VERTIV.

STTelemedia Global Data Centres

MOTEURS Baudouin

White paper

Adapting data center power infrastructure to AI workloads





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Executive summary

Unlike traditional IT loads, artificial intelligence (AI) computing done by graphics processing units (GPUs) is highly transient, creating steep power swings that put stress on the critical power train. Vertiv, ST Telemedia Global Data Centres, and Baudouin conducted comprehensive testing to assess the impact of these workloads on uninterruptible power supply (UPS) systems and generator performance. The results confirm that AI loads can push generators into instability, while the Vertiv™ UPS Power Smoothing feature restores stability and maintains continuous uptime of the critical infrastructure.

Introduction

Traditional IT workloads typically exhibit steady, predictable power consumption with gradual changes in demand. In contrast, AI workloads exhibit rapid, synchronized graphics processing unit (GPU) activity, creating transient load profiles with steep rises and dips.

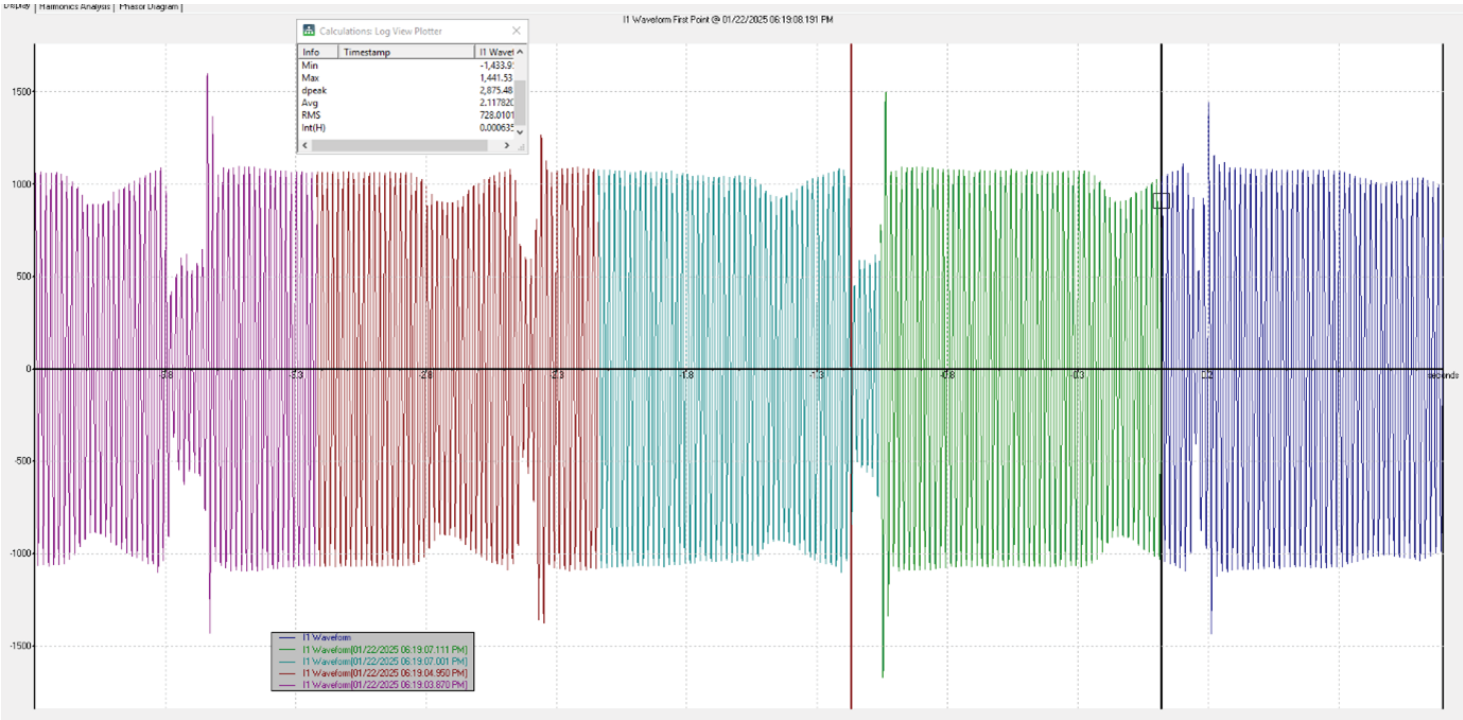


Figure 1. Example load draw from a real data hall in an STT Data Center. Source: ST Telemedia.

