Power Management Reimagined

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Market Drivers: Critical Power Infrastructure
Adding Sustainability Considerations

Drivers	Trend
Reliability / Service Level	• "Fail Small" / Reduce "blast radius" of equipment failures • Lower system level redundancy while reducing single points of failure • Power quality / harmonic mitigation • Fault Management
Operating Capability / Costs	• Increase infrastructure utilization / lower physical redundancy • Larger building block architectures, align equipment sizing • Controls: Increase automation, reduce cost of implementation and risk of human error
Deployment / Modularization	• Deploy in modular chunks vs total build up front, "Normalized" designs • Parallel path design / build activity • Move work from site back into the supply chain (lower cost and improve quality control) – Skids, MERs, FOK testing, remote FWT/CX testing

Sustainability / Decarbonization / Power Availability	• Deploy energy saving operating modes / piloting grid services
	• Reduce diesel generator starts
	• Enable integration of Distributed Energy Resources (DERs)
	  • Fuel Cell, BESS, Linear-Generator, on-site renewables
	  • Manage the challenging landscape of BYOP (Bring Your Own Power)

Initiatives to meet Sustainability Market Drivers

Increase delivered UPS power and efficiency

Increase N+1 utilization

Convert to lithium-ion batteries

Value engineer the critical power system

Reduce diesel generator presence

Environmental certification and LCA

A three-step approach to achieving carbon-free operations

- The first step, which many organizations have already taken, involves matching current energy use with renewable energy.
- The second, which is gaining traction today, focuses on increasing the utilization and efficiency of critical data center infrastructure.
- The final, and ultimately most transformational step, involves the shift away from utility power as the primary data center power source

Dynamic Power Architecture Evolution

UPS as Energy Center

- UPS is both source of power quality, backup and the energy manager
- Grid support capability
- BESS, Fuel Cell and other sources integrated on DC-bus with UPS
- Seamless transition between Operating Modes (DO, DGS, Load Sharing)
- Bi-directional rectifier to support mechanical loads

Battery Energy Storage System (BESS)

- Always On Power leverages BYOP and Sustainability
- Battery system supports Hybrid Power solution
- Grid Balancing supporting renewables
- Power quality improvements through Grid Forming converter

Dynamic Power: Portfolio of Hybrid Power Solutions for Mission-Critical Envirnoment

- Enable users to sustainably integrate and control their always-on power infrastructure and local energy sources
- Reduce/Eliminate Generator CO2 emissions
- Support grid balancing, renewables, and microgrids

UPS as Energy Center Key Technology Elements

	Customer Needs	Technology Enabler	Market Interest
In Deployment	Minimizing energy waste	Highly reliable, **high efficiency** equipment and its usage	◕
		Highly efficient **UPS operating modes**	◕
Early Pilots / Targeted Geo	Grid support to reduce carbon footprint, increase profit / costs savings	**Peak Shaving:** UPS batteries enable cost savings with demand management	◔
		Frequency Regulation: UPS batteries to support power generation constraints through rapid response to grid frequency variations	◔
Lab / Proof of Concepts / Initial customer approaches	Back up power and reduction of operational and embodied carbon footprint	**BESS as an AC source** power backup. Need separate solution for power quality.	◔
		MV Line Interactive UPS for higher efficiency and lower carbon footprint (Rotary UPS to start with). Supporting also Long Duration Batteries	◔
		Fuel Cell Integration: Integrate Fuel Cells to the UPS for backup	◔
		EM Controls while integrating multiple AC and DC energy Sources Including **Long Duration Batteries in HVDC and FC**	◔
		Other technologies (e.g. Phinergy, Mainspring Linear Generator,…)	○
Future Direction	Integrate multiple local energy sources	**UPS integration with renewables/low CO2 sources** (FC, PV, wind) in DC (on battery bus or DC bus) for both backup and prime power	○
		Micro-Grid: Energy Manager using different energy sources in DC (connected to UPS) and AC	○

Grid Services Opportunities

Demand & Response Services can be broadly categorized to target Frequency Management and Demand Management

