

From Principles to Practice: Implementing OCP LVDC Frameworks with a 600kW, 800VDC Sidecar Power System Design

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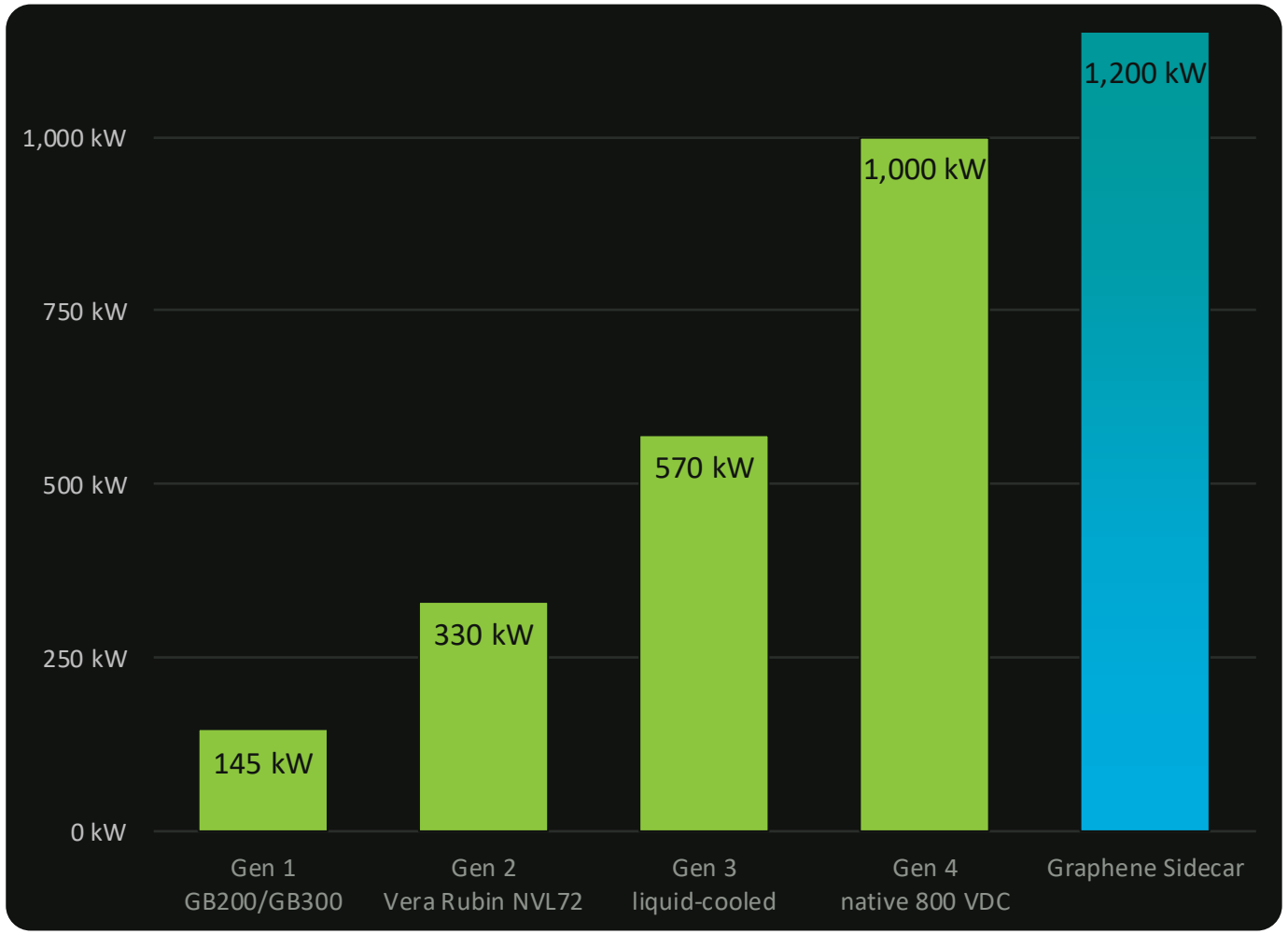
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High-power AI racks require both rapid peak-power support and fast fault protection, but today’s solutions typically treat them as separate challenges.