Extensive industry analyses focused on the impact of these loads on individual data center components, such as the uninterruptible power supply (UPS) or the utility grid.[1] [2] However, a gap remains in understanding how these systems interact when the entire power supply relies on diesel generators, which is a less resilient source compared to the utility grid.

[1] BrijeshW, 2025. Microsoft
[2] Chen, X., Wang, X., Colacelli, A., et. Al., 2025. Arxiv.

These load dynamics pose significant challenges for critical power systems:

- Generators are designed for relatively smooth load ramps and struggle to maintain frequency/voltage under steep load swings.
- The combined concerns can result in frequency oscillations, voltage dips, and bypass synchronization failures.

By absorbing peaks, the Vertiv™ UPS Power Smoothing feature stabilizes generator operation and protects downstream IT loads.

In this assessment, the primary objective was to replicate AI power demand patterns in a controlled laboratory environment to observe their impact on the UPS and generator system (genset). The methodology included:

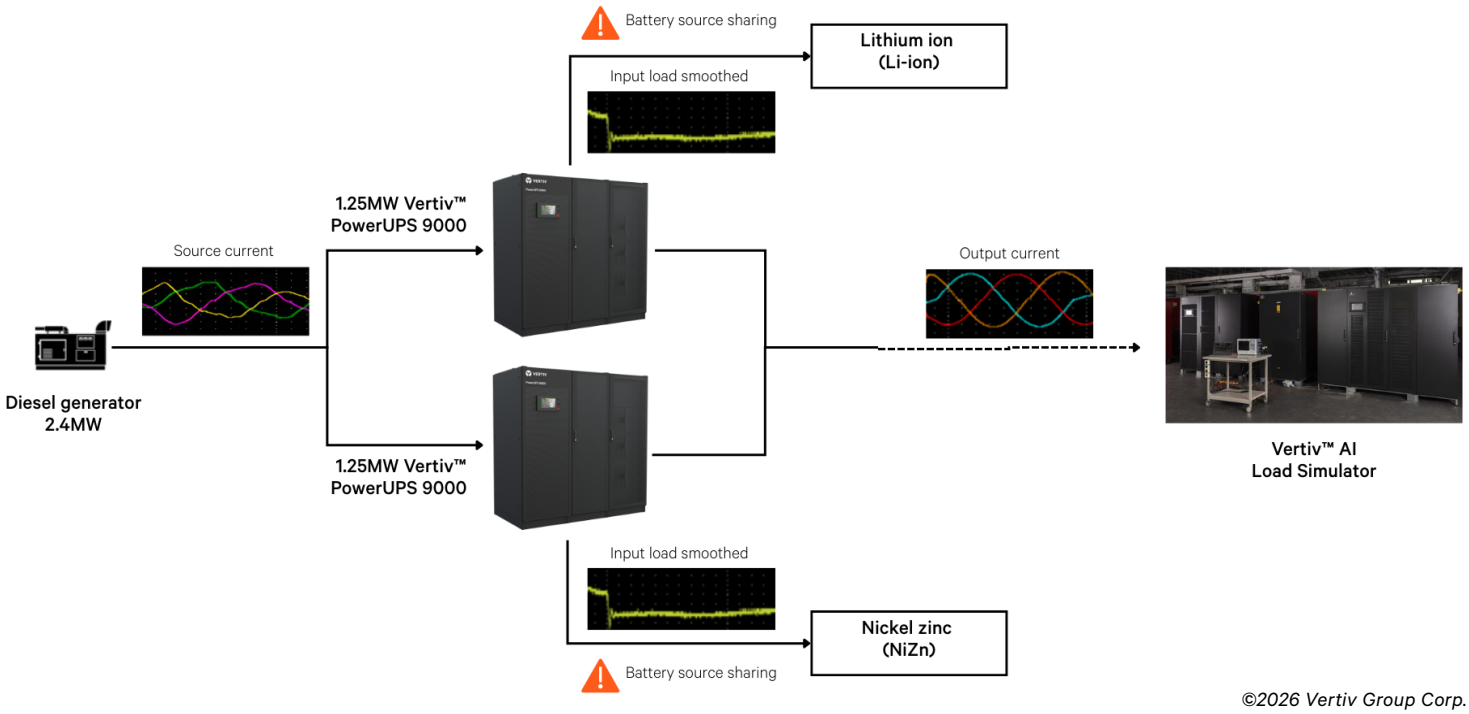
- Using the Vertiv™ AI Load Simulator to reproduce GPU transient profiles.
- Running tests across multiple load scenarios, ranging from moderate (Scenario 1) to extreme (Scenario 3) GPU loads and modified GPU loads through rack-based load smoothing (Scenario 4).
- Introducing intermediate load points (Scenarios 2.1, 2.3, and 2.5) to map the transition from stable to unstable operations.
- Enabling and disabling the UPS load smoothing feature to compare the workloads' performance.