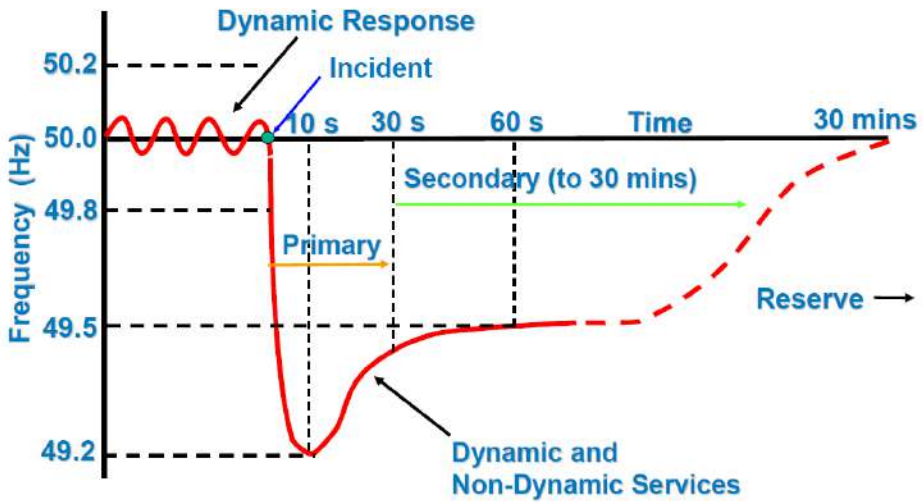
Frequency Management

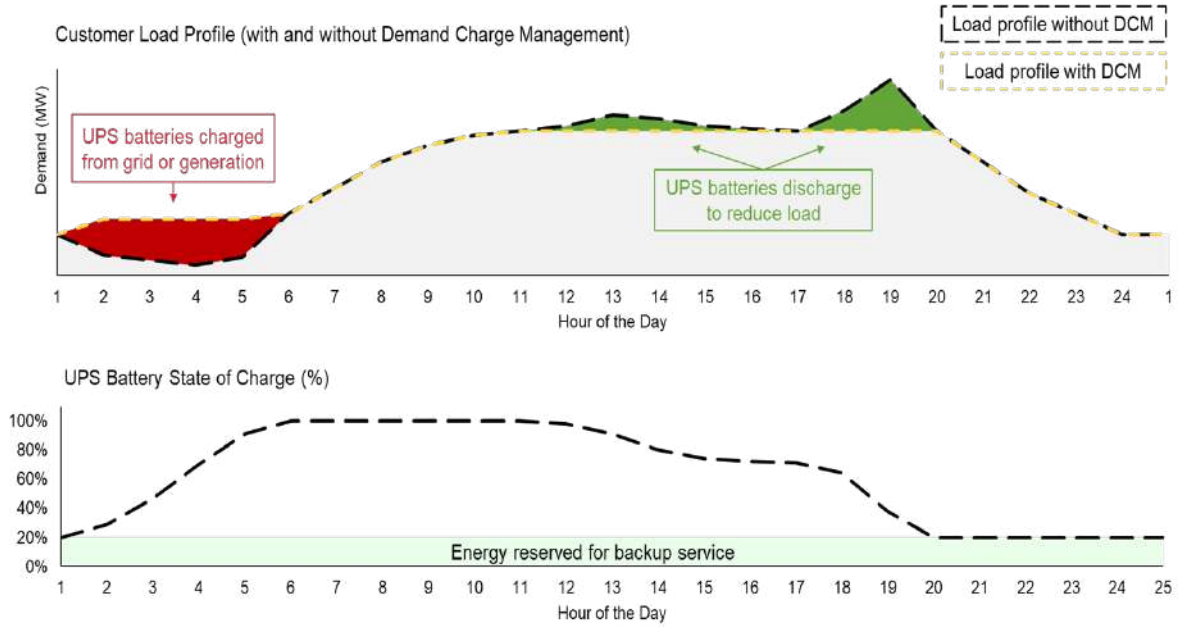
A **fast-acting balancing system** is needed to provide a quick response to sudden frequency variations and increase or reduce the electricity demand within a few Seconds (**fast frequency response** and primary reserves) or minutes (secondary reserve).

