smaller battery, PNM used an algorithm to predict electricity flow through a circuit based on such variables as weather and the circuit's recent history. Then, the utility used this information to dispatch battery resources to augment the PV plant's output. This enabled the utility to serve a portion of its customers' load from the PV/battery energy storage system. The result was a 15-percent reduction on load for substation equipment.

According to the DOE, "Energy storage can reduce the need for major new transmission grid construction upgrades as well as augment the performance of existing transmission and distribution assets." DOE estimates that 70 percent of both transmission lines and power transformers are 25 years or older, while 60 percent of circuit breakers are more than 30 years old.[6]

"Extending the capability of the transmission grid—for example by pre-positioning storage on the load side of transmission constraint points—makes the grid more secure, reliable, and responsive," DOE researchers noted in a paper titled Grid Energy Storage. "Additionally, distributed storage can reduce line-congestion and line-loss by moving electricity at off-peak times, reducing the need for overall generation during peak times. By reducing peak loading (and overloading) of transmission and distribution lines, storage can extend the life of existing infrastructure," the DOE researchers concluded.[7]

5. U.S. Department of Energy, Energy Storage System Firms a Renewable Resource, https://www.smartgrid.gov/files/PNM_Energy-Storage-System-Firms-Renewable-Resource.pdf
6. U.S. Department of Energy, Grid Energy Storage, https://energy.gov/sites/prod/files/2014/09/f18/Grid%20Energy%20Storage%20December%202013.pdf.
7. Ibid.

Power quality management

Given the right control mechanisms, batteries can respond to voltage excursions or frequency violations in as little as 5 cycles or just over one-eighth of a second. This makes battery technology an ideal provider of frequency regulation or volt/VAR support.

On a smaller scale, batteries can dispatch both real and reactive power, making them suitable for localized voltage support along a distribution system.

Adding up the benefits

You can place storage assets at three different connection points: behind-the-meter at end-use customer sites, on the distribution system or on the transmission system.

Grid-scale, transmission-connected storage competes with natural gas generation in fast-ramping wholesale electricity market.

Distribution-level storage deployed at substations can help power providers defer upgrades, relieve congestion, and deliver capacity and more.

Customer-sited storage supports end-use customer needs as well as the grid. In a growing number of markets, behind-the-meter storage can be aggregated and bid into wholesale markets to provide things like capacity and regulation service. Behind-the-meter storage also lightens load, thereby benefitting utilities and transmission system operators alike. For these reasons, RMI's research team found that siting storage behind the meter delivers the greatest potential for value-driving grid services.[8]

Benefits for End-Use Customers

Just as storage can be sited at different levels on the grid, so its value has different market-based earnings and value streams. The way to maximize profit from a storage investment is by mixing and matching these value streams. Here's a look at how value accrues.

Time-of-Use Energy Bill Management

To reduce the impact of time-based rates, storage can be charged off-peak to take advantage of low priced energy and discharged when energy prices are high.

Demand Charge Management

Demand charges can make up 30 percent or more of a C&I customers electric bill.[9] To reduce or avoid demand charges, organizations can charge battery systems when prices are low and discharge them when demand ratchets apply.

8. The Economics of Battery Energy Storage published by the Rocky Mountain Institute. https://rmi.org/insights/reports/economics-battery-energy-storage/
9. http://www.greencharge.net/tips-to-reduce-peak-demand-charges-on-your-electric-bill/

Electric Service Reliability (Back-Up Power)

In 2016, analysts at Information Technology Intelligence Consulting conducted a survey in which 98 percent of respondents said a single hour of downtime costs their organizations more than $100,000.

Eighty-one percent of respondents said the cost surpassed $300,000, and one third suffer downtime losses that top $1 million an hour.[10]

When power outages knock out information systems, recovery often is a lengthy process. According to Price Waterhouse, more than a third of companies take a day or longer to recover, and 10 percent take more than a week.[11]

Looking at the above findings, it's no wonder outages cost businesses billions of dollars a year. A 2012 Congressional Research Service study estimated the inflation-adjusted cost of weather-related outages in the U.S. at up to $70 billion annually.[12]

Renewable energy time shifting and increased PV utilization

Battery systems can prolong the hours during which a facility runs off its PV generators by charging during peak-generation hours and discharge after the sun sets. Asset owners also can gain by using or selling energy at a time when it is more valuable than when it was generated and stored.

