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EXECUTIVE SUMMARY

Supporting Global Megatrends with Energy Storage

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KEY TAKEAWAYS

- Global energy megatrends impact energy storage applications.
- Battery energy storage systems are increasingly coupled with renewable assets.
- Five key energy storage applications capture multiple value propositions.
- ABB offers a range of energy storage systems to address every customer's needs.

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Supporting Global Megatrends with Energy Storage

OVERVIEW

Global megatrends in the energy industry are shifting towards decarbonization, decentralization, and digitalization, leading to increases in renewable generation, new loads from electric vehicles, and an array of distributed assets along the distribution grid.

To support these trends, energy storage solutions (ESS) will be a critical component within the grid of the future. ABB energy storage solutions offer flexibility and reliability to maintain consistent energy supply, reduce energy costs, and meet energy needs of today and into the future.

CONTEXT

Alexandra Goodson discussed global energy megatrends and how they impact energy storage applications. She then shared information on ABB's energy storage systems and energy management system.

KEY TAKEAWAYS

Global energy megatrends impact energy storage applications.

Global megatrends across different industries and segments create needs that energy storage innovations can help fulfill. Three important energy megatrends are:

1. **Decentralization.** Traditional, centralized power generation with long transmission lines that feed load centers located far from a generation site is shifting to decentralized generation, including rooftop solar facilities and other renewable assets located along lines and transmission distribution co-located with some loads. This is driving a push for microgrids and even the ability to disconnect the grid for cybersecurity and/or resiliency. Decentralization also enables a market for demand response programs and ancillary services.
2. **Decarbonization.** The goal to limit global warming and reduce carbon footprint is spurring an increase in renewable generation and decreased dependency on generation through fossil fuels. Decarbonization also includes adoption of electric vehicles, vehicle-to-grid smart charging, and clean assets coming onto the grid to replace the fossil-fuel burning assets.
3. **Digitization.** Decentralization and decarbonization efforts require digital connection to work. Network technologies such as smart meters, remote controls, and cloud management are needed to handle assets behind the meter and assist utilities in accessing information to make decisions, but in a secure way using appropriate cybersecurity protocols.

These three trends come into play across the different applications within energy storage.

> To have all three trends work well together and be successful, we have to have an asset that gives dispatch ability, can support ancillary services and frequency response, and integrates non-dispatchable assets like renewables and helps them support the loads. [ABB's] flexible products help all of these applications.
>
> *Alexandra Goodson, ABB*

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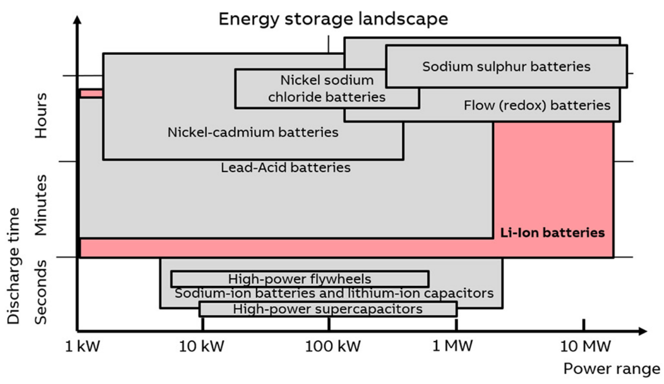
Battery energy storage systems are increasingly coupled with renewable assets.

BESS (battery energy storage system) is a generic name for any equipment that stores energy in batteries and uses or discharges energy later when it is advantageous. Renewable assets are increasingly being coupled with a BESS, whether a large-scale requirement or to support smaller loads with rooftop solar or EV chargers. Often, renewable energy sources are combined with a BESS to store the renewable energy during peak production time and then the energy is used when it is needed.

Batteries are not the only type of energy storage medium; determining an optimal energy storage technology for a given application is based on both the power range required and duration of discharge. However, energy storage for renewable assets is heavily trending toward batteries.

Lithium-ion is a highly versatile, proven technology family of batteries with many chemistries, offering benefits such as higher energy density and power efficiency, superior cycle life, and longer calendar life. This technology is therefore particularly interesting for energy storage solutions.

