The ins and outs of energy storage systems

How you can make the right investment

Advisian
Worley Group

Energy storage systems make renewable energy more reliable, making them critical to the global energy transition

Resilient. Compatible. Reliable. Energy storage is hailed as an important solution to facilitate the energy transition, help organizations overcome costly power bills, and provide a reliable source of power. As the costs of energy storage — especially batteries — continue to fall, they can help organizations use renewable resources on demand, smooth the intermittent volatility of renewable energy, reduce electricity demand charges, offer a substitute for costly peak power rates, and ensure operational resilience.

One of the most popular types of energy storage are battery energy storage systems — electrochemical rechargeable systems that store energy that's generated onsite. This could be natural gas-fired or solar energy, or energy from the main power grid.

Battery energy storage systems add significant value to an organization's operational reliability, particularly when paired with renewable energy. They also provide resilience by providing black-start, back-up power on demand, and can serve as a revenue stream.

Depending on a battery energy storage system's design and operational algorithms, organizations can optimize their operations for battery energy use by tracking and analyzing renewable production, history and patterns of the system's power use, utility rate structures and weather patterns.

Making the right investment choice means understanding what storage solution and operating model is right for your organization.

Types of energy storage

1

Mechanical

Pumped hydro, flywheels, and compressed air storage systems

2

Electrochemical

Lithium ion, lead-acid, flow batteries, metal-air, and sodium-based

3

Electrical

Superconducting magnetic energy storage

4

Chemical

Hydrogen fuel cells

5

Thermal

Heat or cold storage

Consider how your energy storage system will be used

Energy storage is used for a variety of services. From management and ancillary services to power reliability and infrastructure services for the larger grid. However, the most common uses in a commercial or industrial setting are power reliability, demand charge and peak power price avoidance, and streamlining the production of onsite renewable power.

1. **Management**

   Time shifting energy use, peak-shaving and demand charge management.

2. **Ancillary**

   Frequency regulation, supplementing spinning reserve, voltage support and black start capabilities.

3. **Reliability**

   Power quality and reliability through guaranteed backup power on demand.

4. **Infrastructure**

   Non-wires alternatives to provide transmission or distribution relief. This is typically a utility application.

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Identify the best energy storage solution

For the last decade, the energy storage market has been dominated by lithium ion (Li-ion) solutions. However, there are several energy storage solutions to consider when identifying the best option for your organization. Li-ion batteries, flywheel energy storage, flow batteries and sodium-based batteries are the most commercially viable, near-term technologies[1] in the power storage market[2] according to multi-year market analysis.

Li-ion batteries are used for energy management, ancillary services to maintain power stability, and renewables smoothing. They're the most prevalent and mature technology in the industry for applications ranging from one kilowatt to 100 megawatts.

Global market research by the Asian Development Bank ranked Li-ion batteries as the preferred storage system for energy density, round trip efficiency (95 per cent for Li-Ion), eco-friendliness, low maintenance, and lifespan.[3] This is why they're a clear industry leader for commercial and industrial applications.

However, as with all technologies, there are disadvantages, too. Battery life is affected by the number of cycles, depth of discharge and shelf life due to electrolyte breakdown. They also need protection, such as a Conex box or shipping container, to prevent thermal runaway. Improvements are constantly being made to increase their lifespan, energy density, and the number of cycles they can provide.[4]