Demand Management (Peak Shaving)

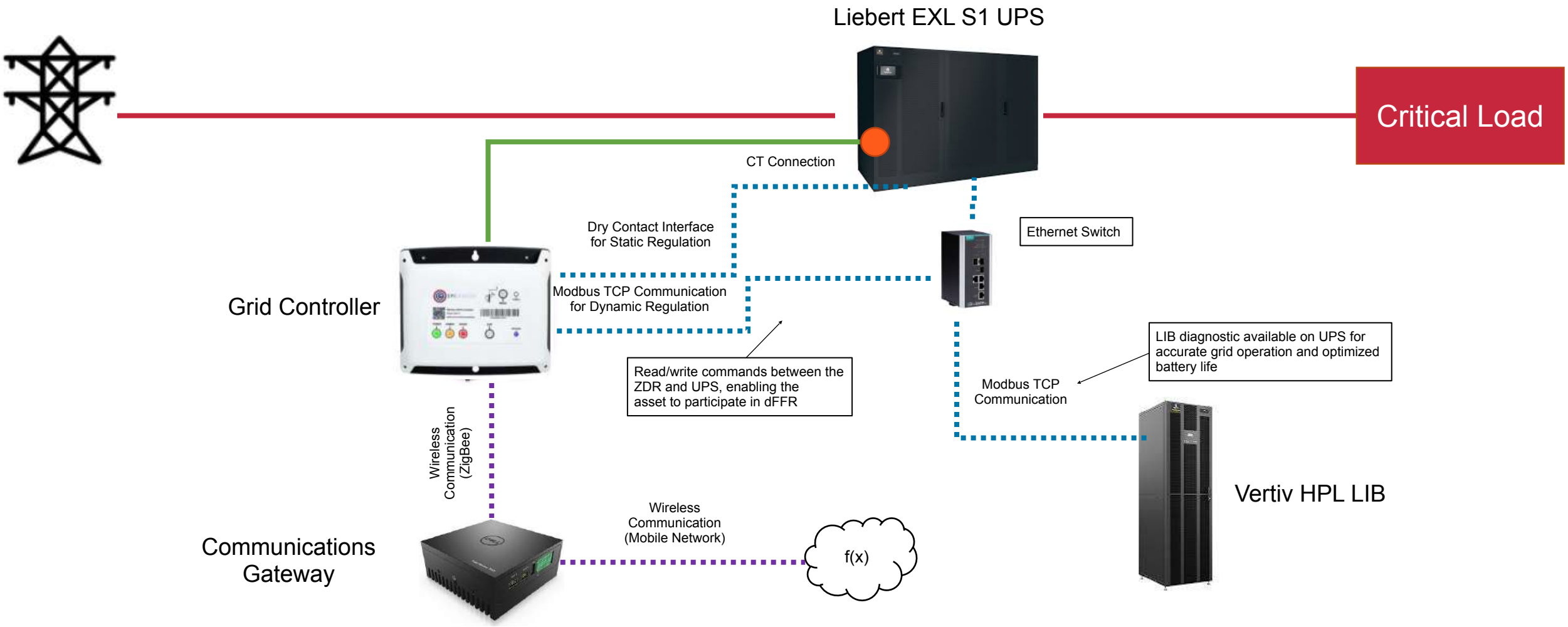
In times of low demand or high supply, energy is fed into storage, from which it is released at times of high demand or low supply. Alternatively, consumers adjust their energy consumption according to the changes in electricity market price or management of different auxiliary power sources.

The faster the response, the higher the revenue opportunity.





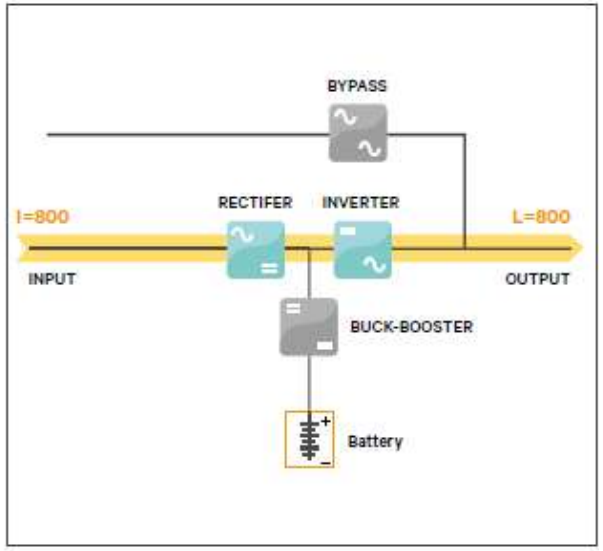
Liebert EXL S1 for Frequency Management – System Outline