Test setup

The testbed was established using a 2.4 MW Data Center Rated (DCR) diesel genset feeding a dual-UPS system. [3] The UPS system consisted of two 1.25 MW units in parallel with distributed battery banks. The AI Load Simulator, connected downstream, generated realistic fluctuating load profiles. Additional load banks provided supplementary resistive and reactive load components.

- 2.4 MW genset (Baudouin 12M55G10D2/5 engine coupled with WHA54.2ZzL17 alternator)
- Two 1.25MW Vertiv™ PowerUPS 9000 UPS in parallel configuration (2.5MW) [4]
- Lithium battery strings and nickel zinc (NiZn) battery strings connected to individual UPS units.

[3] Pre-approved by organizations, Data Center Rating (DCR) is a specific power classification referring to the uptime and reliability requirements of modern data center facilities. Validated through passing a list of rigorous tests, this rating measures for maximum reliability, operational capacities, load factors, and performance metrics, among others.
[4] Vertiv, n.d.



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Figure 2. The test setup to replicate AI power demand patterns in a controlled laboratory environment. Source: Vertiv

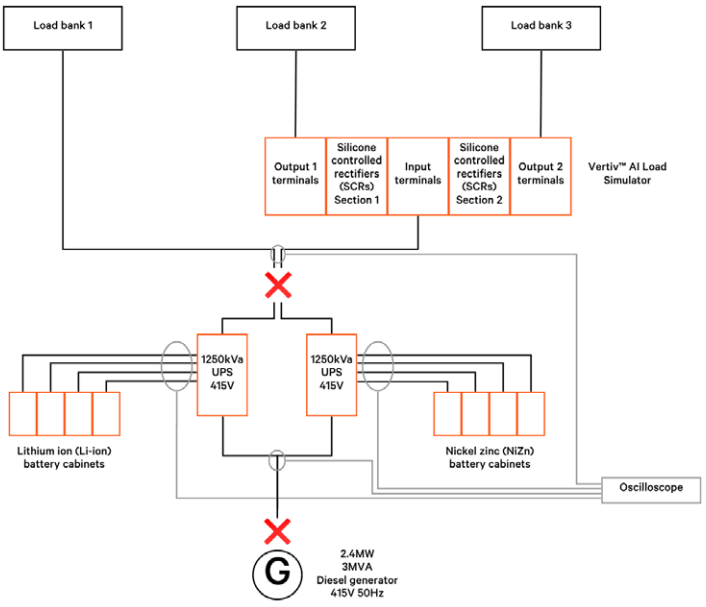
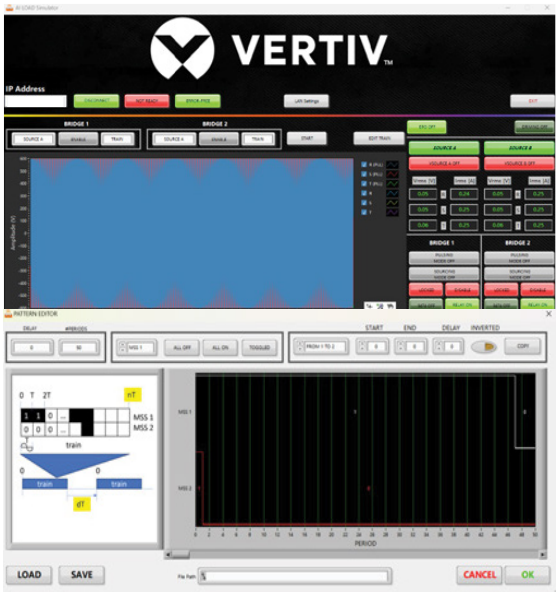