Figure 1: The energy storage landscape



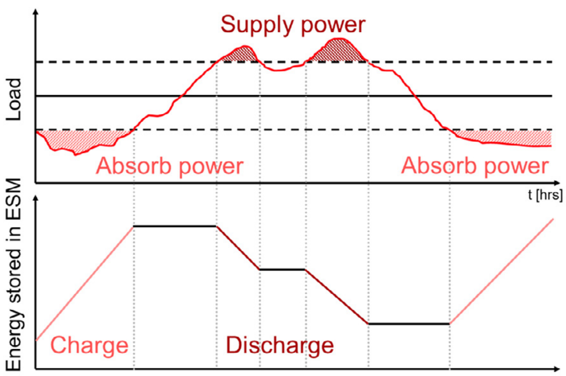
Five key energy storage applications capture multiple value propositions.

There are multiple value propositions that an energy storage solution can address via five core applications: energy shifting; peak shaving; frequency regulation, reserve, and response; capacity firming; and spinning reserve.

1. Energy shifting involves storing electricity in the energy storage system for use at a later, pre-specified time. This bulk energy can be discharged during periods of high demand on the grid, whether by high pricing to sell energy back onto the market or charging in periods of lower-cost energy and then using that energy during higher-cost periods to support load. This is a common potential application for C&I customers to arbitrage electricity rates.

   Coupling energy shifting with a renewable, such as rooftop solar or a co-located solar site, allows leveraging of time-of-day pricing. It can also optimize electricity consumption and defer investment for grid upgrades in cases where existing infrastructure may not be able to support long charging periods, such as EV roadside charging. In these cases, energy can be shifted overnight to use during the day to supplement the grid power.

Figure 2: Using energy shifting to reduce cost and maintain grid performance



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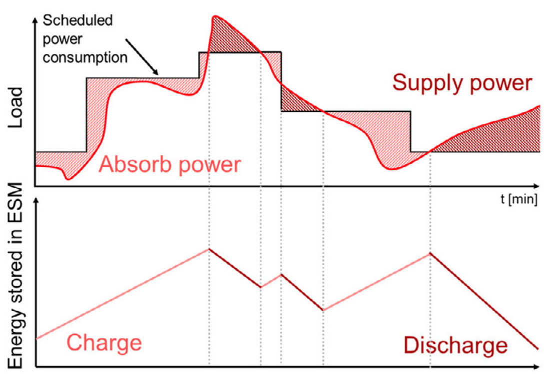
2. **Peak shaving** is similar to energy shifting, but the main driver is to reduce peak demand to ultimately reduce the electricity bill or make operations more economical. Peak shaving is typically applied when the energy storage system is owned by the electricity consumer, rather than by the utility. The goal is to avoid demand charges (power fees) and the installation of capacity to supply the peaks of a highly variable load.

   As with energy shifting, peak shaving reduces electricity bills and helps defer grid upgrades. Peak shaving using an energy storage system can be applied to EV charging, as well, especially when using a high-power charger.

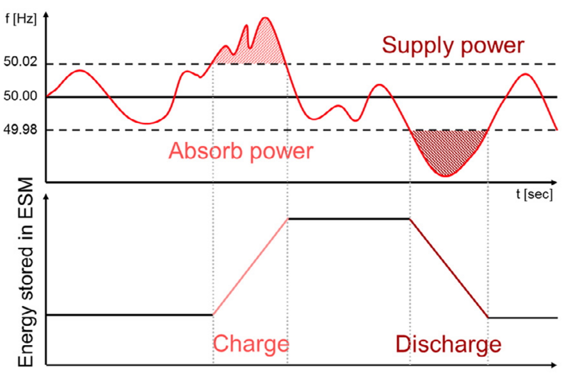
Figure 3: Peak shaving pre-schedules energy management activity based on tariff structure



3. **Frequency regulation, reserve, and response** is when the energy storage system is charged or discharged in response to the frequency on the grid, such as when maintaining a frequency within a certain dead band or following a signal-driving frequency. This approach to frequency regulation (fast frequency response) is a particularly attractive option due to its rapid response time and emission-free operation and can be used to support existing generation assets or as an ancillary service.

   For example, solar farm installation regulations might require the frequency at point of interconnection to be within a predefined dead band, leading to solar developers installing energy storage systems that would drop frequency quickly and temporarily at the point of interconnection, in the event of passing weather conditions such as a dark cloud moving over the panels.