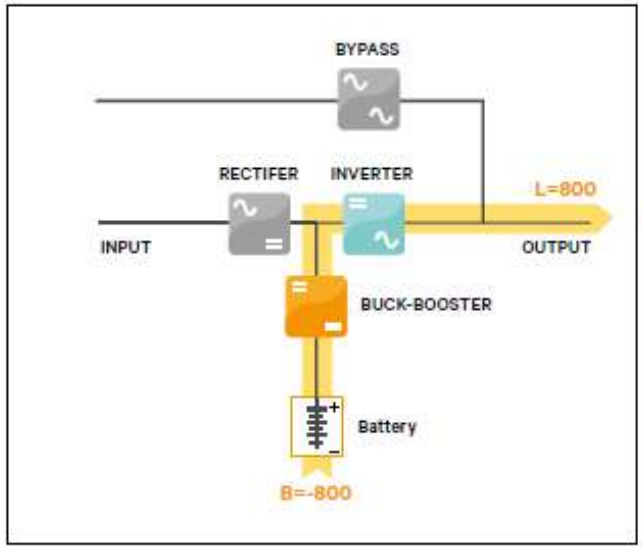
Static regulation via dry contact with predefined fixed power response activated at a predefined frequency deviation
Dynamic regulation via Modbus with dynamic power response based on frequency deviation