Figure 3. Single-line diagram of test setup. Source: ST Telemedia.

Vertiv™ AI Load Simulator

The Vertiv™ AI Load Simulator is a patented test system designed to accurately replicate the electrical behaviour of AI-driven compute loads, specifically the fast-switch and irregular power profiles of GPU clusters operating under training or inference cycles. The simulator includes advanced monitoring and analytics capabilities, delivering real-time insights and detailed reports on how the infrastructure responds to sudden, fluctuating power demands. [5]



Vertiv™ AI Load Simulator
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Figure 4. The Vertiv™ AI Load Simulator computer-based load profile configurator software platform used for tracking electrical load fluctuations. Source: Vertiv

Reactive and capacitive load banks

The load banks are essential to differentiate the three levels of the load profile in the test scenarios. Load banks require granular load steps to facilitate iterative adjustments and identify generator-specific limits.

Load bank 1	Simulating non-AI loads, including system losses, network, storage, server loads, and HVAC, among other systems.
Load bank 2	Simulating GPU loads.
Load bank 3	Simulating GPU peak power draw.

Table 1. Respective load bank purpose for load profile simulation.

[5] Remelli, A., 2025. Vertiv.

Test scenarios

Four test scenarios simulate various load scenarios, summarized below as follows:

Scenario 1: Currently observed load profile from H100 GPUs

In this scenario, the load banks were set up to replicate the actual load profiles recorded by power quality meters in STT data halls. These profiles account for customer loads that are not exclusively GPU-based, recognizing that customers do not always operate at full capacity and that other typical loads, such as HVAC systems, are also present.

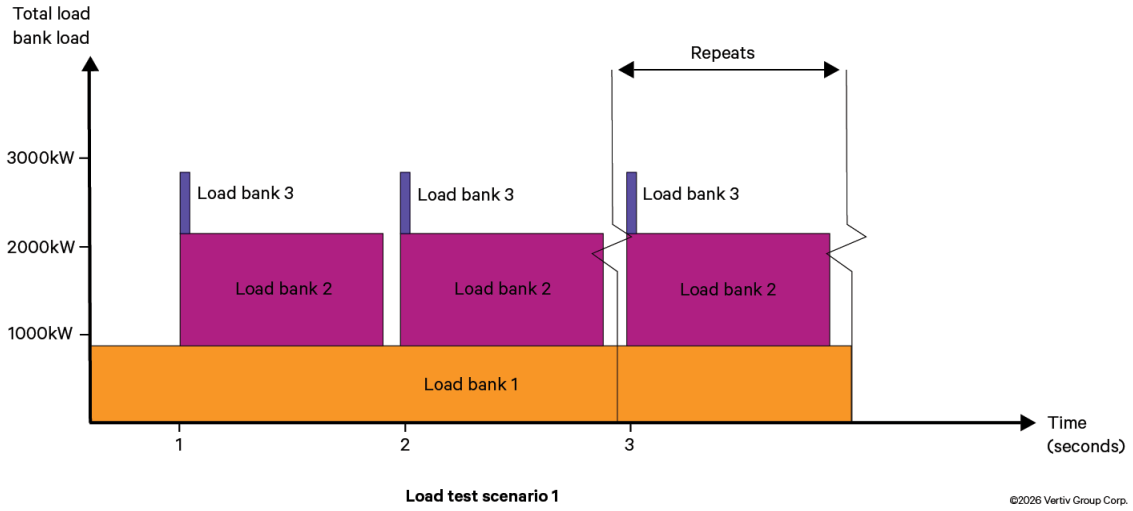


Figure 5. Test scenario 1: Load banks in data halls are not maximized. Source: Vertiv

Scenario 2: Currently observed load profile H100 GPUs with data hall power increased to 100%

Scenario 2 builds on top of Scenario 1, but with each of the loads increased to reflect the observed profile wherein the customer's data hall load runs at 100% of contracted capacity.

