Battery Energy Storage Systems in AI Data Center Design

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The Rising Power Demands of AI Data Centers

Training today's largest AI models often requires tens of thousands of AI accelerators (xPUs) working in unison, creating massive and unpredictable demands on power systems. Traditional Data Centers average 5–10 kW per rack, whereas an AI accelerator rack can demand 30–100+ kW, resulting in unprecedented power demands. For example, Meta plans to bring a 1 GW supercluster, called Prometheus, online in 2026[1]; Amazon's AI Megasite in Indiana, USA, is expected to draw 2.2 GW[2]; and the OpenAI/Stargate campus in Abu Dhabi, built in partnership with Emirati AI, is planned to use 5 GW[3].

Renewable energy, a containerized BESS', and a Data Center are highlighted.

Learn about how [other electrified applications can benefit from DKCMS™](). Image copyright Dukosi.

Power Variability and Grid Stability Challenges

There are challenges with supply reliability, whether from the grid or via independent operations, and also, surprisingly, challenges that stem from the AI workloads themselves.

A paper[4] co-authored by Microsoft, OpenAI, and NVIDIA describes how large AI workloads experience high variability in power consumption during the initial "training" phase[5] as a new model is built; power usage swings dramatically as compute-intensive phases draw enormous energy, while communication-heavy phases require much less.

At a recent event, Google Cloud representatives evidenced a ~15x difference in load fluctuations between a traditional Cloud and AI Data Center, from 1.5 MW to 15MW peak-to-trough swings in just seconds[6]. These fluctuations don't just challenge Data Center infrastructure; they can also ripple outward to affect the power generators or broader power grid. As a result, stabilizing these workloads has become a critical priority for operational reliability, and to avoid disconnections for safety reasons.

Ensuring Reliability with Battery Energy Storage Systems (BESS)

Despite these considerable power supply challenges, AI Data Centers still require "five nines" uptime (99.999%), meaning outages must be almost entirely avoided. Battery Energy Storage Systems (BESS) is therefore an essential component in AI Data Center design.

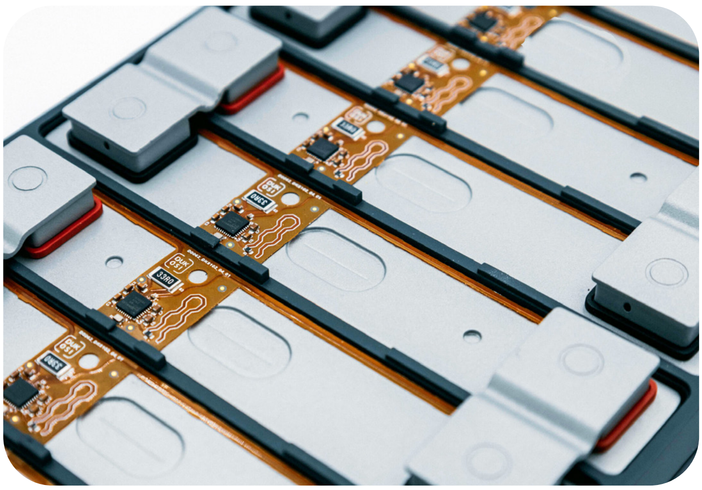
A BESS can provide an instantaneous secondary source of power, and can smooth out short-term spikes and dips (grid frequency stabilization) ensuring stable power delivery. Without them, even a short grid disruption could crash workloads, cause significant financial losses, and damage reputation in a highly competitive market.

How BESS Supports Dynamic AI Workloads

Switching between AI compute and communication modes causes rapid frequency swings; the fast response times of batteries enable them to inject or absorb power within milliseconds, much faster than traditional generators, making them ideal for counteracting sudden deviations in grid frequency. Grid operators might find they cannot supply enough during peak hours, allowing the BESS to fill the gap (peak shaving).

Dukosi Cell Monitoring System (DKCMS™) Advantages

The chip-on-cell architecture of Dukosi Cell Monitoring System (DKCMS) provides industry-leading cell voltage accuracy, and cell-level temperature readings; both of which can feed into a more accurate State of Charge (SoC), State of Available Power (SoP) and State of Health (SoH) estimations. SoP is crucial for frequency stabilization, peak shaving, and fast demand of power, while accurate and fine-grained SoH can help plan any required maintenance further in advance, ensuring uptime is maintained.