We’re proposing a first-of-its-kind sidecar solution that combines solid-state circuit protection and high-power storage technology for peak power management performance.

"We are now a power-limited industry."

Jensen Huang, *GTC 2025 keynote*



Rack power grew 7× in four generations.

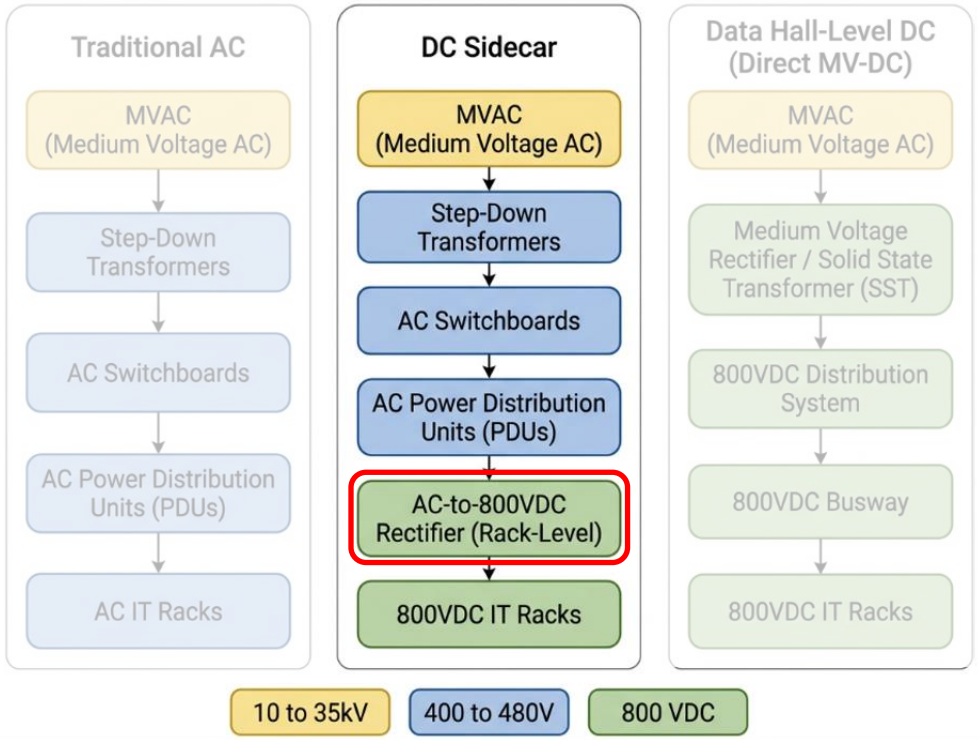
The rack didn't.

NVLink requires GPUs to sit physically close to act as one synchronous accelerator. Copper reach sets the distance; density follows. Power delivery has stopped being a supporting function and become a primary constraint on scalability.*

**NVIDIA, 800 VDC Architecture: Industry Alignment & Execution, 2026*
GPU - Graphical Processing Unit

GrapheneSidecar leverages
Benefits of 800 VDC without Upstream Electrical Infrastructure Changes

- GrapheneSidecar connects to the **existing AC distribution** and provides **protected 800 VDC output**.
- GrapheneSidecar provides active peak shaving and load smoothing to ensure AC input **power is smooth**,
- GrapheneSidecar integrates **backup on 800VDC side**.



