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Understanding BESS: Battery Energy Storage Systems for Data Centers

White Paper 185

Version 1

Energy Management Research Center

By Patrick Donovan

Executive summary

Data center owners aspire to maintain resiliency, mitigate energy costs, be sustainable, monetize underutilized assets, and reduce reliance on diesel generators. This creates valid use cases for the adoption of battery energy storage systems (BESS). In this paper we define what a BESS is, describe trends driving adoption, and explain its components, functions, use cases, and architecture considerations. We also provide guidance on what conditions most favor adopting Li-ion BESS for data center use.

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Introduction

The data center industry largely relies on double-conversion online uninterruptable power supplies (UPSs) and diesel generators to maintain operations when the utility grid becomes unavailable or unstable. Today's high efficiency UPSs with lead-acid or lithium-ion batteries maintain critical IT loads without interruption. They run long enough (5-15 minutes typically) for backup generators to start up and take over the load. However, today, data center owners are presented with market and technology trends that supports adding a different type of battery system to the data center power infrastructure, in addition to their existing UPSs. These are called battery energy storage systems, or BESS. Note, a BESS is not a UPS. They are each designed for different applications.

A BESS is an electrochemical device that stores energy from the utility grid and/or renewable energy sources, and supplies energy either back to the grid or to a load depending on financial, sustainability, and/or resiliency requirements. BESS are distributed energy resources (DERs)[1]. These bi-directional, long-run energy storage systems can provide data centers with five key outcomes:

- Additional backup power and greater independence from the grid
- Decreased reliance on, or elimination of the need for, diesel generators
- Reserve market participation (grid services)
- Demand charge avoidance and time-of-use/tariff management
- Increased use of renewables

These can provide resiliency, environmental sustainability, and energy cost reduction benefits. And these make BESS a technology worth considering for many data centers. The return on investment (ROI) in deploying a BESS, however, is highly dependent on the specific use case(s), load profile, local market conditions and other factors. BESS vendors will run models using your specific inputs and use cases to help you understand the likely financial payback or ROI.

The purpose of this paper is to:

- briefly explain market and technology trends driving general BESS adoption.
- describe BESS types, components, and services they provide.
- explain basic BESS architecture considerations.
- provide guidance on what conditions most favor adopting Li-ion BESS for data center use.

Note, there are different types of BESS. In this paper, we are specifically talking about lithium-ion (li-ion) BESS installed "behind-the-meter" (BTM) at data center sites, as compared to the often-larger grid-scale systems dedicated to supporting utility grid operations.

Five market and technology trends fueling BESS adoption

Battery energy storage systems have been commercially available for a few decades. However, cost and technology constraints limited their use early on to a few niche applications (e.g., remote power for military applications). Current market and technology trends, however, have led to strong market growth. Globally, the overall BESS market (i.e., all sizes and types) surpassed $19 billion USD in 2022[2] and is

[1] "Distributed energy resources (DERs) are small-scale energy resources usually situated near sites of electricity use, such as rooftop solar panels and battery storage." – International Energy Agency

[2] https://www.grandviewresearch.com/industry-analysis/energy-storage-systems-market

forecasted to have a global CAGR of 23% between 2023 and 2032[3]. The following is a brief description of five market and technology trends fueling BESS adoption.

Increasing renewable energy penetration

The push to move away from fossil fuels is driving vast deployments of solar and wind energy globally. Their intermittent supply and low inertia, however, creates grid stability challenges for grid operators. BESS can be used to help balance supply and demand, stabilize frequency, and store surplus renewable energy for use later[4] thereby helping to stabilize the larger grid and improve energy utilization. The increasing need for this capability is resulting in markets (e.g., grid services) and other incentives (e.g., peak shaving) to help pay for and monetize BESS as an asset both BTM and in-front-of-the-meter. At a facility level, storing generated electricity on-site for later use is often more lucrative than selling to the grid at that moment; this applies both to BTM applications and utility scale PV plus storage projects.

Rising energy prices and supply constraints

Volatile energy costs and utility supply[5,6] create uncertainty for facility operators. BTM BESS can offer increased energy independence and energy bill cost savings by allowing users to store energy when prices are low and use it when utility prices are high. Stored energy can also be used to peak shave to avoid costly demand charges that can lower energy bills significantly. Depending on the rate structure and load profile, these demand charges can represent a significant percentage of your energy bill. Additionally, the utility may be constrained and unable to meet the peak needs of the facility. In this case BESS can provide the additional power required during peak times. Often sized for the whole site or, at least for critical loads, BESS energy can be used when grid supply is unstable.

