WHITE PAPER

Energy Storage Is a Core Power Strategy for Next-Generation Data Centers

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As more data centers come online, particularly those supporting hyperscale and AI-driven workloads, battery energy storage systems (BESS) are increasingly relied upon to address a range of power supply challenges driven by evolving needs for power availability, reliability and speed to market.

Historically, data centers have relied on grid power supplemented by diesel generators and localized uninterruptable power systems (UPS). Centralized, utility-scale batteries were rarely deployed, due to cost, perceived risk and lack of compelling use cases.

Today, those earlier power solutions alone are often insufficient, as the data center industry has entered a new phase of power demand. This shift started to emerge around 2024 with the convergence of increased AI workloads, grid capacity constraints, and the maturation of grid-scale battery technology. All these factors have made centralized BESS both economically and operationally viable.

Hyperscale facilities now frequently require hundreds of megawatts on aggressive development timelines that present new considerations for traditional grid planning and interconnection processes. At the same time, AI workloads introduce rapid and high-magnitude power fluctuations that require new approaches to managing grid stability and power quality.

In addition, the time required for interconnection studies and approvals across different transmission regions are leading many data center developers to seriously consider behind-the-meter power solutions as the best way to meet aggressive in-service dates. These versatile solutions can be tailored to do more than just meet significant power demands, but can also address volatile load fluctuations, provide redundancy, support UPS needs, provide black start functionality and deliver peak shaving capacity, among other operational requirements.

As a result, lithium-ion BESS are increasingly viewed not as an ancillary technology but as a core reliability and power quality asset capable of bridging gaps between grid availability, on-site generation and mission-critical loads.

Why Data Centers Are Considering BESS

Because data centers have unique load characteristics, a wide range of complex factors must be carefully evaluated when assessing power supply options.

One of the first considerations is whether grid interconnection is viable within the required development time frames or whether a behind-the-meter solution is better suited. While grid power

is generally preferred, interconnection queue timelines often do not support the aggressive schedules for data center projects, prompting many developers to evaluate behind-the-meter solutions that incorporate on-site generation resources, in some cases even supporting loads of 1 gigawatt (GW) or more for large-scale facilities.

Even when a data center is able to secure a viable grid interconnection that aligns with the project schedule, analysis of its load characteristics may still reveal periods of power shortfall. In these cases, a BESS can play a critical role by supplementing grid supply during these periods of shortfall, enabling successful interconnection even if it is only required for a relatively limited amount of time over the course of a year. In those instances, the inclusion of batteries can be the determining factor in obtaining grid interconnection approval.

Regardless of the interconnection approach, on-site BESS facilities can serve as spinning reserve capacity or help smooth load fluctuations because of their ability to ramp up or down and transition as a generator to a load nearly instantaneously. When a large-load facility is grid connected, batteries still may be a preferred resource for load fluctuation corrections, for peak shaving during periods of extreme weather when utility rates are higher, or for backup power needs. Depending on the topology of the BESS, it can also serve as campus-level UPS infrastructure, protecting against a loss of utility while also serving to smooth load fluctuations to the utility.

Battery solutions can also help offset supply chain challenges and the cost of installing on-site generation resources. With capital costs for turbines, boilers, heat recovery steam generators, and balance of plant equipment continuing to rise, BESS installations can address a range of ancillary needs. Even if batteries support load demands for only a limited number of hours each year, the economic payoff to avoid overbuilding generation capacity may be significant.

Maturing Technology Option

Lithium-ion batteries (LIBs) currently dominate the global energy storage market and have emerged as a baseline storage technology for data center applications. Their widespread adoption is driven by a combination of proven performance at utility scale, well-established global supply chains and declining costs. Years of deployment as utility-scale transmission-connected assets have reduced both technical and commercial risk, making lithium-ion battery systems the most bankable and readily deployable storage solution for large, mission-critical facilities such as data centers.

Within the broader lithium-ion category, lithium iron phosphate (LFP) has become the chemistry of choice for battery energy storage facilities and, in turn, for most data center energy storage applications. Safety and cost are the primary drivers behind this shift. Compared to nickel manganese cobalt (NMC) chemistries, LFP batteries require higher temperatures to initiate thermal runaway and are inherently less volatile, which reduces the likelihood of thermal runaway propagation. This characteristic is particularly important for high-density installations adjacent to mission-critical infrastructure.

In addition to the potential safety advantages, LFP offers compelling economic benefits, with battery pack prices steadily falling over the last couple of years, strengthening the economic case for large-scale deployment. Lithium-ion batteries also offer longevity, with suppliers commonly providing 20- to 25-year performance guarantees, closely aligning with typical data center investment and depreciation horizons. Furthermore, a slowdown in electric vehicle demand has further reinforced LIBs with the creation of a surplus global manufacturing capacity, supporting price stability and near-term availability for energy storage projects.

While lithium-ion, and the LFP category in particular, currently represents the most practical and mature option today, several alternative energy storage technologies are being actively evaluated. These include sodium-based batteries, vanadium flow batteries, flywheels, supercapacitors and various other forms of long-duration energy storage. Although these technologies may offer advantages in specific niche applications, they generally lack the commercial maturity, deployment scale and long-term performance history required for broad adoption in data center environments at this time. As a result, they are viewed as complementary or future options rather than near-term replacements for lithium-ion systems.