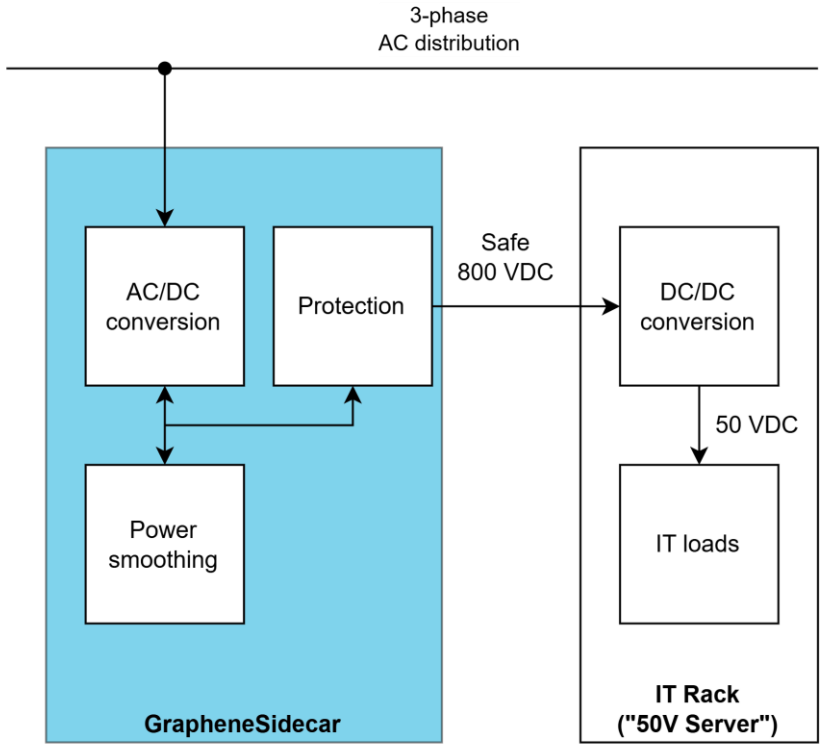
Power infrastructure evolution.
GrapheneSidecar implements the AC-to-800VDC conversion, potentially feeding multiple IT racks.
Original image source [1]

[1] J. Adrian, M. Tu, *Powering the Next Era of AI: How Google, Microsoft and Nvidia Are Standardizing and Accelerating the Industry Transition to LVDC*, OpenCompute blog

GrapheneSidecar leverages

Benefits of 800 VDC without Upstream Electrical Infrastructure Changes

Concentrating the power conversion equipment in the sidecar enables **increased compute density** in the IT rack.



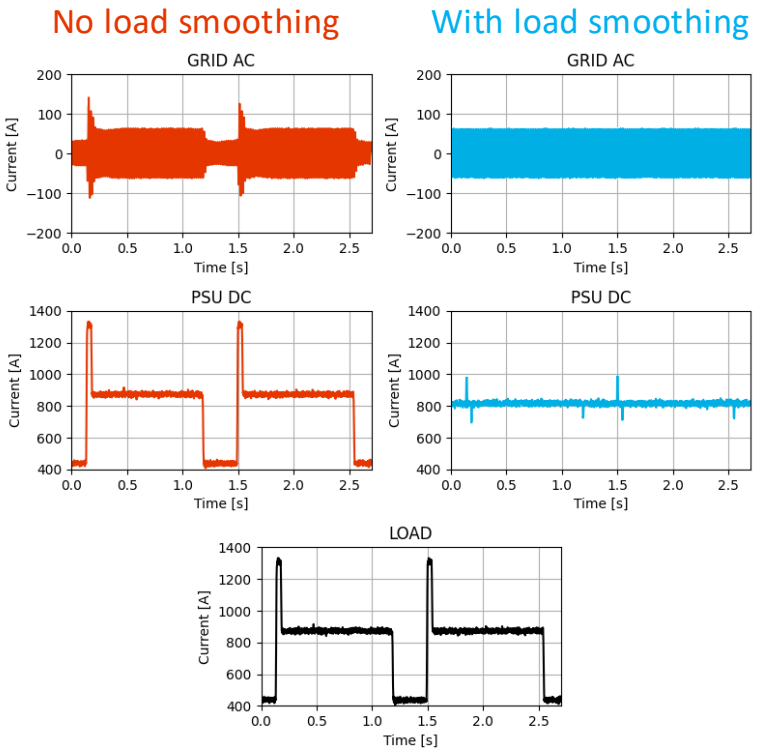
GrapheneSidecar implements AC/DC conversion from three-phase AC to 800 VDC, power smoothing, and fast fault protection of the 800 VDC output. The sidecar is compatible with both the "50V server" and the "Next gen 800V native server" architectures as described in [1].