Figure 4: Frequency regulation, reserve, and response offers charging and discharging in small cycles



4. As generation decentralizes and the industry shifts to renewable assets that produce intermittent energy, electricity generation can be turned up or down and dispatched by a grid operator. **Capacity firming** allows the variable, intermittent power output from a renewable power plant, such as wind or solar, to be maintained at a committed level for a period of time.

   Digitization plays an important role. Using built-in parameters, the energy storage system smooths out the power, so the grid sees consistent rather than intermittent energy, making it easier to manage.

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Figure 5: Capacity firming uses built-in parameters to smooth the power supply

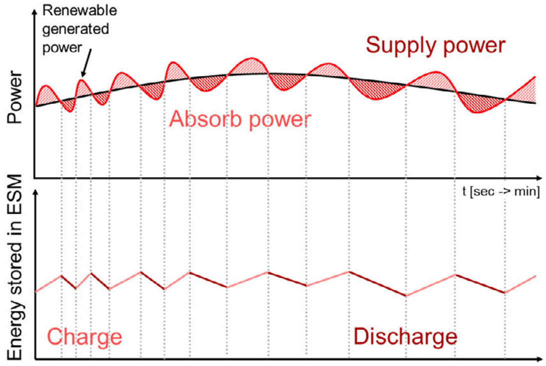
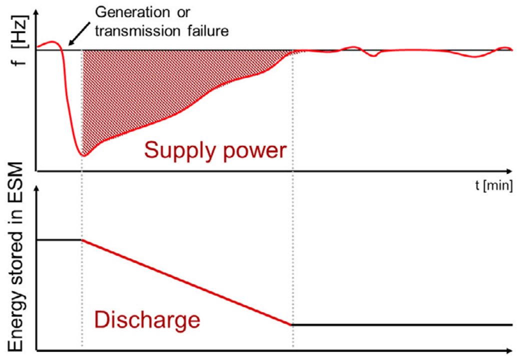


Figure 6: Spinning reserve reduces cost and emissions



5. In a spinning reserve application, energy storage systems can respond within milliseconds and supply power to maintain network continuity, while the back-up generator is started and brought online. This enables generators to work at optimum power output, without the need to keep idle capacity for spinning reserves. This eliminates the need to have back-up generators running idle. To provide effective spinning reserve, the energy storage is maintained at a level of charge ready to respond to a power failure. Often, cost and CO2 emission savings are easy to quantify in cases where spinning reserve is applied.

   Spinning reserve is a reliable first step in displacing diesel generators. While working groups are re-searching long-duration storage technology, ABB currently recommends against replacing a full diesel generator or system with an energy storage sys-tem. Complete diesel generator replacement is possible from an energy supply standpoint, but not economical.

ABB offers a range of energy storage systems to address every customer's needs.

ABB offers different levels of energy storage systems based on customer-specific controls and intelligence requirements: the smaller eStorage Flex, the higher-capacity eStorage Max, and the eStorage OS energy management system. Depending on the needed C-rate and how the system will be used, the ultimate sizing will vary, but every solution is lithium-ion battery based, scalable, and includes critical fire detection and suppression.

ABB recommends designing safety systems to not only meet insurance providers' requirements, but to achieve minimal impact of a potential thermal runaway, especially in reaching other battery cells. Preventing propagation lowers the impact of a thermal runaway.

ABB eStorage Flex units are smaller capacity systems that are pre-wired, pre-tested, and AC-coupled, offered in three different sizes: Flex-10, Flex-20, and Flex-40.

In Europe, ChargePoint Operators (CPOs) generate revenue from charging EV vehicles, motivating CPOs to install EV chargers as quickly as possible. Because many charge locations are fairly remote, existing grid infrastructure at the location may only be a low-voltage