Government policy and incentives; public pressure

The need to move away from fossil fuels combined with the need to optimize and stabilize the growing supply of renewable energy has many governments implementing policies and incentives to encourage the adoption of BTM BESS, through tax credits, net metering programs, and time-of-use (TOU) rate structures. Taking advantage of these opportunities can have a significant positive impact on the ROI of BESS. So, understanding available incentives and their terms and conditions is important when evaluating whether to adopt BESS.

This drive for sustainability includes efforts to reduce air and noise pollution. These efforts have led to permitting challenges and other operational limitations for those data centers trying to deploy and use diesel generators. In one case, persistent objections and protests by the public caused one large data center owner to adopt BESS instead of diesel gensets in one location in order to move forward with new construction[7].

Battery Technology Advancements

Early BESS systems used older lead-acid type batteries. Driven initially by the pc laptop industry and then by the EV and BESS industry itself, lithium-ion batteries have become the optimal technology choice for energy storage systems. Compared to traditional lead-acid, li-ion has much higher energy density, longer lifespans, higher cycle life, and are better optimized for multi-hour runtimes.

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[3] https://www.grandviewresearch.com/press-release/global-lithium-ion-battery-market

[4] Note, given high energy use intensity of data centers relative to available space for Solar PV, there may not be excess renewable energy for export for BTM BESS use cases.

[5] https://www.forbes.com/sites/miltonezrati/2023/03/24/americas-electric-grid-is-weakening/

[6] https://www.wsj.com/articles/americas-power-grid-is-increasingly-unreliable-11645196772

[7] https://www.datacenterdynamics.com/en/news/microsoft-replaces-diesels-with-battery-system-at-swedish-data-center/

Specifically, lithium iron phosphate (LFP) and lithium nickel manganese cobalt oxide (NMC) batteries, offer the best combination of safety, cost, cycle life, and energy density and, are the most used battery chemistries today in BESS. Their attributes are well suited for the applications BESS are intended for.

Declining costs

The cost of BESS components has been in decline due to increasing production as well as improved design and manufacturing. As a result, they have become a more attractive investment for data center owners. This trend is expected to continue as production scales up further and as both manufacturing and battery recycling processes improve. As an example, one kWh of lithium-ion battery pack cost $7500 in 1991. In 2024 that same stored energy only cost $133 and is expected, by some, to eventually reach $80 per kWh by 2030[8]. Note, these costs are for a single battery pack only. As explained later in the paper, a BESS is a complex system composed of many components and sub-systems.

Other facilitating factors

Many of the same market trends above have also led to the parallel growth and development of smart grid and microgrid markets and technologies that further fuel the adoption of BESS.

Smart grid integration technologies

The software and control systems needed to effectively manage BTM BESS and to make them grid-interactive exists today from various vendors as mature offers. This is a key enabler for grid services and demand response program participation. Without this, the BESS would be limited to supplying energy to onsite loads only.

Microgrid proliferation

In response to the desire for greater independence from the utility grid and for reducing reliance on fossil fuels, microgrids using onsite solar or wind are proliferating. BTM BESS play an important role in microgrid deployments by increasing self-consumption of the microgrid's onsite renewables and helping reduce costs through grid services and participation in reserve markets. They also can be used as a stable grid-forming[9] source and for black-start capabilities[10] when the utility power is lost.

Mature safety regulatory environment

As both the BESS and microgrid markets have grown and matured, a host of safety standards and certifications are now in place to help reduce risk and ensure safe operations. This includes certifications covering the batteries (e.g., UL1642, UL1973, UL9540), power conversion systems (e.g., UL1741), interactions with the utility grid, and general electromagnetic compatibility and harmonics. The National Fire Protection Agency (NFPA) 855 is a standard for the safe installation of stationary energy storage systems. In addition to electrical and fire safety standards, (IEC 62933-5-2, for example) standards bodies also cover BESS performance testing requirements (e.g., IEC 62934) and environmental considerations (e.g., IEC 62936).

[8] https://www.automotivedive.com/news/lithium-ion-battery-prices-record-low-production-bnef-bloomberg/701081/

[9] A "grid-forming source" refers to the role of maintaining the voltage and frequency of the local electricity grid, independent of the main grid, typically within a microgrid. This means the BESS acts like a mini power plant, ensuring stable and reliable power supply even if the main grid connection is lost.

[10] Black start means to restart the supply of power after the Utility grid has lost power.