Power factor improvements

Organizations that get penalized for low power factor might be able to use battery storage systems and their inverters to support power factor correction. Advanced inverters can generate or absorb reactive power that is generated by inductive motors and other equipment, the primary cause of power factor issues.

Benefits for utilities

Transmission Congestion Relief

There are several ways utilities can deal with congestion: dumping energy upstream from congestion, providing load management and energy efficiency downstream from the congestion, paying congestion charges or adding transmission capacity. Much, if not most, of the congestion ahead will likely occur as more renewables compete for the existing transmission capacity. Given the possible shortfall of transmission capacity within many regions, congestion charges are quite possible. Storage could help utilities reduce congestion charges and defer transmission upgrades.

Transmission and Distribution Deferral

Utilities can add the financial value associated with deferring a utility T&D upgrade to their profit and loss statements. That value reflects the utility's financial carrying charge for the new equipment involved in the upgrade. Carrying charges include the costs for financing, taxes and insurance incurred for one year of ownership of the equipment used for the upgrade. For a utility, that amount is also known as the revenue requirement.

Load Following

In many regions, market-based pricing exists for this service, and it generally reflects the marginal cost of providing capacity (fuel and maintenance) as well as capacity cost, or the amount needed to secure capacity via wholesale markets. When paired with solar production, solar capacity has no fuel cost. And, when utilities don't need to buy or generate capacity, they avoid the associated costs altogether.

Resource adequacy

Utilities can use grid-scale storage to make many electric energy buy-low/sell-high transactions. Benefit may take the form of lower energy cost or profit if the energy is sold in the energy marketplace.

10. http://itic-corp.com/blog/2016/08/cost-of-hourly-downtime-soars-81-of-enterprises-say-it-exceeds-300k-on-average/
11. http://www.eatonenewsletterbuilder.com/uploads/201302211027502012_ANZ_BlackOut_Report.pdf
12. Economic Benefits of Increasing Electric Grid Resilience to Weather Outages, Executive office of the President, 2013. https://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf

Benefits for ISOs and RTOs

Load shifting

Control algorithms that determine when to charge and when to discharge storage to optimize financial benefit can boost storage-system ROI via load shifting. Along with looking at the price of energy, the algorithm will need to look at the energy storage asset's round-trip efficiency and discharge duration.

Black Start

Grid operators tap black-start generation assets to bring their systems back online. Storage can serve as a stand-in.

Frequency Support

Frequency regulation involves a rapid and automatic rise or decrease in power in response to frequency deviations from ANSI standards. Regulation service matches system-level load and capacity on a moment-by-moment basis to maintain a stable 60-hertz frequency in North America or a 50-hertz frequency in Europe.

Spin/Non-Spin Reserves

Spinning reserve is the generation capacity that's available immediately to serve load in the case of unexpected outages.

Storage can cost-effectively stand in for synchronized reserves, the type that can respond within 10 seconds to 10 minutes to service frequency issues or outages, as well as non-synchronized reserves that respond within 10 minutes to serve curtailable loads. A BES system also could operate as supplemental reserves that can pick up load within an hour to back up any disruption to spinning and non-spinning reserves.

Building up the value stack

Considering all the benefits that could be had from a single storage system, why aren't organizations mixing and matching their applications to pile on greater investment return? Because doing so takes more than storage alone.

The other key element needed is intelligent control that is completely integrated with the storage solution deployed. That combination storage and control should emphasize fast controls that maximize the benefit of the energy storage for grid support and financial payback. The solution must be able to facilitate multiple functions that are continuously re-prioritized based on the unique opportunities at each site.

How is this done? One good analogy would be an audio equalizer you might find on a high-grade stereo system. Equalizers manipulate frequencies to change the tone of a stereo or instrument. The levers on the devices change the output of bass and treble, and you might adjust the balance depending on what song you're listening to.

Just as you can adjust the levers of an equalizer to fit your listening preferences, a storage control system should allow you to adjust priorities and system goals to fit your needs at any given time. The solution should allow you to see a trade-off analysis that shows the relative costs and benefits of system sizing and the control features that can be included in your specific system.