Figure 7: Core components of every ABB energy storage system

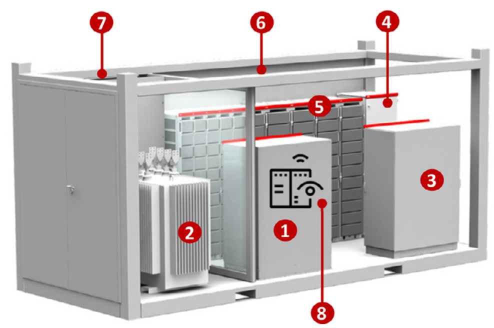
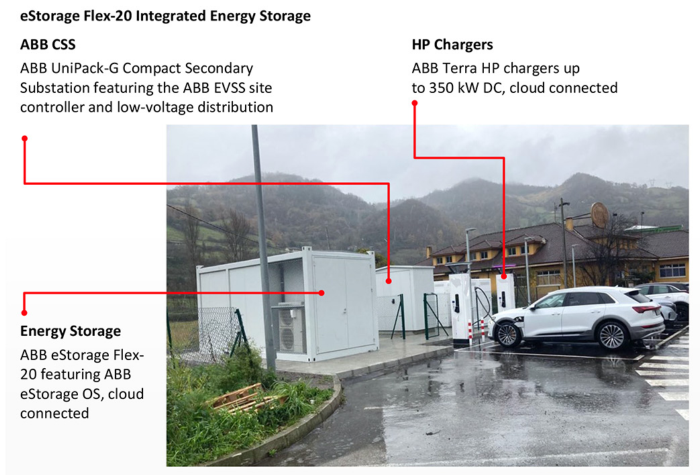


Figure 8: eStorage Flex-20 Integrate Energy Storage



connection, limiting the power that can be pulled and provided through a high-power charger. To address this problem, ABB installed a Flex-20 solution with approximately 500 kilowatt hours (Kwh) of energy, using the capacity provided by the solution to peak shave.

Due to grid limitations, a set power threshold could not be exceeded, so on-site controls were applied to monitor power pulled from the grid, discharging to supplement energy when the threshold was approached. In addition, the energy storage systems formed the grid, using the inverter to create synthetic inertia to set the frequency and voltage for that "mini microgrid." This allowed the chargers to continue charging vehicles in the event of a grid outage by using capacity in the energy storage system, further supporting the CPO in generating revenue quickly, for as long as possible.

ABB **eStorage Max** applications are typically composed of multiple feeders (one feeder being a transformer and all equipment behind it, including batteries and inverters). Typically there are duplicate feeders to meet power and energy requirements.

ABB provided frequency regulation to the grid in a 20 megawatt hour (Mwh) project. While the project's full scope was 200 Mwh, the operator wanted to locate different 20 Mwh sites throughout the country. Each of six feeders includes battery containers, coupled with the inverter and protection, then the transformer. When determining power and energy requirements for an energy storage system, measuring on the installed capacity side, the high side of the transformer, or other location is one factor in understanding system sizing.

ABB **eStorage OS** is an energy management system that can be applied in four variations:

- Variant 1, Fieldbus connectivity with integrated monitoring and protection for external control.
- Variant 2, On-premise energy management system with integrated HMI and smart algorithms for optimal performance.
- Variant 3, On-premise energy management system with advanced cloud connectivity and microgrid possibilities
- Variant 4, Combining eStorage OS variants produces a microgrid controller to manage all different distributed generation and load assets.

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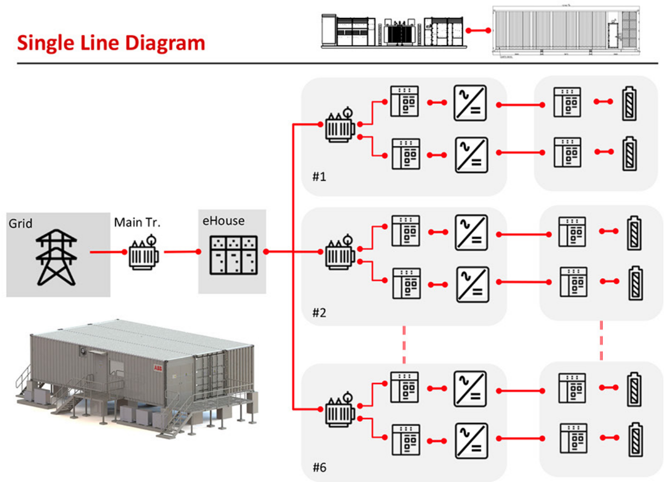
Figure 9: An ABB 20 Mwh eStorage Max project



BOM

- Modular design to meet the customer requirement
- Pre-engineered solution reduce engineering time