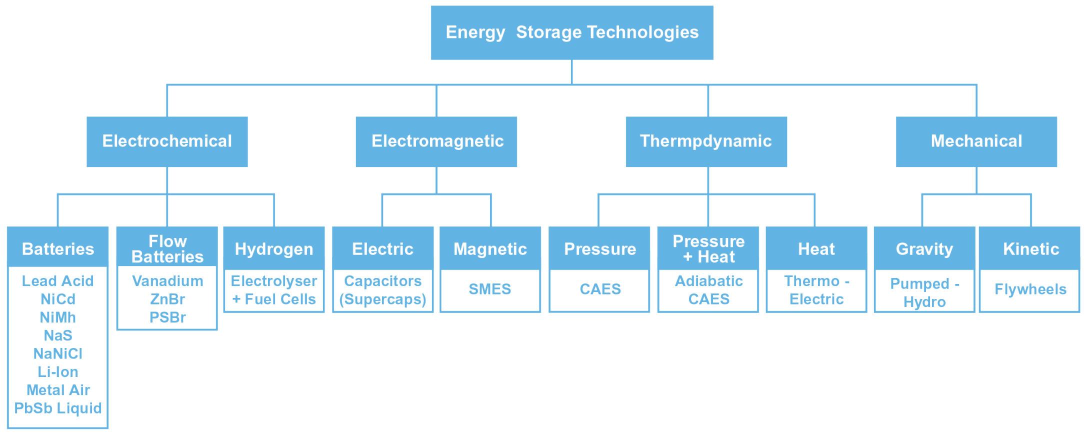
BESS types, components, services, and benefits

Types of energy storage

Figure 1 shows the various types of energy storage technologies[11]. Energy storage refers to the capture of energy produced at one time for use later to reduce imbalances between energy demand and energy production. BESS is one form of the electrochemical type of energy storage system. This paper focuses on lithium-ion battery energy storage systems. They are the dominant type used behind-the-meter at data center and other industrial sites. The other electrochemical types, flow batteries and hydrogen, are discussed to varying degrees along with BESS in Schneider Electric White Paper 14, *The Reality of Replacing Diesel Generators with Natural Gas, Energy Storage, Fuel Cells & Other Options*.

Figure 1

Shows a taxonomy of energy storage technologies; this paper focuses on the "batteries" type, specifically, lithium-ion as it is the dominant choice in the market today given its better combination of performance on safety, energy density, cycle life, and lifespan.



A further way to categorize a BESS system is where it is sited[12] (Figure 2). In general, BESS can be installed at three different levels within the utility grid: transmission, distribution, or behind-the-meter (BTM). BESS systems installed at the transmission and distribution levels tend to be very large (ie, multi-megawatts to hundreds of megawatts) and are owned and operated by the utility or larger independent power producers (IPPs) for the purpose of balancing and serving the larger utility grid. BTM BESS range from a few kilowatts to many megawatts of power capacity. They are owned and operated typically by the site owner and provide direct benefits both to the larger grid and to the site owner.

Figure 2

BESS can be further categorized based on where they are installed within the utility grid: transmission, distribution, or behind-the-meter.

BESS components and management systems

A behind-the-meter BESS for data centers (see Figure 3) is cement pad-mounted outside and typically includes the following major components installed either in cabinets or an ISO container depending on size:

- Batteries: BESS typically includes large-format lithium-ion battery packs to store electrical energy. As noted above, these are usually LFP or NMC chemistries with a discharge rate of 0.5 (i.e., 2 hrs.) to 1C (i.e., 1 hr.). The system

[11] https://www.sciencedirect.com/science/article/pii/S2352484720312464

[12] https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf

also includes the battery management system (BMS) to manage charging and discharging properly and safely.

- Power conversion system (PCS): The PCS refers to all the components responsible for converting electrical power between the battery system, grid/renewables, and the loads. This includes a bi-directional inverter that converts DC energy stored in the batteries to AC power for both the grid and loads. There is also an internal control system (i.e., firmware) that monitors the battery state, grid conditions, user commands, etc., to manage and direct operations inside the unit.
- Cooling and ventilation: Cooling and ventilation systems are essential to maintain optimal operating temperatures for the batteries in the BESS.
- Integrated fire detection and suppression system: This is typically a dry pipe sprinkler system with heat, smoke, gas sensors, and anti-deflagration systems.
- Electrical protection system: Electrical protection devices such as circuit breakers, fuses, and surge protectors are used to ensure the safety and reliability of the BESS and protect against electrical faults.
- Control and monitoring system: This system provides real-time monitoring and control of the BESS. It allows data center operators to monitor battery performance, energy flows to and from the BESS, and system status. It also enables them to adjust operational parameters, set alerts, and view historical data.
- Energy management system (EMS): The EMS is responsible for optimizing and coordinating the operation of a microgrid including the BESS, if included. It monitors overall energy usage, grid conditions, renewable energy sources, and other relevant parameters to determine the most efficient battery charging and discharging strategies for the BESS. The EMS can be programmed to prioritize energy cost savings, load balancing, backup power, or other specific objectives. The EMS may also connect to external programs such as virtual power plants (VPP).
- Integration with data center infrastructure: The BESS needs to be integrated with the data center's electrical distribution network, including the main electrical panel, distribution boards, power monitoring system, and energy management system if there's a microgrid. These integrations enable power supply and coordination between the BESS, the data center's load, and onsite renewables.