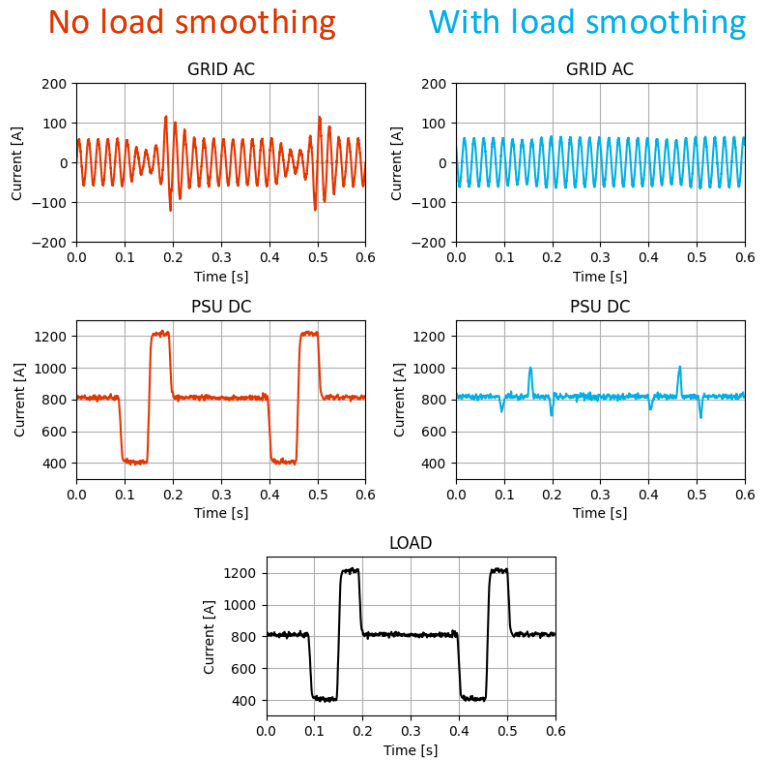
[1] Data Center Facility – Low voltage direct current power distribution. OpenCompute, 3/2026. OpenCompute whitepaper

GrapheneSidecar enables the integration of **Load Smoothing Near the Load**

Load smoothing (or Peak shaving) is essential to avoid **grid power fluctuations** at **subharmonic frequencies** that can cause oscillations, grid instability, or even blackout.

Utilizing **electrical double-layer capacitors** (EDLCs) gives high power density allowing to **lower the minimum power floor** (MPF) of the GPUs, which reduces energy consumption and GPU wear.