BESS Deployment Factors

BESS offer a compelling deployment advantage for data centers, as they can be brought online more quickly and at lower capital cost than traditional gas turbines or other forms of on-site generation. Despite these advantages, batteries are rarely deployed as a stand-alone solution; instead, they function most effectively as part of a diversified power portfolio that may include gas generation and renewables such as solar or geothermal. This hybrid approach reflects both the operational strengths and the inherent duration limitations of current battery technologies.

Battery degradation plays a critical role in BESS sizing and life cycle planning for data center applications. Degradation is typically managed through design strategies that include initial overbuild and planned augmentation, often occurring within the first three to five years of operation. However, unlike merchant energy storage projects, which commonly optimize around lifecycle cost, market participation, and arbitrage opportunities, data center owners prioritize reliability, performance certainty and long-term operational resilience. All these factors frequently result in increased initial sizing.

Most commercially available BESS installations are constrained to two- to four-hour durations based on market availability — a configuration that is well suited to many grid-scale use cases. In data center environments, however, the emphasis often shifts from sustained energy discharge to power capacity, particularly for load smoothing and fluctuation mitigation driven by AI-related demand volatility. In these scenarios, systems are frequently sized with higher power capacity rather than duration alone, providing additional energy margin that can help offset battery degradation over time and, in some cases, avoid or significantly delay the need for battery augmentation.

As a result, BESS sizing for data centers is highly use-case dependent. Load smoothing and fluctuation mitigation are primarily driven by power capacity (MW), whereas spinning reserve and backup applications require sufficient energy capacity (MWh), determined by ramp rates, start times and required ride-through duration. Although most available products are optimized around two-hour or four-hour durations, many data center use cases do not require full-duration discharge, reinforcing the importance of clearly defining operational objectives early in the design process.

Integrating BESS into data center electrical infrastructure also requires careful attention to physical and electrical considerations. Designers must account for additional switchgear and redundancy, and increases in short-circuit duty, impacting equipment ratings. Failure to plan for future battery integration or expansion can significantly constrain later upgrades and increase retrofit complexity.

These physical integration challenges are closely coupled with controls architecture. Effective BESS deployment depends on centralized control systems capable of balancing load and generation across all on-site resources, including batteries, gas generation and renewables. Individual resource controllers must interface seamlessly with a master control system that manages dispatch, charging and reserve availability. In practice, these systems operate much like microgrid controllers, even when a data center is grid-connected.

Today, data center BESS deployments are AC-connected, typically at medium-voltage levels such as 34.5-kV. However, evolving IT hardware requirements are accelerating interest in high-voltage DC architectures. Emerging designs envision 800V DC buses feeding advanced computing equipment, enabling direct DC-to-DC integration of energy storage, reduced conversion losses and faster response times. While widespread deployment of DC-centric architectures is still seen as a next-generation technology, the industry is clearly trending toward hybrid and increasingly DC-oriented power systems.

Safety, Codes, and Footprint

Safety considerations are fundamental to the design and deployment of BESS in data center environments and must be addressed regardless of specific use cases. BESS installations at data centers should adhere to the same codes and standards that govern stand-alone energy storage systems, with NFPA 855, UL 9540 and UL 9540A serving as the primary, universally accepted standards for system design, certification, testing and evaluation of thermal runaway risk. Fire alarm and detection systems should follow NFPA 72 guidance, while large-scale fire testing conducted under UL 9540A plays a critical role in evaluating system failure behavior at scale. As these standards continue to evolve, along with the potential for additional guidance within NFPA 75 (the fire protection standard commonly applied to data centers), successful implementation increasingly relies on engagement with experienced engineers who are familiar with both energy storage systems and data center environments.

The test data generated through these standards and protocols extends well beyond basic code compliance. Results from large-scale fire testing inform site layout decisions, equipment spacing, hazard mitigation strategies and emergency response planning. This data helps owners avoid overly conservative or ineffective design requirements imposed by authorities having jurisdiction (AHJs). As BESS installations continue to increase in size and complexity, the use of validated test data, listed equipment, and adherence to applicable standards and codes becomes increasingly important for balancing safety, constructability, permitting, cost and schedule considerations.

Footprint considerations further intensify the importance of rigorous safety design, as BESS energy density continues to increase, reducing land requirements where land near data centers can command premium costs. While these trends improve project economics and site efficiency, they also reinforce the need for strict adherence to established safety codes and standards so that higher-density installations do not compromise long-term operational safety or resilience.

Foundational Asset

As hyperscale data centers continue to grow in physical footprint and power demand, the cost and operational advantages of deploying grid-scale lithium-ion BESS are becoming increasingly compelling. Ongoing advances in battery technology are driving safer and more energy-dense systems while also enabling more streamlined integration and efficient construction methods. Together, these improvements reduce overall project complexity while lowering liability and risk. This is particularly important for large-scale facilities, where safety, constructability and reliability are tightly linked.

Despite these common drivers, many hyperscalers are currently pursuing their own BESS strategy based on unique operational requirements, risk tolerance and business objectives. Some prioritize speed to market, while others place greater emphasis on long-term reliability, redundancy, or flexibility in power sourcing. However, as the benefits of utility-scale BESS configurations become more apparent, especially in terms of scalability, resilience and economics, this approach is increasingly being evaluated as a core component of hyperscale data center development.

Battery energy storage systems are no longer optional add-ons within data center power architectures. They are rapidly becoming foundational infrastructure that enables faster project delivery, improved reliability for AI and high-performance computing workloads, and more flexible and adaptable power systems. As battery technology continues to mature and integration approaches evolve, BESS will play an increasingly central role in how data centers are powered, protected and scaled to meet the demands of next-generation digital infrastructure.

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