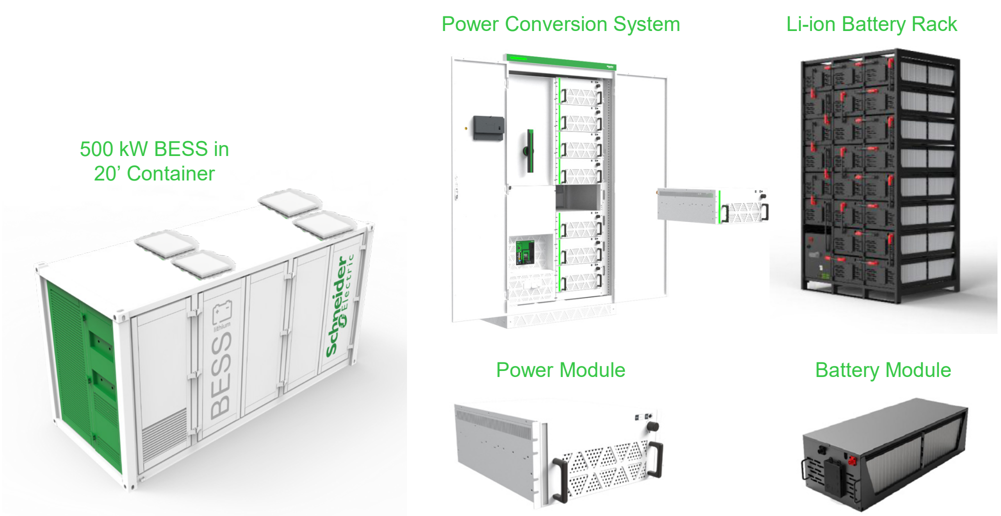


Figure 3

An example BESS from Schneider Electric showing a close-up external view of the PCS and battery packs.

BESS services

According to the Rocky Mountain Institute[13], BESS provides up to thirteen different services to three different stakeholder groups: customers (i.e., data center owners), utilities, and independent system operators/regional transmission organizations (ISOs/RTOs). BTM BESS can provide all thirteen services (Figure 4). BTM BESS services provided to utilities and ISOs/RTOs can often be monetized (for the owner) through grid services programs, participation in reserve markets, an/or indirectly through other offered incentives (e.g., incentive tax credits, net metering programs, etc.). This monetization will reduce cost of ownership and reduce your data center energy bill. The magnitude of the value generated will depend on what is offered in your location, what you have to offer in terms of load mitigation and energy storage volume, and what you are willing to participate in as the owner of the data center.

Figure 4

A list of the 13 services that BESS will provide to data center owners, ISO/RTOs, and utilities. BTM BESS can provide all 13 services. The data center owner can, therefore, potentially earn value from all 13 services either directly through grid service and reserve markets, or indirectly through financial incentives and programs.