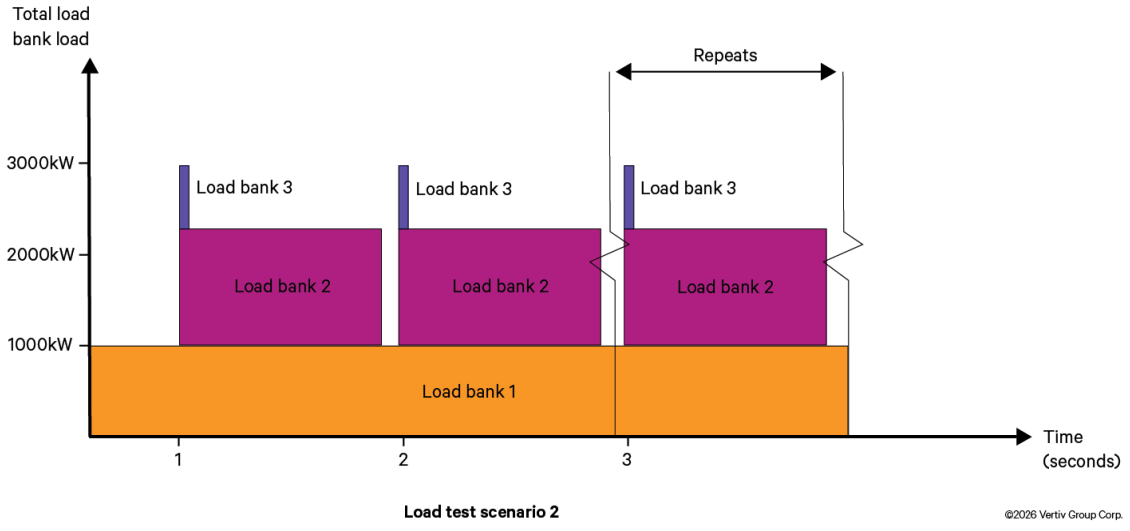


Figure 6. Test scenario 2: Load banks in data halls run at 100%. Source: Vertiv

Scenario 3: Worst-case GPU loading

Scenario 3 assumes that all IT loads in the data hall that this power system supports are GPU loads (e.g., customer's networking or storage systems would be supported by other power systems).

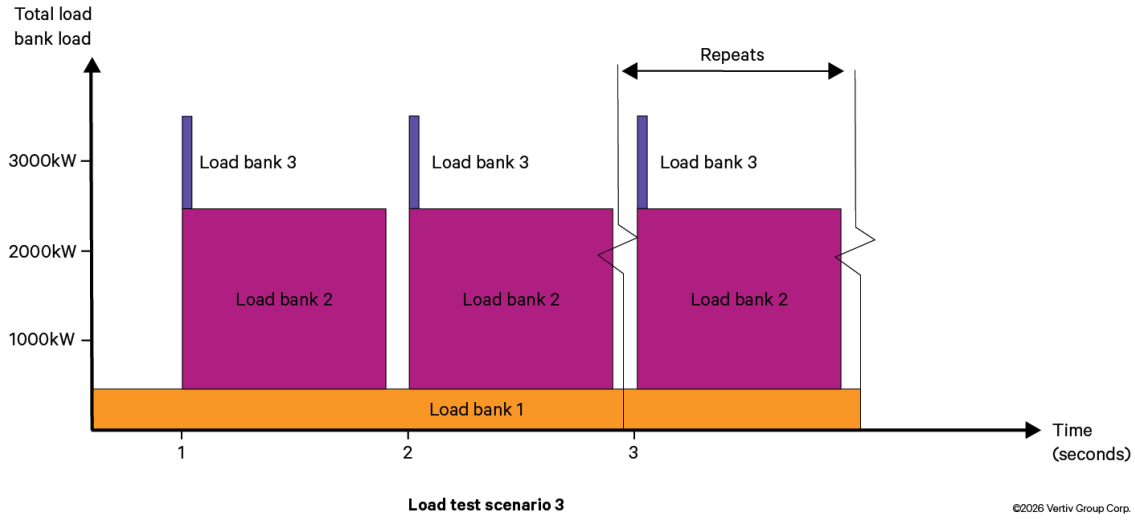


Figure 7. Test scenario 3: All IT loads in the data hall are GPU loads. Source: Vertiv