Intelligent Power Converter Operating Modes

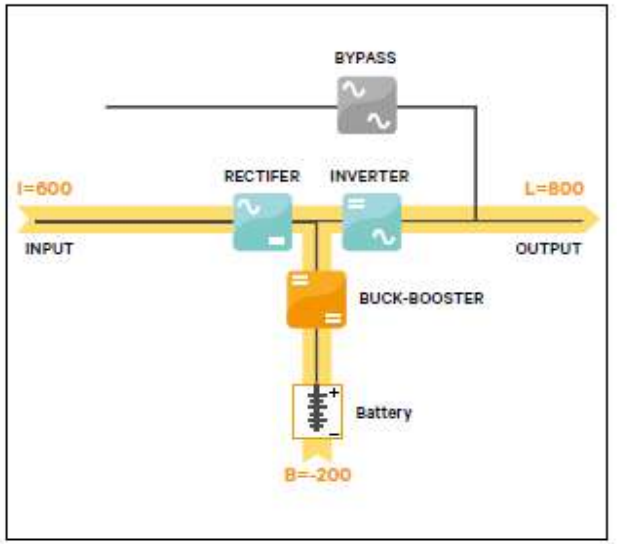
Normal UPS Operation



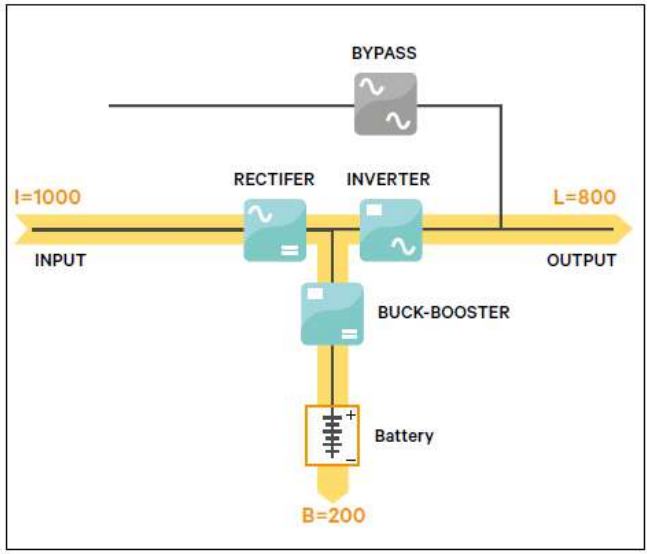
On Battery Mode



Source Sharing Mode

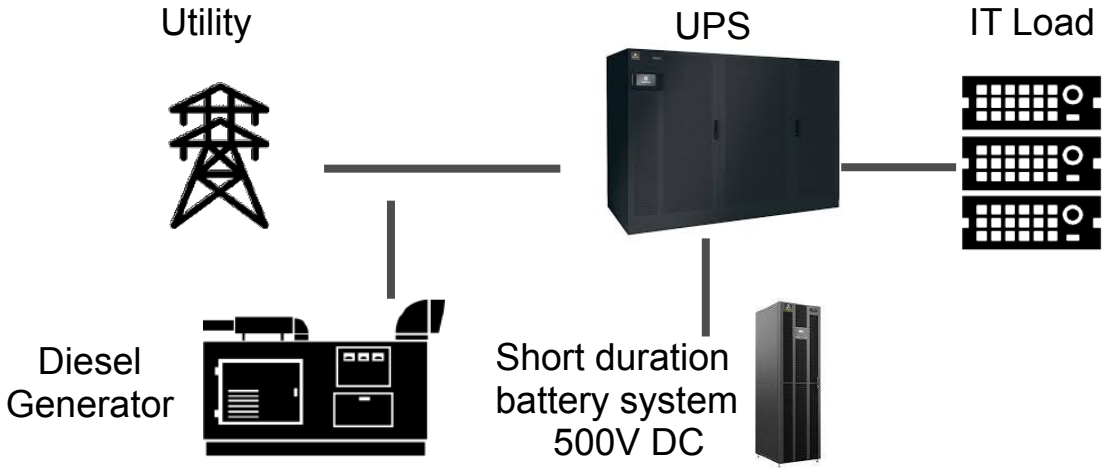


Battery Recharge Mode



Export Mode (Not Shown): The UPS is also able to manage energy export into the grid. When required, the UPS works as a bi-directional power converter, by discharging the batteries to inject power upstream the UPS.

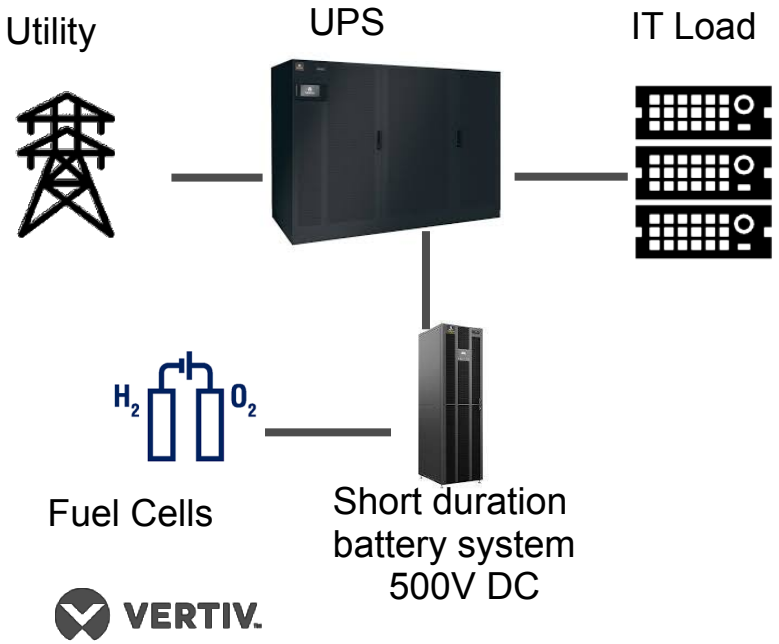
Backup Power Options- Current and Future