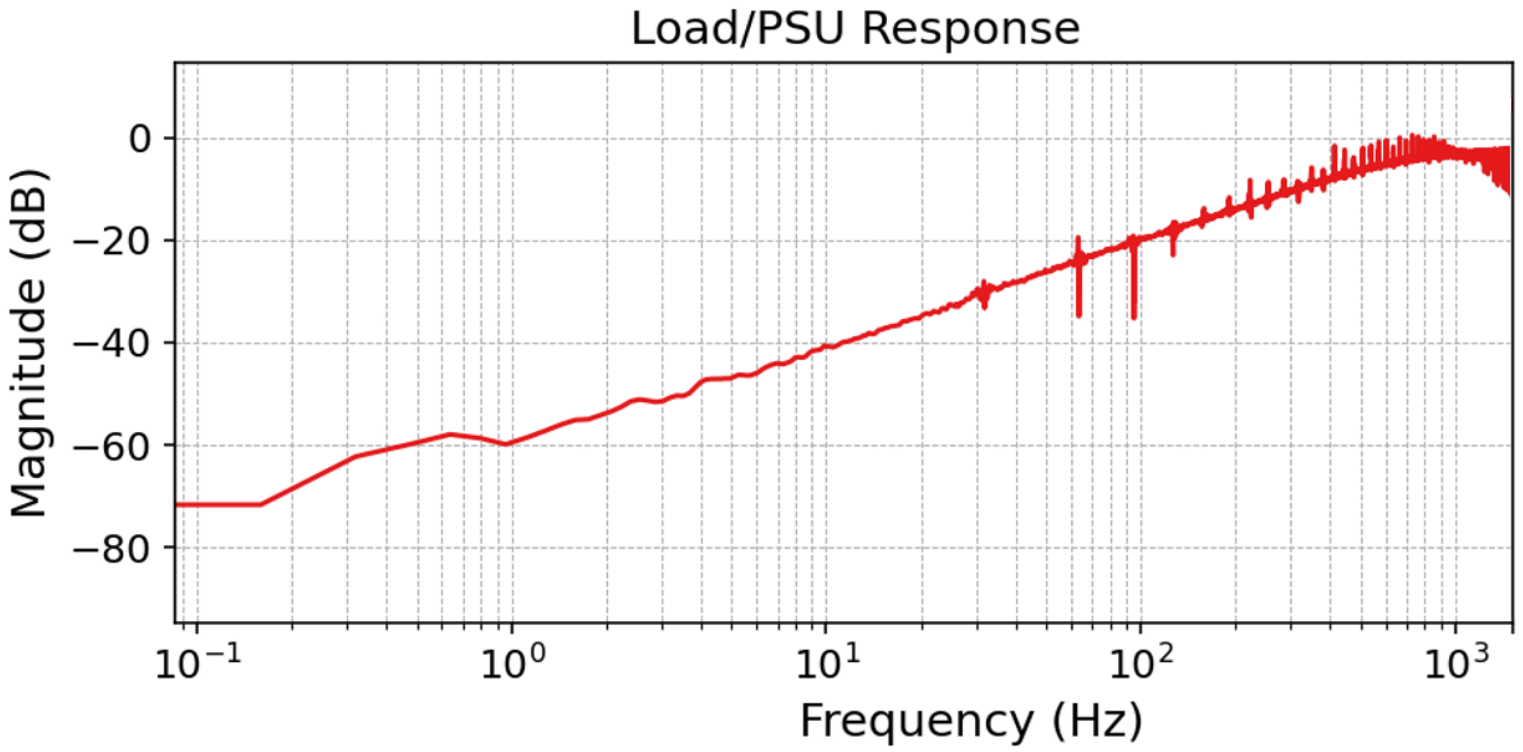




Measurements by Skeleton Technologies, load profiles influenced by NVIDIA generic profiles presented in [1].

[1] R. Dimitrov, H. Petty, N. Srivastava, M. Blake, "How New GB300 NVK72 Features Provide Steady Power for AI", NVIDIA Technical Blog, 6/2025, Available online

Laboratory test results
Load to PSU Current Attenuation as a Function of Frequency



PSU - Power Supply Unit

Results: Very high attenuation across wide frequency range

Subharmonic components in the range 0.1 – 55 Hz are important to attenuate to maintain grid stability. Filtering the subharmonics in the sidecar, close to the loads, is the best possible location as the whole upstream sees a fluctuation-free power demand.