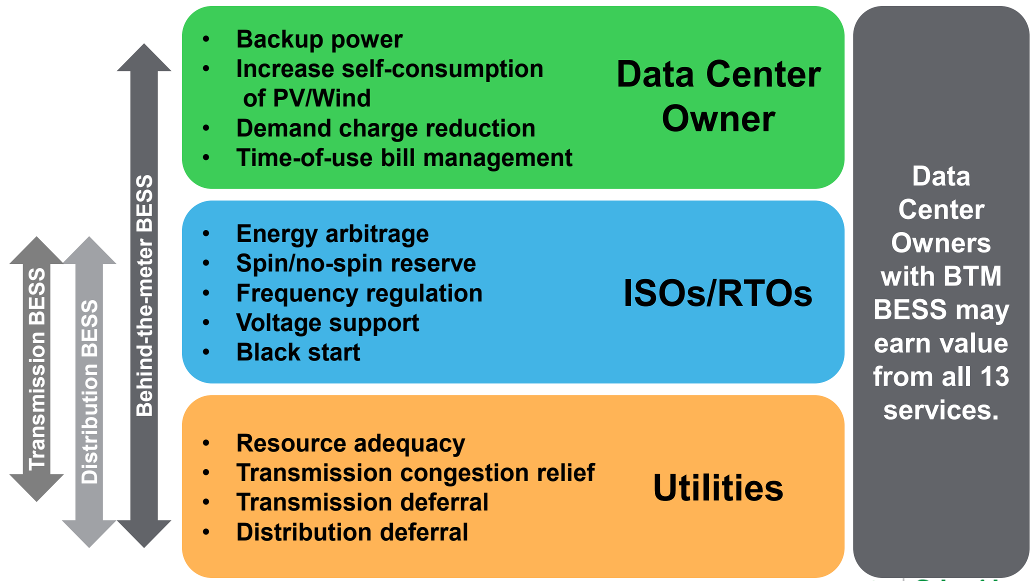


Table A1 in the Appendix at the end of this document defines each of these thirteen services. For a more detailed explanation, see this Rocky Mountain Institute report.

5 key outcomes and their benefits

The ability of a BTM BESS to offer these 13 services provide data center owners with five potential key outcomes that bring resiliency, deployment speed, sustainability, and cost benefits:

- Additional backup power and greater independence from the grid
- Decreased reliance on, or elimination of the need for, diesel generators
- Market participation (grid services)
- Demand charge avoidance and time-of-use/tariff management
- Increased use of renewables

[13] https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf

Each of these are briefly described below with examples of how the benefit is achieved.

Additional backup power and greater independence from the grid

BESS will typically add one to four (or more) hours of battery runtime to what the UPS already has (5-15 minutes in most cases). This extra battery runtime would enable the data center to remain operational for many or most instances of utility outages without needing diesel generators to startup. This would reduce the risk of a failed generator startup which is a common cause of system downtime. Note, if li-ion battery prices continue to decrease, its likely that even higher runtimes may become common.

Decreased reliance on, or elimination of the need for, diesel generators

As stated above, having one to four hours of battery runtime for the BESS along with a UPS for the IT and networking equipment means that the data center's IT operations should be able to ride through many or most utility outages that might occur without needing the generator to also start up. This not only could mean greater resiliency, but with less hours of generator use, it could also mean less Scope 1 emissions and air pollution.

For those data centers facing regulatory and public pressure over deploying generators due to environmental and noise concerns, BESS offers a potential means to replace diesel generators and remove any related permitting problems. Being able to do so can speed up deployments of new data centers. However, this may not be a feasible option depending on your ability to manage outages that go longer than the BESS runtime. When deciding whether 2 hours of backup time is sufficient vs. the traditional 24-48 hours of backup from a diesel genset, there are two key considerations: reliability of the site's electric utility and software resiliency and workload redundancy. With the right technologies and operational skill, workloads can be mirrored at other sites, or they can be moved to other locations. This could change the backup needs of the IT equipment enough that one to four hours of backup is sufficient.

Market participation (grid services)

Reserve markets are specialized electricity markets where power providers offer reserve capacity to ensure grid stability. When demand unexpectedly spikes or generation falls short, these backup resources (such as a data center BTM BESS) can be quickly activated to maintain grid balance assuming the right controls are in place. BESS owners would then be paid for this participation, thereby, offsetting data center energy bill costs. BESS could be used to help regulate frequency, provide spinning reserve[14], and provide demand response. Using a BESS for energy arbitrage[15] is also possible through participation in wholesale energy markets.

Without a BESS, data center operators have often decided that the operational risk was not worth the benefit of demand response participation since it required transferring the whole site onto generator power. With a BESS, however, this risk is eliminated since the site and its critical loads can remain grid-tied while the BESS is supplying power to the utility grid. Additionally, expanding the use of generators to grid services can increase site emissions considerably, while increasing the use of BESS for grid services has a much smaller corresponding increase in scope 2 emissions.

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[14] This refers to a specific type of backup power available to quickly respond and maintain grid stability in case of unexpected changes in demand or generation. It's crucial for ensuring reliable and consistent power delivery. BESS offers fast response and a clean energy source.

[15] BESS can be configured to charge when prices are lower and then discharge into the grid when prices are higher to make a profit.

Demand charge reduction (peak shaving) and time-of-use/tariff management

Most electric utility bills include a demand charge. It is a fee on the data center electricity bill based on the highest amount of power (in kW) the site used at any single moment during the billing period, typically measured in intervals of 15 or 30 minutes. It's separate from the energy charge, which is based on the total amount of energy you used (kilowatt-hours, kWh). Demand charges are designed to encourage more even use of energy and to help pay for infrastructure needed to supply power continuously at that peak level. By using the BESS stored energy to reduce the total load on the utility grid at the right times, these demand charges can be reduced or avoided. This is referred to as “peak shaving” or “load shifting”.