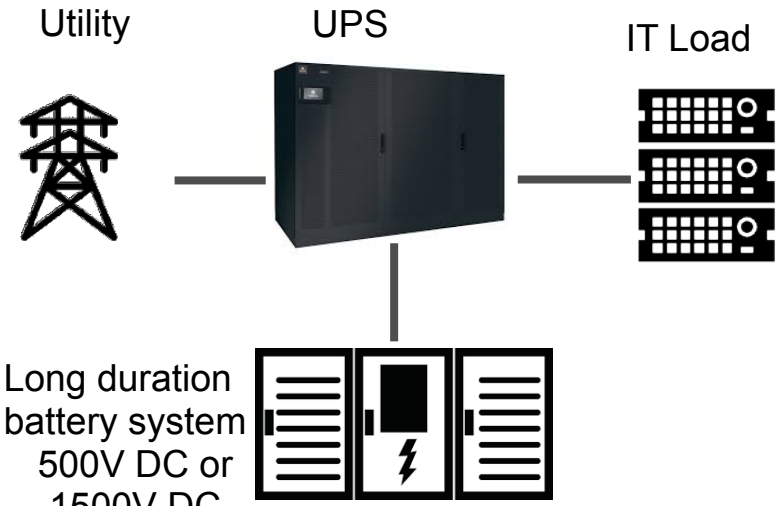
CURRENT

FUTURE

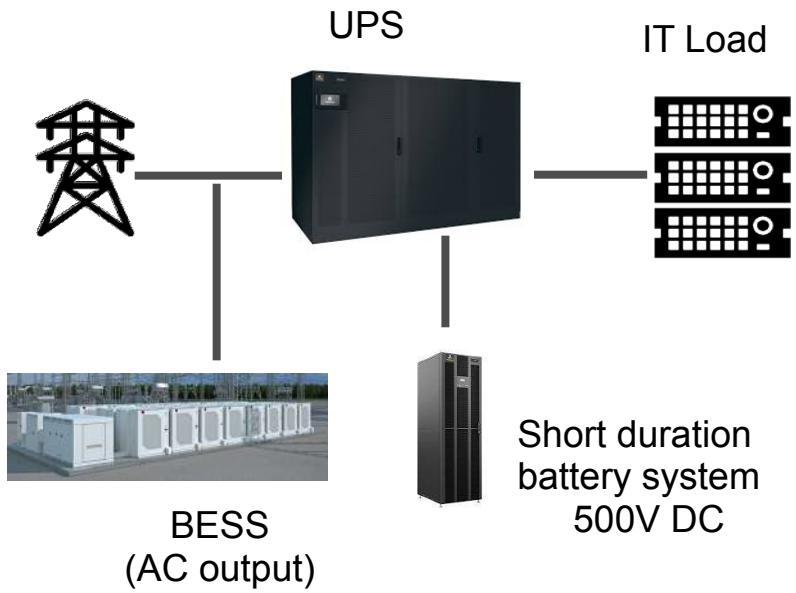
Scenario 1



Scenario 2

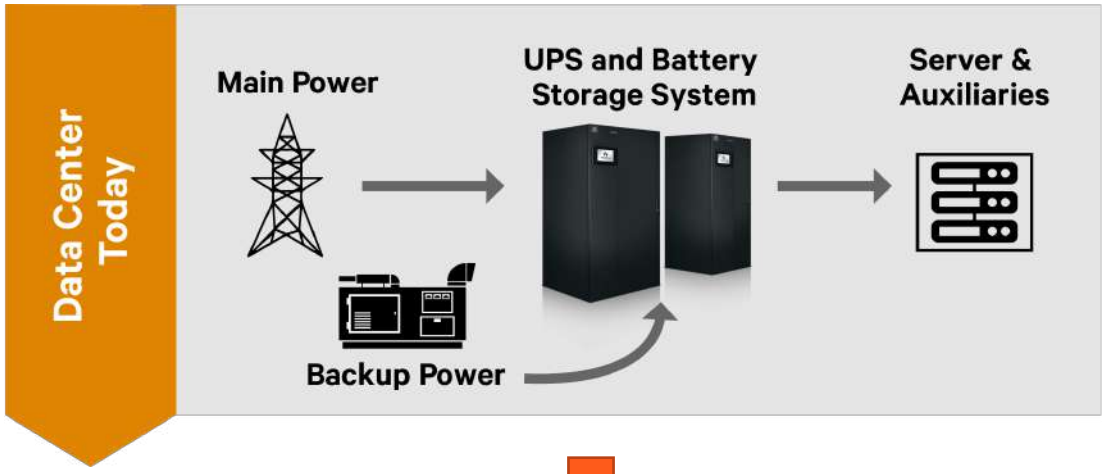


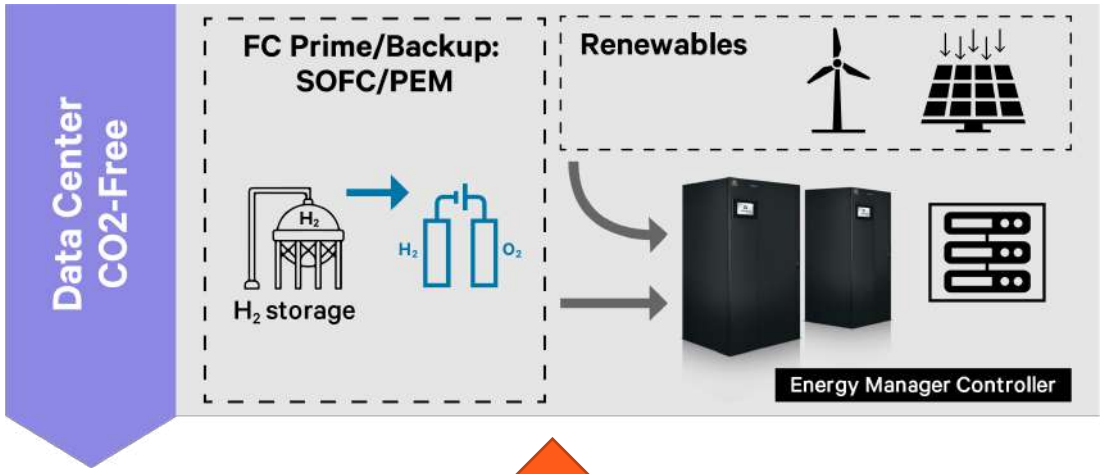