Scenario 4: Rack-based load smoothing

In Scenario 4, Scenario 1 is adjusted to reflect the end user reducing load peaks and troughs at the rack level. These actions may include optimizing the GPU algorithm or installing ultracapacitors within the rack to help smooth out power fluctuations.

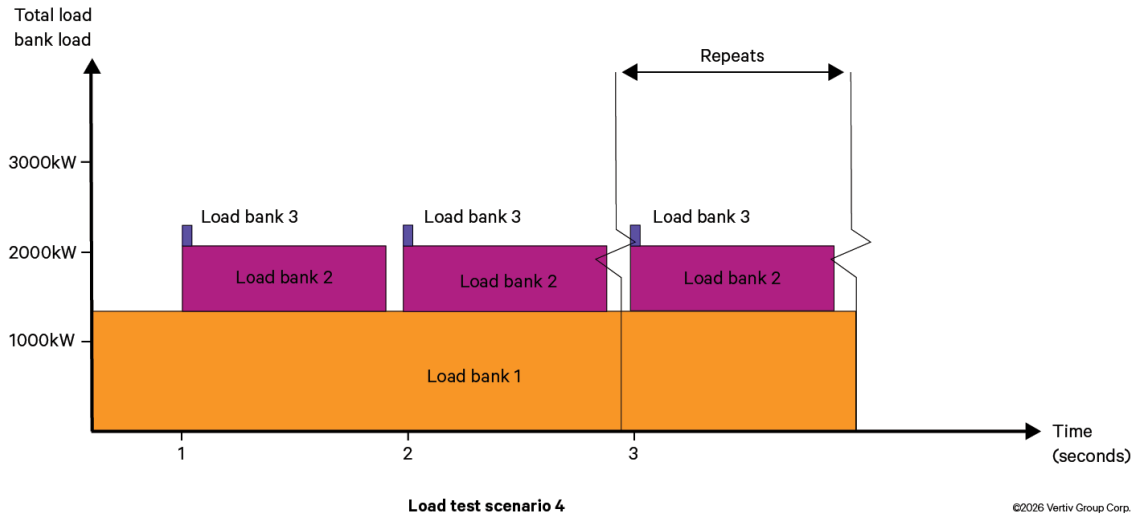


Figure 8. Test scenario 4: All IT loads in the data hall are GPU loads. Source: Vertiv

Data	Scenario 1 (Typical 90% of rated capacity)	Scenario 2 (Rated capacity)	Scenario 3 (Worst case)	Scenario 4 (Rack-based smoothing)	
Generator rating	2400	2400	2400	2400	kW
UPS rating	1250	1250	1250	1250	kVA
UPS quantity	2	2	2	2	
Assumed load power factor	0.95	0.95	0.95	0.95	Leading
Test voltage	415	415	415	415	V
Percentage generator capacity subject to AI loads (Percentage of the total load or AI server)	54%	60%	84%	54%	
Nominal AI server load (kW)	1296	1440	2000	1296	kW
Nominal other IT loads (kW)	504	560	0	504	kW
Nominal total IT load on UPS (kW)	1800	2000	2000	1800	kW
Peak AI server load factor (Surge of AI load steps)	1.5	1.5	1.5	1.2	
Peak AI server load (kW)	1944	2160	3000	1555	kW
Peak total IT load on UPS (kW)	2448	2720	3000	2059	kW

Table 2. Power system parameters across AI workload test scenarios

Results and analysis

Summary

- AI loads impact the ability of diesel generators to maintain a stable frequency.
- Affects UPSs ability to synchronize with the bypass.
- Impact can be reduced by implementing the Vertiv™ UPS Power Smoothing mode.
- Implementation of UPS load smoothing only when the diesel genset's mode of operation is required (e.g., mains failures) appear to have negligible impacts on battery life for Li-ion or NiZn batteries.
- Endurance testing of diesel generators on AI loads did not show any signs of increased wear on the engine components.