Similarly, BESS can be used for energy tariff management by consuming/producing and/or storing energy according to variable electricity tariff rates. Also referred to as “time-of-use” (TOU) management, this means you can charge the BESS during off-peak rate hours and discharge during high-peak rate hours to help lower overall data center energy bills.

How much of these outcomes and benefits are realized ultimately depends on what applications the BESS is being used for, having effective energy management software, whether there is a microgrid, what rate structures are in place, and what programs and services are available at that location. Another factor is the BESS architecture and what mode of operation it supports. The next section goes into this aspect.

Increased use of renewables

BESS can store excess renewable energy when generation exceeds demand and release it during periods of high demand or low renewable energy availability. This helps to balance the grid, reduce curtailment of renewable energy and thus increase their value, and maximize the use of clean energy resources. Without a BESS, excess renewable energy production would be sold at less lucrative prices or lost. Similarly, a BESS could be configured to charge its batteries when the utility is less carbon intensive and then discharge when the grid is more carbon intensive (e.g., at night). In these ways, a BESS can reduce overall Scope 2[16] emissions. Note, in the case of onsite renewables, it’s unlikely for there to be excess renewable energy available for export given the high energy use intensity of data centers relative to space that’s available for Solar PV.

BESS architecture considerations

This section briefly describes some aspects of BESS that affect your data center architecture and the data center’s sequence of operations between operating modes (e.g., transfer to and from backup sources).

Operating modes: grid-tie vs grid-forming

The ability for a data center site to operate with (i.e., grid-tied) and without the presence of the utility (i.e., islanded mode) is driven by both the operating modes of the electrical sub-systems (i.e. BESS inverter) as well as the electrical architecture (i.e., how the systems are coordinated and programmed to work together).

The two primary modes of the BESS inverter are grid-tied and grid-forming This latter mode is what enables a BESS to be the anchor resource and operate the data center in islanded mode. While some sites may be architected to only run when

[16] Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.

grid-tied, it is recommended that a data center **BESS be designed for both grid-tied and islanded operation to get the full value of the system.**

Grid-tie mode is when the BESS is connected to the larger utility grid and relies on it (or other source like onsite diesel generators) for maintaining its own voltage and frequency. When connected to the utility grid the BESS can take in power from the grid or onsite renewables to charge the batteries or the BESS can discharge its batteries and export that power to the site load or utility grid. In this mode, the BESS can be used in parallel with the grid for peak shaving to reduce demand charges during peak electricity use periods. This mode can also increase self-consumption of renewables by storing excess solar production, for example, in the batteries, and thereby, reduce reliance on the grid.

Islanded operation means that the site is operating without the utility and using the BESS as an "anchor" resource to form its own grid. This requires a BESS that uses a voltage source inverter (VSI). A VSI can generate and actively control the voltage and frequency within the BESS or larger microgrid. This is necessary for microgrid operations and for "islanding" operation. As noted above, using a BESS in this way can reduce dependence or potentially eliminate the need for diesel generators. Islanded operation requires more complex control schemes, so it is important to work with a vendor who has expertise and experience with operating microgrids with BESS.

BESS inverters are not as tolerant of inrush currents (i.e., large, instantaneous current drawn by loads on startup) as traditional backup generators. Using the BESS as an anchor resource requires understanding the specific loads to identify conditions that might cause an overload and shutdown the BESS. Having a qualified vendor perform a detailed site characterization and loading analysis, will validate proper BESS sizing, as well as determining the right islanding sequence of operations.

BTM BESS vs. UPS

Although BESS and UPS both have batteries, inverters, and can supply power to the loads in the event of a utility outage, they are not the same. They are each designed for different applications. UPSs are designed to provide a large amount of **uninterrupted** power to mission critical loads in the event of an outage. While a double-conversion, online UPS can provide uninterrupted power (0 millisecond transfer time), a BESS will take several seconds to re-power loads which means **UPSs are still needed for IT equipment loads in a data center**. Beware of vendors who tout very low BESS inverter transfer times as that does not give an accurate picture of the actual time it takes for the full system to supply battery power to connected loads. There are other components that must switch or disconnect, such as the main breaker which might take 50 ms to open. Another key difference between a UPS and BESS is that the BESS also has a bi-directional inverter (the UPS does not) that enables it to export power to the grid when appropriate. **Figure 6** shows a simplified block diagram of a data center electrical architecture showing BESS, PV, and a UPS.