Scenario 3

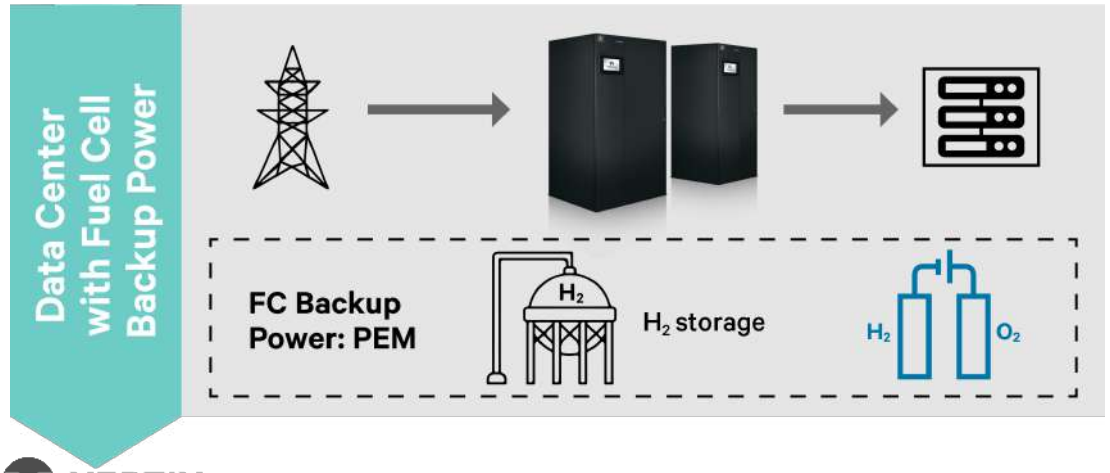


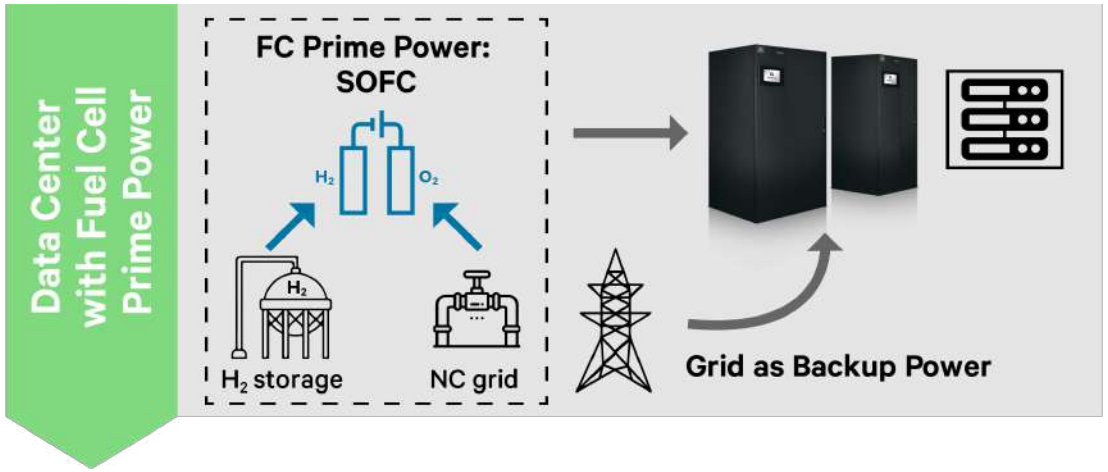
VERTIV.

The Path to CO_2 Free Operation: Fuel Cell Integration for Backup and Prime Power