When operating on an infinite source, such as the utility grid, the Vertiv™ UPS seamlessly transferred the current load without any observable impact on system performance at the tested scale, due to the UPS system's Battery Shield AI Load feature, which is embedded in the system.

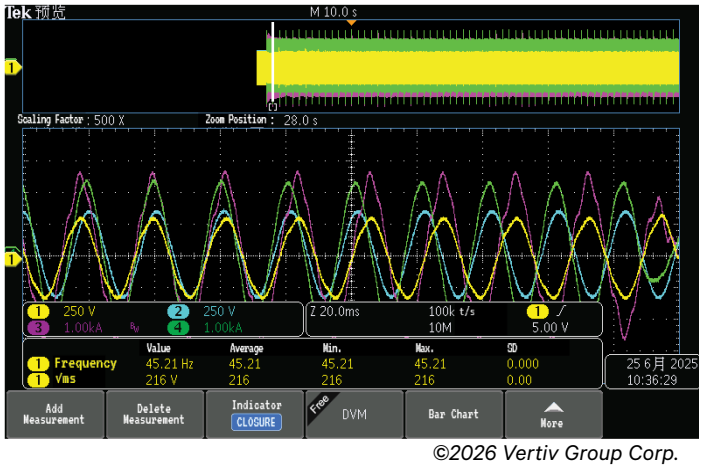
Conversely, when running on a finite source, such as a diesel generator, rapid current peaks and dips were passed directly to the genset. This caused the generator to struggle in maintaining voltage and frequency within the UPS input tolerance window (±10% in this test), as required by IT load power quality standards. The degree of voltage and frequency drift depended on the proportion of AI loads versus traditional loads connected to the generator.

Under standard UPS programming, batteries were not engaged to support the load, meaning the generator absorbed the full impact of the AI waveform. As a result, output frequency fluctuated significantly, preventing the UPS from synchronizing with the bypass once AI loads exceeded approximately 75% of the 2 MW IT load (Scenario 2). This highlights the importance of gradually walking loads onto the generator during transfer from the utility to the generator, as AI load peaks can contribute to step-load conditions.

To mitigate these effects during testing, the patented Vertiv™ UPS Load Smoothing mode was activated. A maximum smoothing level of 20% proved sufficient to reduce generator stress under real-world conditions (Scenarios 1 and 2), eliminating the need for higher settings. This feature leverages battery capacitance to pre-emptively reduce current peaks seen from the generator, allowing stable operation without transferring the full load to the batteries.

Scenario 2: Workload test at rated capacity of the genset

Standard system configuration



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- Generator voltage and frequency dipped approximately ± 10% and - 10%, respectively.
- Inverter asynchronous alarm present.

With Vertiv™ UPS Load Smoothing mode enabled



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- Generator voltage and frequency dip reduced by approximately +/-0.5% and -4%, respectively.
- Shorter duration of inverter asynchronous alarm present.

In Scenario 3 (i.e., with IT load capacities at 100% AI load), with the load smoothing feature enabled, the digital power meter recorded negligible frequency variation. However, the bypass remained out of sync with the UPS. While smoothing improves generator stability, some phase shift persists. The main limitation of the 20% smoothing setting occurs when the AI load becomes so high that the UPS cannot synchronize with the bypass. Increasing the frequency slew rate to 2 Hz/s—the rate at which the UPS adjusts its frequency to match the input—extends the range of AI load where synchronization is possible without increasing smoothing percentage, thereby reducing battery stress. Nevertheless, once GPU load exceeds 75% of total IT load, even with the increased slew rate, the UPS cannot synchronize with the bypass for a synchronous transfer back to the inverter. In these rare cases, a higher smoothing percentage on the rack or UPS side (or a combination of both) will be required.