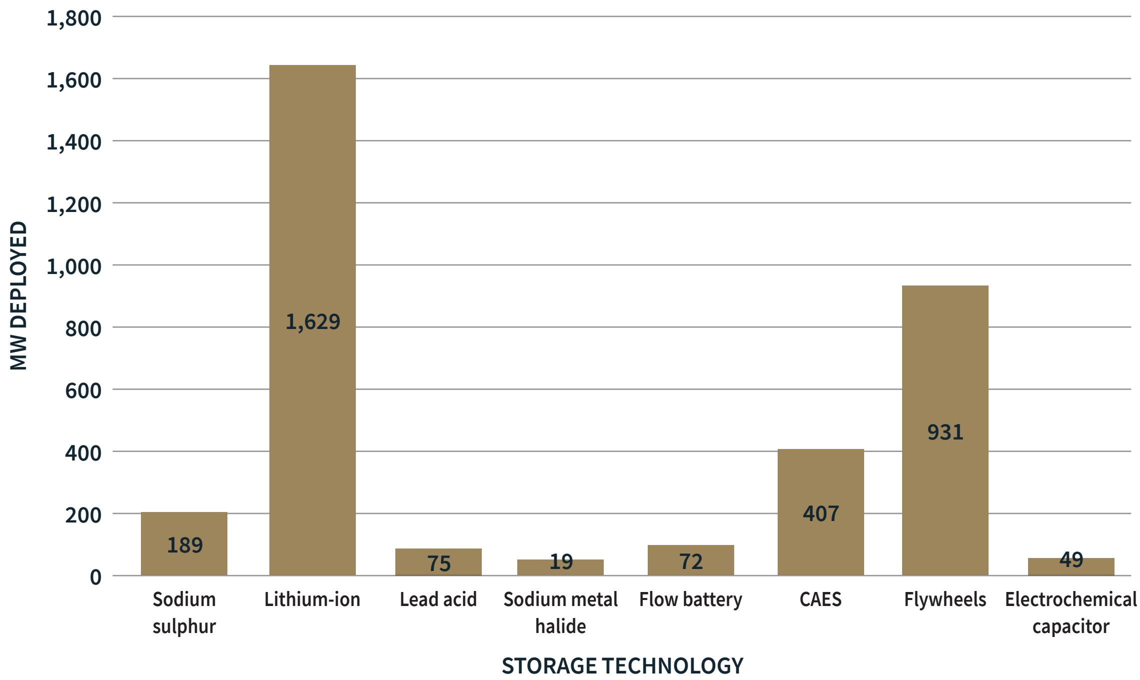
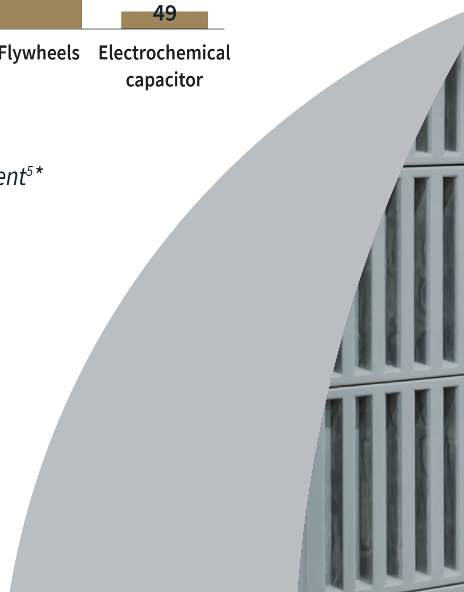


*Figure 1 - Energy storage technology trends by global deployment[5]**

**Thermal energy storage is widely deployed, but not captured here because it's not typically measured in megawatts.*

[1] Pumped storage hydro is the most common type of storage but very locational and space specific we did not include them in our analysis
[2] PNNL 2019. "Energy Storage Technology and Cost Characterization Report."
[3] ADB. 2018. "Handbook on Battery Energy Storage System".
[4] PNNL 2019
[5] PNNL 2019



Flywheel energy storage is the second most common energy storage solution. Powered through rotational energy — not battery based energy — they're commonly used with other generation assets such as natural gas-fired generation to provide a power source that can't be interrupted when operation integrity is needed. For example, central utility plant reliability.

Flow batteries are large and heavy. They're only used for stationary, low cycle, long duration (i.e. six-plus hours) energy applications such as power reliability and resilience to support critical or remote operations. They're best suited for utilities or transport such as rail and have relatively high operating costs.

Sodium-based batteries are high energy density, high efficiency batteries used mostly for large-scale storage for renewable energy. They have a relatively short lifecycle, high annual operating costs and high operating temperatures (300°C-350°C), making them rare.