ESM	Block type (Skid + eHouse 40ft)
Application	Frequency Regulation
Power	20MW at POI (grid connection point)
Energy	20MWh, 1C at POI
Dist. Transformer	3 winding, 13.8/0.69kV, 4.5MVA
Main Transformer	13.8/230kV, 27MVA
Grid connection Voltage	230kV
HVAC	20RT
Fire Fighting	NOVEC

Figure 10: A microgrid controller configuration using eStorage OS

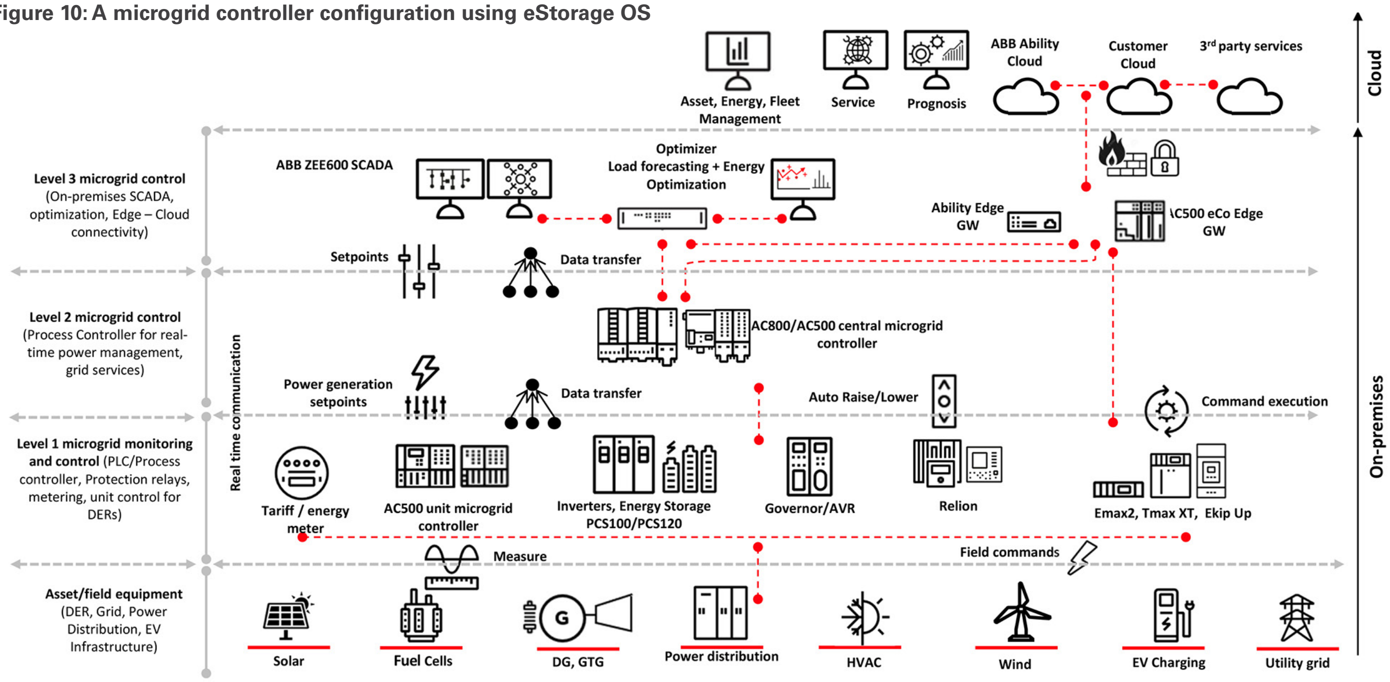


ABB. To learn more, visit https://new.abb.com/low-voltage/industries/energy-storage-systems

BIOGRAPHY

Alexandra Goodson

Global Product Marketing Manager, ABB

Alex Goodson began her career at ABB quoting medium voltage transformers. She later transitioned into the energy storage market and worked for a battery manufacturer and ESS integrator. She returned to ABB in 2020 to support the Energy Storage Solutions global product group as a global product marketing manager. She has over 10 years of experience with energy storage. Alex graduated from Missouri University of Science and Technology in Industrial Engineering. She works from her home office in Jacksonville, Florida.