GrapheneSidecar delivers **Superior Power Density**

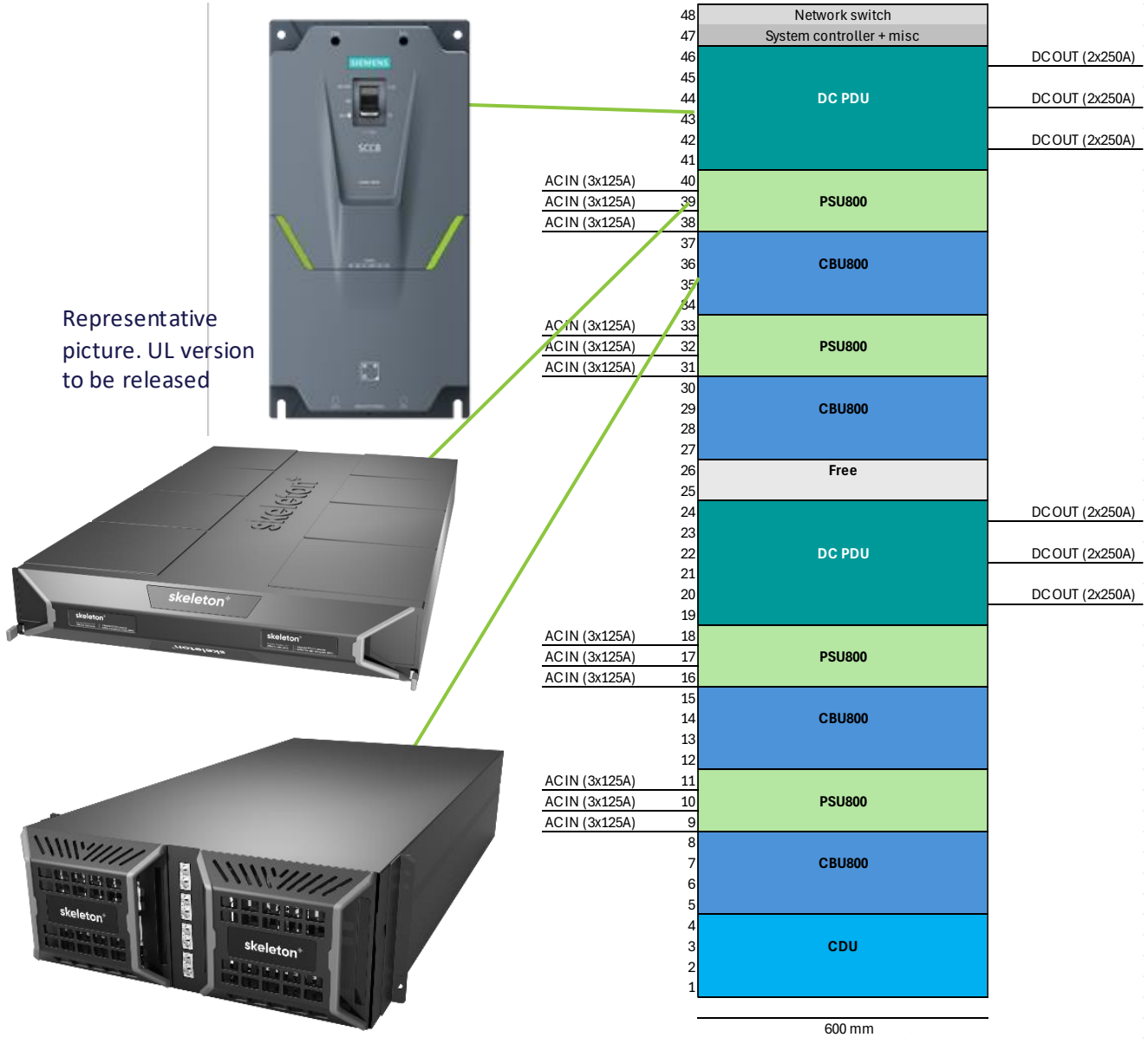
Liquid cooling allows packing **1.2 MW** of power into a 48OU cabinet.

PSU is 3OU high and delivers **300 kW continuous power**. It implements isolation and allows **bidirectional power flow** for applications like utility grid support with the CBU/BBU* energy.

Load smoothing is implemented with a **capacitor bank unit** (CBU) each providing 160 kW of continuous power and **240 kW peak**.