Determine the right battery size

If selecting a battery energy storage system for your organization, how it will be used must be considered to determine the right size. To evaluate this, the industry typically examines the battery's power rating, energy rating, depth of discharge, and anticipated use profile.

Power rating is measured in kilowatts and is the amount of power that can flow in or out of the battery in an instant — like capacity for solar photovoltaic. A higher power rating is desirable for high charge/discharge uses such as frequency regulation.

Energy rating is measured in kilowatt-hours and is indicative of how much energy can be stored — or, how much electricity can be delivered over the course of an hour. A higher energy rating is best for long periods of discharge such as backup power or peak shifting.

When evaluating the energy rating, consider how long your operations need energy resilience or reliability support. This can be simplified using the following equation: the amount of energy storage you need (i.e. kilowatt hours per day) multiplied by your operational needs (i.e. the duration in days or hours of power needed). This equals the total kilowatt hours per day of storage needed.

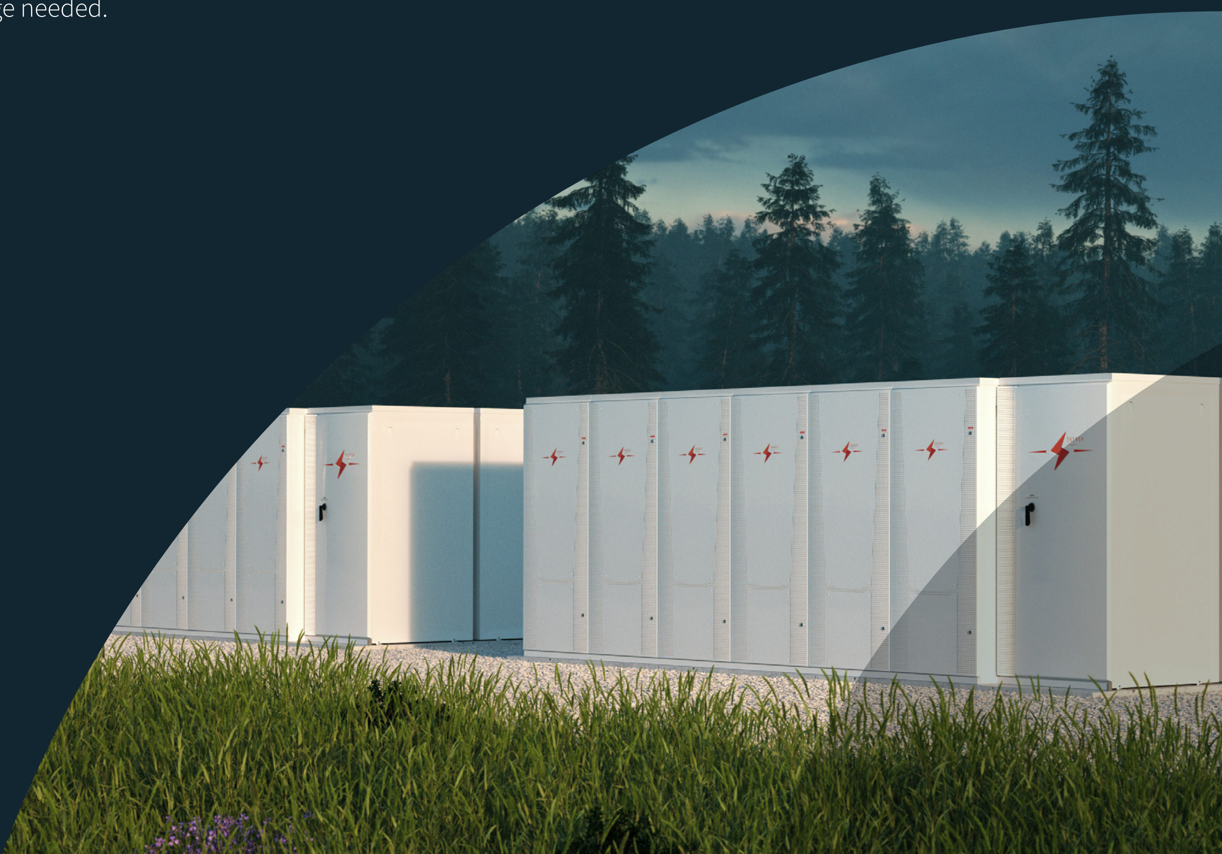
Depth of discharge is the amount of energy that's moved out of the battery on a cycle of charge and discharge. It is shown as a percentage of the battery's total energy rating.