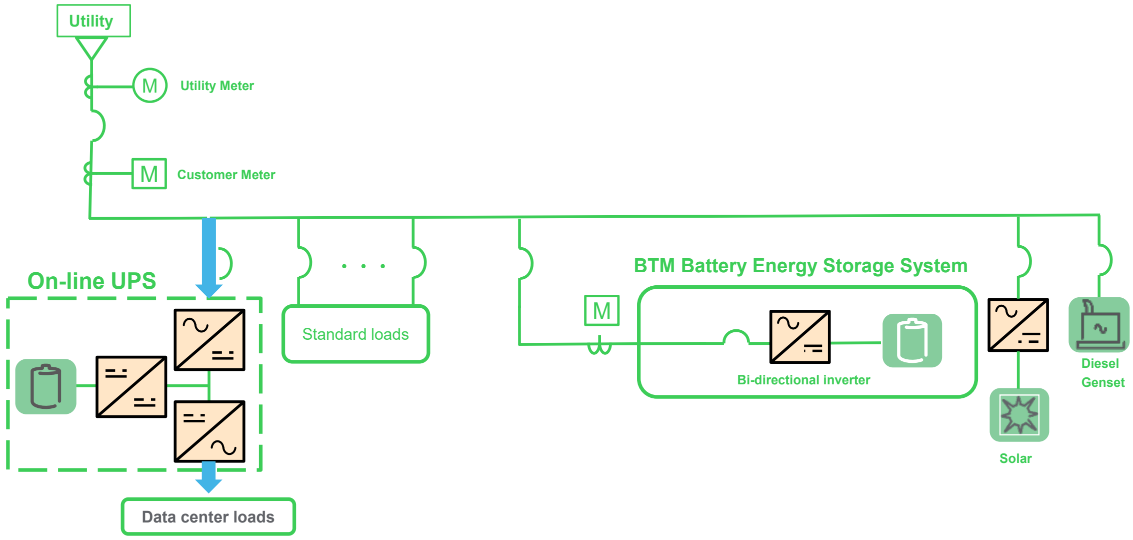

Figure 6

A simplified block diagram showing a typical AC-coupled BTM BESS and solar installation at a data center.

With a basic understanding of what a BTM BESS is, the services it can provide, and how it operates within a data center, the next section of the paper will provide guidance on what conditions most favor adopting Li-ion BESS for data center use.

Conditions favoring BESS adoption in Data Centers

As stated earlier, the ROI or value of a BTM BESS is difficult to calculate being highly dependent on many local factors including:

- BESS size (i.e., how much dispatchable energy), architecture, modes of operation
- Presence of onsite renewables or not
- Electricity rate structures
- What applications the BESS is used for
- Availability and terms of grid services and demand/response programs
- Availability and use of government incentives
- Price put on Scope 1 carbon emissions or restrictions on diesel deployment

As one Sandia National Laboratories report said, *"energy storage project valuation methodology is typical of power sector projects through evaluating various revenue and cost assumptions in a project economic model. The difference is that **energy storage projects have many more design and operational variables to incorporate, and the governing market rules that control these variables are still evolving.** This makes project valuation for energy storage more difficult."* For this reason, it is important to choose a BESS vendor who has the expertise and ROI models that can take in all these considerations for your particular use case to quantify the value of a BTM lithium-ion BESS.

Regardless, these systems will offer much more value when a BESS is used for as many applications and services as local conditions permit. This is referred to as "value stacking". Adopting BESS for a data center is likely favorable when it is sited in areas with…

1. variable electricity rate structures and higher demand charges

2. high amounts of renewable energy where grid-stabilizing services are needed.
3. government incentives for deploying BTM energy storage.
4. microgrids that offer onsite renewables.
5. public pressure, regulatory limitations, or permitting problems due to the planned use of diesel generators that is preventing planned data center growth.
6. unstable/unreliable grid conditions where a BESS is desired as the first line of backup power defense before using generators.
7. reliable grid conditions with redundant or known grid reconfigure sequences resulting in short grid outage durations suitable for finite BESS runtimes.

Conclusion

This white paper provides a comprehensive overview of what a battery energy storage system (BESS) is and how it provides value in the context of data centers. BESS stores energy from the utility grid and/or renewable energy sources, and supplies energy either back to the grid or to a load depending on financial, sustainability, and/or resiliency requirements. BESS is a form of distributed energy resources (DERs)[17]. These bi-directional, long-run energy storage systems can provide data centers with five key outcomes:

- Additional backup power and greater independence from the grid
- Decreased reliance on, or elimination of the need for, diesel generators
- Reserve market participation (grid services)
- Demand charge avoidance and time-of-use/tariff management
- Increased use of renewables

Unprecedented demand for energy is outstripping new capacity growth. Limited capacity combined with increasing renewable energy penetration is destabilizing the grid creating uncertainty, limiting growth, and increasing costs and downtime risks for data centers. Battery Energy Storage Systems (BESS) are an important tool for addressing these growing challenges and for taking advantage of new markets aimed at sustaining the grid.