Solid-state circuit breaker (SSCB) are designed to form factors that are better fit in cabinet formats. They are implemented to ensure reliable protection to faults at all current levels and to protect against arc flash and capacitor discharge

**BBU – Battery Backup Unit*

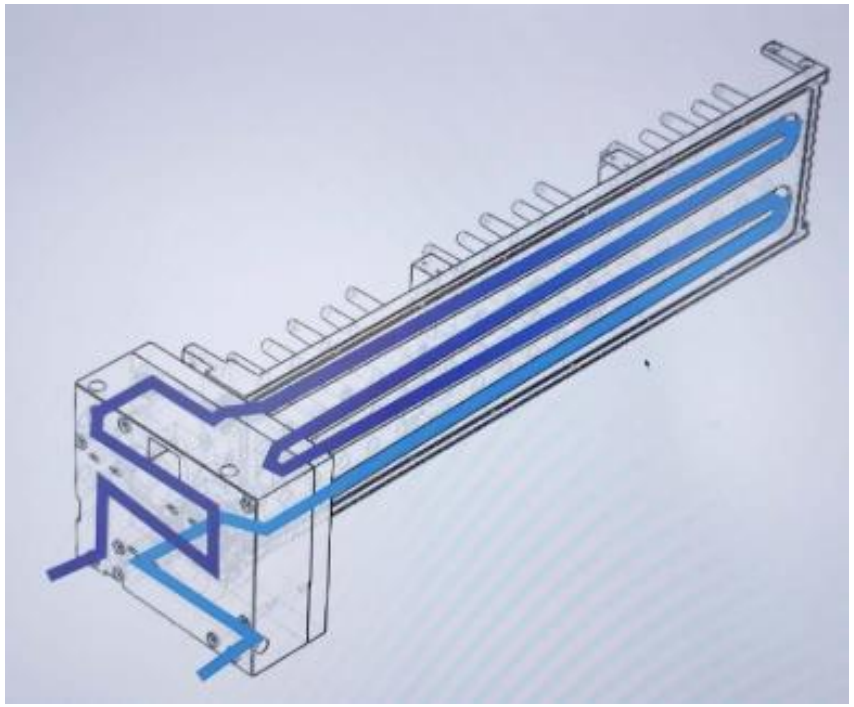


GrapheneSidecar delivers

Superior Power Density with Liquid Cooling

Liquid cooling allows direct conduction of heat away from the hotspots and enables the use of smaller, more power-dense **semiconductor switches** and **magnetic components** and **packing the energy storage efficiently.**

Currently, the power infrastructure is almost exclusively air-cooled, but as the power density grows, the liquid cooling infrastructure that is already available for the GPUs is likely to be extended to the power components.





Skeleton CBU800 module (bottom) and its cooling circuit (top).

Power electronics (delivering 80 kW continuous power and 120 kW peak) occupies 10-15 % of the volume – the remaining space is filled with supercapacitors.