As a rule of thumb, the minimum state of charge for Li-ion batteries is 20 per cent. A battery's cycle life is the number of complete charge and discharge cycles that the battery can perform before its capacity falls below 80 per cent of its initial value.

Anticipated use profile is the number of charge and discharge cycles that have the largest impact on the battery's life. Batteries that are cycled frequently and have a high depth of discharge, will need replacement earlier because they have shorter lifespans. Typical lifespans are 20-25 years.

If used for peak shaving and energy arbitrage, energy degradation is consistent and predictable. However, renewable energy smoothing can be volatile as it depends on the weather and needs rapid ramp rates.

To ensure your battery investment is the right choice, it is important that you have resources and expertise in energy storage system modeling and optimization to determine the best solution for your operation.



[6] Electropaedia 2020

Take advantage of multiple revenue streams

Li-ion batteries are still expensive, even though their prices continue to fall. According to *Lazard's levelized cost of storage analysis*, the capital equipment costs (i.e. not total installed cost) for a 1MW/4 MWh Li-ion battery energy storage system is between US$223 and US$323 per kilowatt hour. This equals to a total installed project cost ranging from US$775 per kilowatt hour and up.[7] However, battery equipment costs — the largest component of a battery energy storage system — are expected to decrease to an average around US$189 per kilowatt hour by 2025.

Many organizations who own a battery energy storage system often look for other ways to recoup the cost of their batteries through multiple revenue streams such as demand response and peak shaving. This is called value stacking.

The challenge with value stacking is that these revenue streams often call for competing operational viewpoints. For example, to participate in a utility or an independent system operator demand response program, the energy storage system must be available on demand. This means that it can't be leveraged or discharged for other purposes when needed for a demand response event or if the payments associated with these programs are forfeited.

The size of the battery, however, will depend on its intended use. That's why the primary use of the battery must be to the benefit of your organization. Whether that is as insurance against a grid outage or for utility services associated with resource adequacy.

[7] Lazard's Levelized Cost of Storage Analysis – Version 4.0, 2018. URL: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf

Making the right investment choice

There are many things to consider when adding an energy storage solution to your operation. Flywheels are a reliable power source that can't be interrupted. Whereas Li-ion battery energy storage systems are the most economical solution.

Understanding the main purpose of the energy storage system and determining the size needed to support your organization efficiently will ensure that you make the right investment choice.

How Advisian can help

Backed by Worley's 48,000 engineering and project delivery experts, we have the experience, best practices and expertise to help you implement your next battery energy storage system. From technology analysis and business model development to engineering design and procurement, construction and commissioning of small to utility scale systems.

We recently completed the feasibility analysis, consulting, conceptual engineering and permitting support for the installation of eight Li-ion battery energy storage systems in commercial buildings across several cities in the US.

This included five in New York City, two in San Francisco and one in Los Angeles. The battery energy storage systems ranged from 100 to 200 kW for two to four-hour durations. We identified battery energy storage systems sizes that were economically and technically feasible, performed site walkdowns, developed conceptual layouts and one-line diagrams and developed project planning schedules.

We also developed permitting process reports, including key relationships with city agencies, utilities and certification planners to ensure successful permitting, interconnection and implementation in accordance with fire and safety codes and with the client's accelerated timeline for deployment.

ENERGY STORAGE PROJECTS

75+

BATTERY ENERGY STORAGE SYSTEM PROJECTS

35

LARGEST BATTERY ENERGY STORAGE SYSTEM PROJECT

30MW

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