When operating purely on batteries for discharge testing against an AI workload, lithium battery autonomy increased by 4%, likely due to the 40ms troughs in the AI load profile. Battery temperature remained unaffected by discharge/charge rates, and no significant impact on battery life was observed after 300 hours of endurance testing with smoothing enabled. Thanks to the combination of 20% smoothing and frequency slew rate adjustment, battery discharge to support generator instability in Scenario 3 occurred only at the onset of fluctuations.

Finally, tests showed no significant difference between 400 V and 415 V configurations.

Although subjected to an AI-controlled load profile, the Baudouin generator, due to its fuel injection integrated algorithms and calibration, demonstrated a strong capability in responding to load changes. A post-endurance examination confirmed that wear on the primary friction components was equivalent to that observed in a non-AI tested unit, which has been validated by over ten thousand hours of field operation.

Number	Part	Position	Status	Evaluation
1	Crankshaft	Crank pin diameter	OK	Within Baudouin standard tolerances
2	Crankshaft	Main journal diameter	OK	
3	Crankshaft bearing	Bearing thickness	OK	
4	Connecting rod bearing	Bearing thickness	OK	
5	Cylinder liner	Inner diameter	OK	
6	Piston ring	Close gap clearance	OK	
7	Rocker arm shaft	Outer diameter	OK	
8	Rocker arm	Sleeve inner diameter	OK	
9	Piston pin	Outer diameter	OK	
10	Connecting rod	Big end inner diameter	OK	

Table 3. Inspection after the generator was disassembled revealed that the parts did not exhibit any abnormal wear. The wear and tear present was within Baudouin standard tolerances. Source: Baudouin

Conclusions and recommendations

The fluctuating power demands of AI workloads can cause the generator's output frequency to vary. When the proportion of AI load on the generators surpasses a certain threshold, these frequency fluctuations become too large for the UPS to synchronize with the bypass. Up to this threshold, the issue can be managed by increasing the UPS slew rate to 2 Hz/s and enabling advanced load smoothing features on the UPS. However, if the threshold is exceeded, the frequency fluctuations may be so severe that, even with increased power smoothing or if the UPS is switched to static bypass during diesel generator operation (for example, during emergency maintenance), it might not be possible to move back from static bypass to the inverter without an interruption in the power supply.

The exact threshold at which this occurs will vary depending on several factors, including but not limited to the rating of the generator, the percentage of AI loads versus the HVAC loads put on the generator, the amount of load smoothing provided by the UPS, and the exact AI load profile, among other possibilities.

Despite the frequency variations, long-term exposure to AI load profiles did not appear to adversely impact the generator or the battery life for either of the battery technologies tested.

Key AI data center design recommendations:

- Set UPS slew rate to at least 2Hz/s.
- Always run the UPS in double conversion mode (so frequency fluctuations do not move/be transferred to critical loads).
- Place less disruptive loads, such as HVAC, on the same diesel generators to reduce the impact of AI workloads. Implement load smoothing functions when available on the UPS.
- Always walk-in loads on the generators when transferring to and from utility.
- Consider the sequence of operations for planned UPS maintenance to avoid placing the UPS on bypass direct onto the diesel generators when supporting AI loads.

References

1. BrijeshW. (2025). *Microsoft. Power stabilization for AI training datacenters*. https://techcommunity.microsoft.com/blog/azurecompute/power-stabilization-for-ai-training-datacenters/4460937.

2. Chen, X., Wang, X., Colacelli, A., Lee, M., and Xie, L. (2025). Arxiv. *Electricity demand and grid impacts of AI data centers: Challenges and prospects*. https://arxiv.org/html/2509.07218v1.

3. Remelli, A. (2025). Vertiv. *Vertiv™ AI Load Simulator: Innovation for precise power validation*. https://www.vertiv.com/en-us/about/news-and-insights/articles/blog-posts/vertiv-ai-load-simulator-innovation-for-precise-power-validation/.

4. Vertiv. (n.d.). *Vertiv™ PowerUPS 9000*. https://www.vertiv.com/en-us/products-catalog/critical-power/uninterruptible-power-supplies-ups/vertiv-powerups-9000/.



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