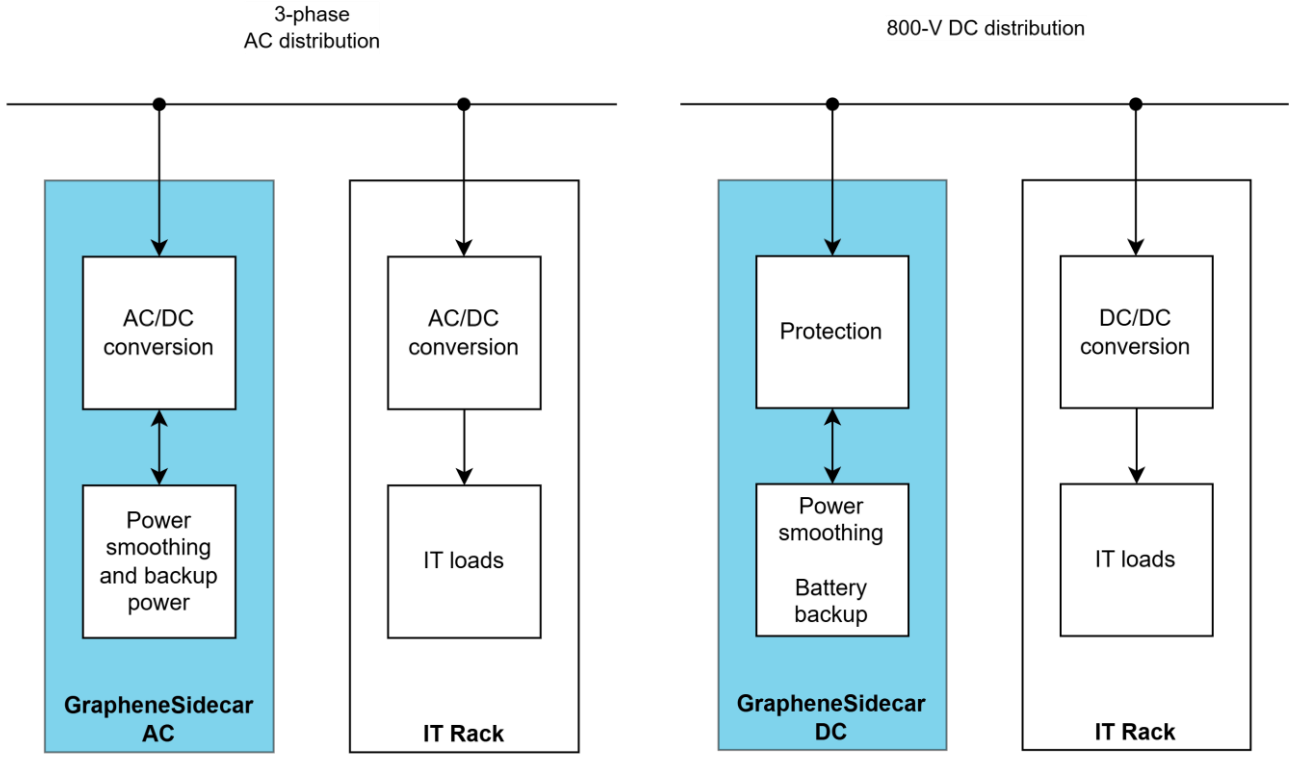
GrapheneSidecar is built **With Flexibility in Mind**

The GrapheneSidecar components allow building different kinds of sidecars.

GrapheneSidecar AC suits perfectly to existing installations where load smoothing needs to be implemented without modifying the IT racks.

GrapheneSidecar DC is future-ready for 800-VDC distribution in the data hall.





Left: GrapheneSidecar AC leaves out the DC PDU. It can be used as an AC-connected load smoothing unit or a single-conversion UPS.

Right: GrapheneSidecar DC leaves out the AC/DC conversion and can connect directly to 800-VDC distribution implementing load smoothing or battery backup.

Both designs utilize the same building blocks presented earlier.

A power sidecar is not just a relocated power shelf

What moves out of the IT rack

Conversion
415–480 VAC in over 12× 100A whips, out as 800 VDC via 6× 18.3 kW PSU shelves

Backup
BBUs giving 80 kW for 60 seconds

Redundancy
N+N feed configurations that no longer fit in the compute rack

Interface
Up to 250A interlocked DC whips, de-energized on mate and unmate

What the sidecar must add

Sub-second energy storage
slew rate control, input current shaping, smoothing and fault holdup, spanning microseconds to roughly one second

Fault current limiting
current limiting on every fault-contributing source, capacitors included, because DC arc flash methodology depends on it

Protection zoning
residual current monitoring using Solid State Circuit Breaker as fault energy grows

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The sidecar has to make a 600 kW rack look stable and predictable and that is a control and energy storage problem.

Get ready for the next-generation of rack level power architecture

- As rack power approaches 1 MW, power smoothing and fault protection can no longer be treated as separate functions.
- The industry needs scalable architectures that maintain stability, safety, and serviceability in 800 VDC environments.
- Combining solid-state circuit breakers for fast protection with high-power storage for peak load mitigation.

CALL TO ACTION

1. Help define power smoothing and protection requirements for 800 VDC
Join the Power Distribution sub-project and contribute to its LVDC workstreams.

2. Build on the Diablo sidecar specification
Extend the open sidecar architecture with standard interfaces for energy storage, load smoothing and solid-state protection.

3. Share benchmark load profiles
Common test profiles and attenuation targets, especially for the 0.1–55 Hz sub-harmonic band, will let the industry compare solutions on equal terms.

Thank You!