Cost Optimization and Grid Resilience

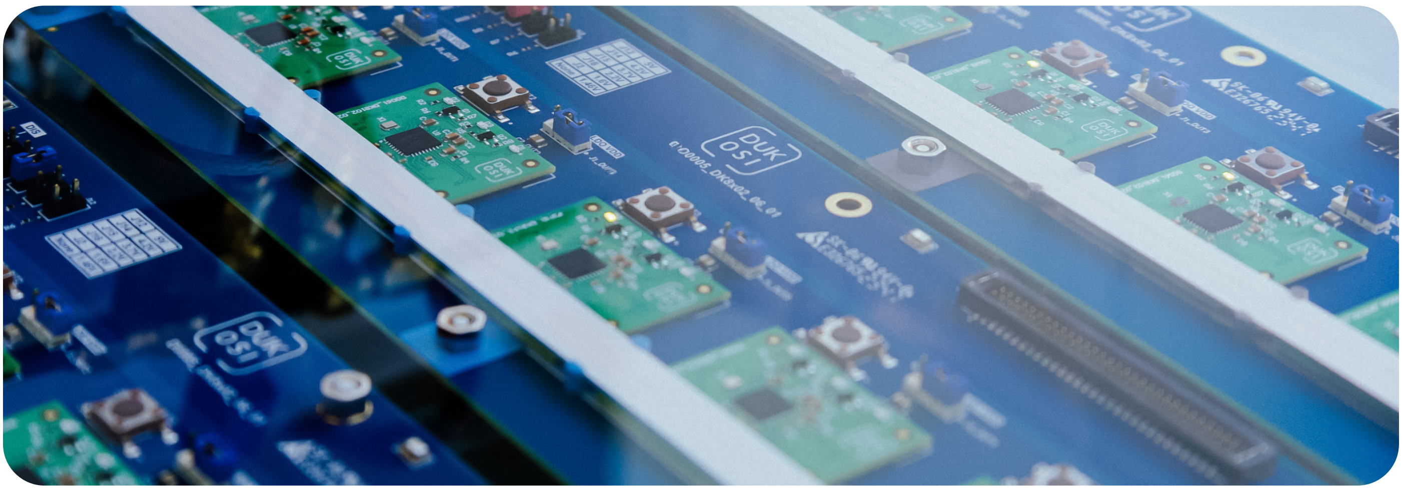
Beyond operational stability and capacity, operational cost is also a key factor. All BESS can benefit from charging when electricity prices are low and discharging when prices are high, helping to offset regular or unexpected price fluctuations. Improved SoC and SoP accuracy allows for more usable energy per cell, meaning fewer cells are needed for a given system size, or operators can unlock additional capacity: both of which reduce costs, but it can also be a lifeline in rare events grid instability. Having the confidence to accurately observe, and run cells for a short period beyond their guidelines is a highly valuable tool, especially when it's to ensure operational stability.

Regulatory Drivers and Real-World Deployments

While BESS may not be legally mandated, in some jurisdictions, regulators require large Data Centers to maintain on-site resilience, which typically includes a large-scale BESS in partnership with uninterruptible power supply (UPS) and generators. For example, earlier this year xAI deployed 168 Tesla Megapacks at its Colossus supercomputer in Memphis, TN[7], totaling over 650 MWh of energy storage. The company claims this will strengthen the reliability of its operations by managing outages and demand surges.

Future Design Innovations: Integrated Batteries and Cooling

As we look towards future designs, there is also the potential for deeper integration. Traditionally, batteries are siloed outside the main operational area for safety and simplicity. However, disaggregating them among the racks – each supporting a smaller number of compute units – could improve power management, providing fine-grained control over the fluctuations described above. This approach could also allow sharing of liquid cooling systems[8], reducing space, materials and costs. Both servers and batteries are even (separately) exploring immersion cooling in next-generation designs, creating further synergies that could reduce costs even as power and cooling demands increase. Safety remains a concern in such cohabiting arrangements, but with advanced battery cell monitoring technologies like DKCMS, which uniquely tracks up to three temperature points on each cell and immediately alerts when any individual cell exhibits abnormal temperature behavior, the risk is becoming increasingly manageable.



An example of DKCMS operating submerged in an inert dielectric fluid.

Supply Chain and Manufacturing Efficiency

The rush to build AI Data Centers globally has further knock-on effects , like choosing the right supplier, and manufacturing fast and reliably. DKCMS can work with a number of BMS host processors from global tier-1 suppliers, providing a layer of design and supply chain flexibility, while also providing the assurance of the necessary quality standards[9].

DKCMS enables fully automated production lines, which can accelerate production on tight schedules, while also reducing labor cost and improving yield and through-put. It achieves this through its simpler architecture: removing the complex wiring harness used in other battery architectures and replacing it with a more reliable single bus antenna that can be integrated directly into the battery housing.

Cybersecurity and Provenance in Battery Systems

The U.S. Cybersecurity Committee also raised concerns during its August 2025 meeting, where industry leaders highlighted risks from non-standard or under-documented batteries sourced from unapproved suppliers in grid expansion projects. These concerns apply not only to digital equipment but also to the battery cells themselves, making supply chain verification critical in infrastructure projects. By integrating on-cell storage of cell-level data for provenance information, DKCMS can enhance supply chain security. The Dukosi Cell Monitoring chip can even be embedded inside the prismatic cell can during manufacturing, making it physically tamper-proof. When operational, DKCMS uses near field contactless connectivity and C-SynQ® closed communications protocol that's fully contained within the battery, unlike legacy far field wireless BMS.

Conclusion: A Balanced Solution for the AI Power Era

Operational performance, reliability, safety, deployment speed, supply-chain and cybersecurity, and cost are usually a difficult balancing act for even the most experienced project managers, but the Dukosi Cell Monitoring System can tick all the boxes for even the most demanding BESS operations

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Dukosi Ltd develops revolutionary technologies that dramatically improve the performance, safety, and efficiency of battery systems, and enable a more sustainable battery value chain. The company provides a unique cell monitoring solution based on chip-on-cell technology and C-SynQ® communication protocol for electric vehicles (EV), industrial transportation and stationary battery energy storage markets.

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