Control algorithms you should look for include those that support:

- Peak shaving
- Solar firming
- Demand shifting
- VAR support
- Auto Demand-Response
- Microgrid applications

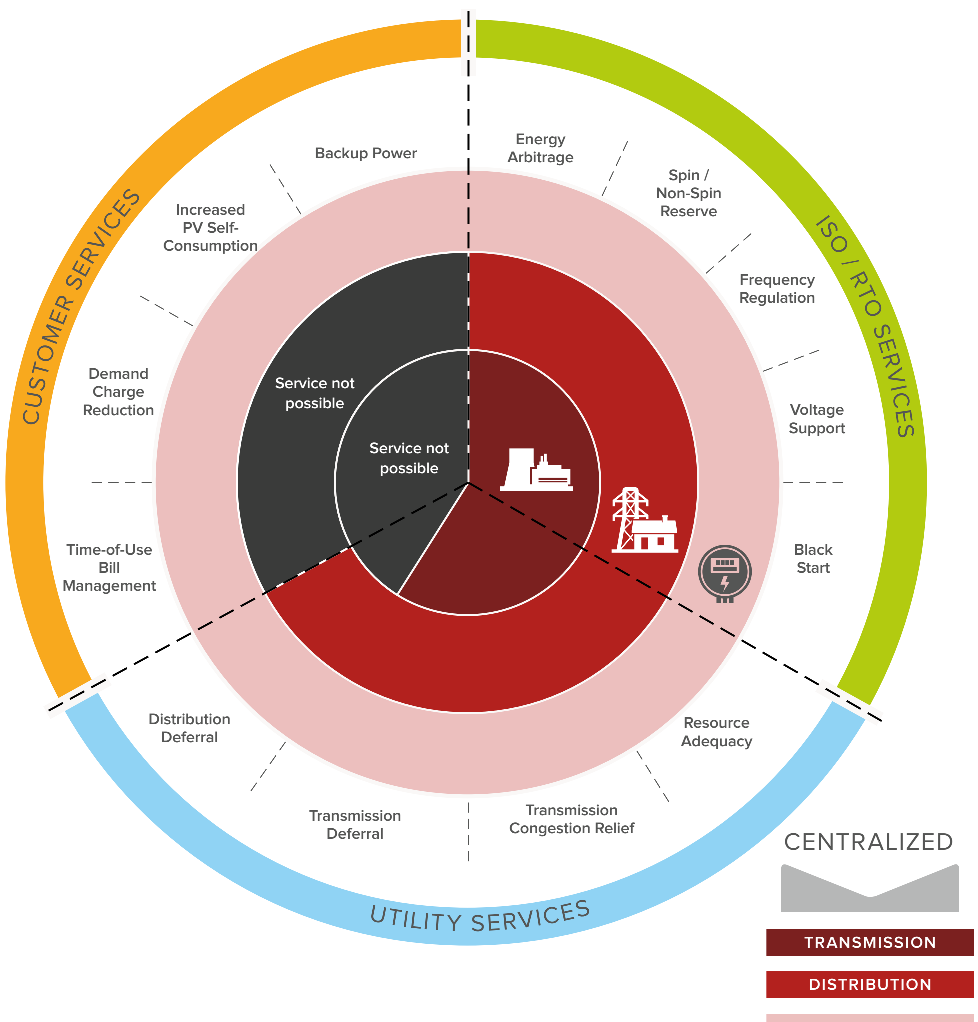
In addition, you should look for a solution that maximizes the storage medium via a higher ratio of inverter power rating to energy storage capacity. Typical storage solutions use approximately 1 kW of inverters for each 4 kWh of storage. If you have a system with 4kW for each 4kWh of storage, it will allow the system to get much more value out of the expensive storage medium at a relatively low cost.

This next solution characteristic doesn't impact ROI, but it's something to consider for facility and end-use-customer applications. You need a solution provider who can customize the storage containers themselves, as they typically look like the cargo shipping containers you'd expect to see on a busy dock. Such containers may not fit in a building basement or look good siting near a building, so like the applications themselves, your storage solution container should be designed just for you.

Finally, you should look for a solution with built-in storage and inverter modules that are independent, but coordinated. That allows for scalability and growth, as well as reliability. If a single module is inoperable for maintenance or any other reason, the other modules continue to provide financial benefit and power surety.

Given these capabilities, storage can – like the legendary holy grail – cure a variety of ills and deliver a wide range of benefits. Smart storage buyers will grab that grail and fill it to the brim with revenue-creating applications.

Batteries can provide up to 13 services to three stakeholder groups



Source: The Economics of Battery Energy Storage, https://rmi.org/insights/reports/economics-battery-energy-storage/.

About the Author:

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