BESS can help stabilize the grid by balancing supply and demand. Acting as a distributed energy resource (DER), BESS can reduce data center energy costs through participation in grid services and by peak shaving to reduce or eliminate expensive demand charges. In conjunction with the UPS, a BESS offers additional backup for resiliency and increased independence from the grid by offering one to four hours of energy storage and possibly more as li-ion battery costs continue to decrease. And if the utility is unable to meet the peak needs of the facility, BESS can provide the additional power required during peak times. BESS can also reduce reliance on, or even eliminate, diesel generators to reduce noise pollution and Scope 1 emissions. And, finally, BESS can increase use of renewables by storing excess renewable energy when generation exceeds demand and releasing it during periods of high demand or low renewable energy availability.

[17] "Distributed energy resources (DERs) are small-scale energy resources usually situated near sites of electricity use, such as rooftop solar panels and battery storage." – International Energy Agency

About the author

Patrick Donovan is a Senior Research Analyst for the Energy Management Research Center at Schneider Electric. He has over 28 years of experience developing and supporting critical power and cooling systems for Schneider Electric's Secure Power Business unit including several award-winning power protection, efficiency, and availability solutions. An author of numerous white papers, industry articles, and technology assessments, Patrick's research on data center physical infrastructure technologies and markets offers guidance and advice on best practices for planning, designing, and operation of data center facilities.

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Appendix

Table A1A

Data center owner BTM BESS service names and definitions

	Service name	Definition
Data center owner services	Backup power	By minimizing electricity purchases during peak electricity-consumption hours when time-of-use (TOU) rates are highest and shifting this purchase to periods of lower rates, behind-the-meter customers can use energy storage systems to reduce their bill.
	Increase self-consumption of PV/Wind	Minimizing export of electricity generated by behind-the-meter photovoltaic (PV) systems to maximize the financial benefit of solar PV in areas with utility rate structures that are unfavorable to distributed PV (e.g., non-export tariffs).
	Demand charge reduction	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers
	Time of use bill management	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers.

Table A1B

ISOs/RTOs BESS service names and definitions

	Service name	Definition
ISOs/RTOs services	Energy Arbitrage	The purchase of wholesale electricity while the locational marginal price (LMP) of energy is low (typically during nighttime hours) and sale of electricity back to the wholesale market when LMPs are highest. Load following, which manages the difference between day-ahead scheduled generator output, actual generator output, and actual demand, is treated as a subset of energy arbitrage in this report.
	Spin/no spin Reserve	Spinning reserve is the generation capacity that is online and able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage. Non spinning reserve is generation capacity that can respond to contingency events within a short period, typically less than ten minutes, but is not instantaneously available.
	Frequency Regulation	Frequency regulation is the immediate and automatic response of power to a change in locally sensed system frequency, either from a system or from elements of the system. Regulation is required to ensure that system-wide generation is perfectly matched with system-level load on a moment-by moment basis to avoid system-level frequency spikes or dips, which create grid instability.
	Voltage support	Voltage regulation ensures reliable and continuous electricity flow across the power grid. Voltage on the transmission and distribution system must be maintained within an acceptable range to ensure that both real and reactive power production are matched with demand.

	Service name	Definition
	Black start	In the event of a grid outage, black start generation assets are needed to restore operation to larger power stations to bring the regional grid back online. In some cases, large power stations are themselves black start capable.

Table A1C

Utilities' BESS service names and definitions

	Service name	Definition
Utilities' services	Resource adequacy	Instead of investing in new natural gas combustion turbines to meet generation requirements during peak electricity-consumption hours, grid operators and utilities can pay for other assets, including energy storage, to incrementally defer or reduce the need for new generation capacity and minimize the risk of overinvestment in that area.
	Transmission congestion relief	ISOs charge utilities to use congested transmission corridors during certain times of the day. Assets including energy storage can be deployed downstream of congested transmission corridors to discharge during congested periods and minimize congestion in the transmission system.
	Transmission deferral	Delaying, reducing the size of, or entirely avoiding utility investments in transmission system upgrades necessary to meet projected load growth on specific regions of the grid.
	Distribution deferral	Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades necessary to meet projected load growth on specific regions of the grid.