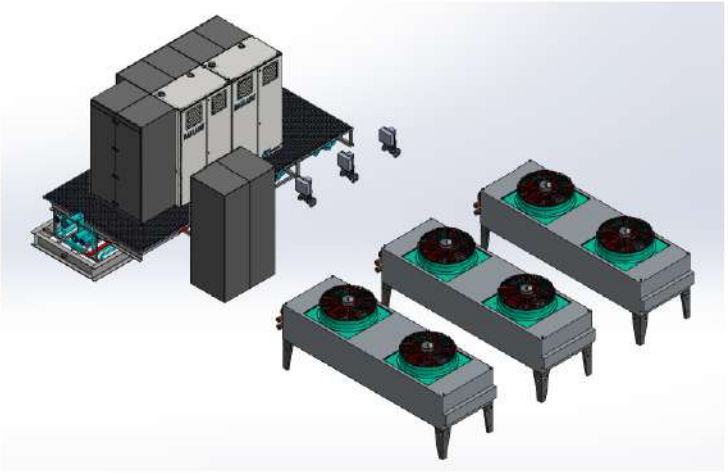






UPS Integration with Fuel Cells- Proof of Concept

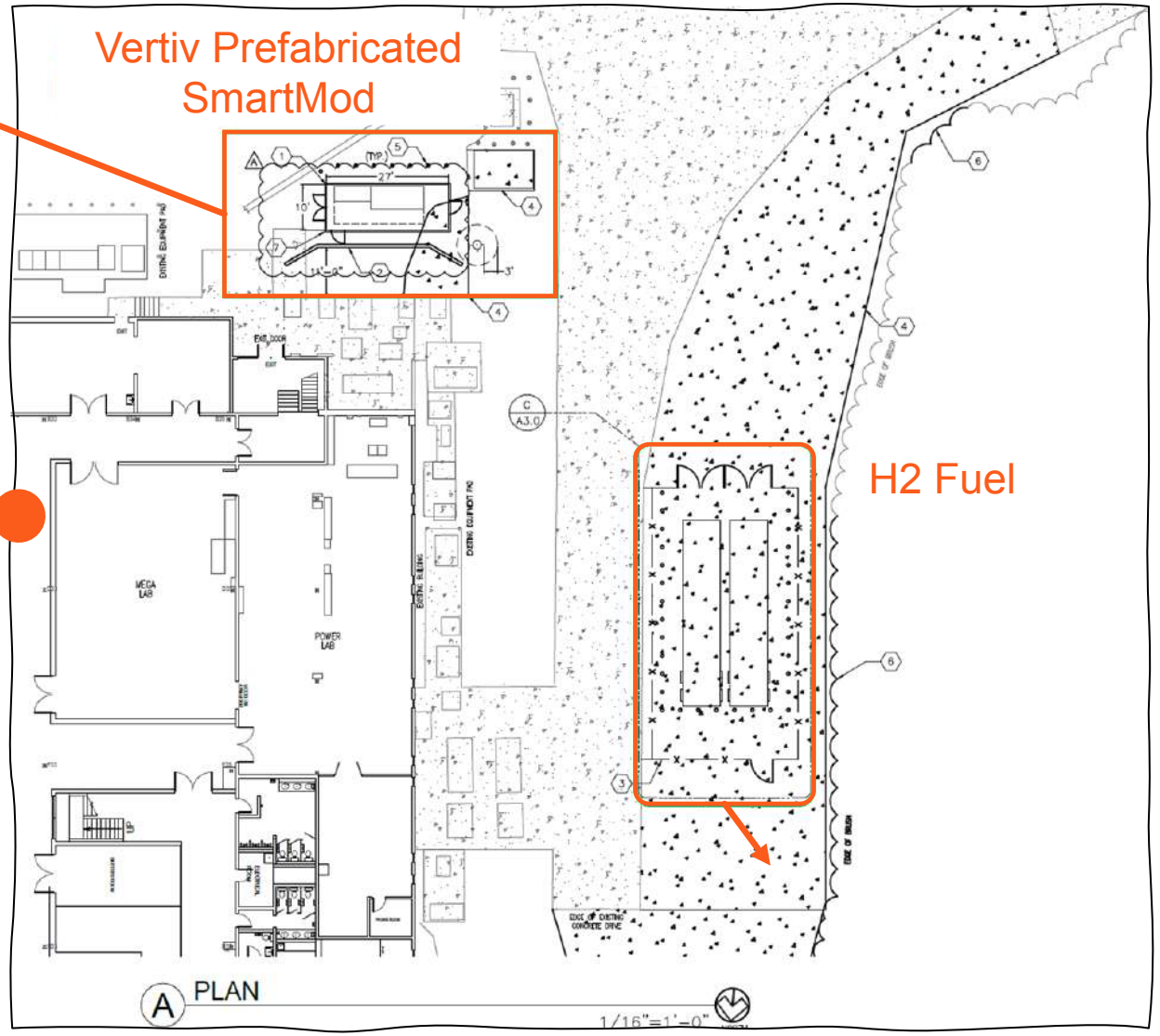
FC 400kW, FC DC/DC, Cooling system



Demonstration area

HPL6

EXL S1 1200kVA



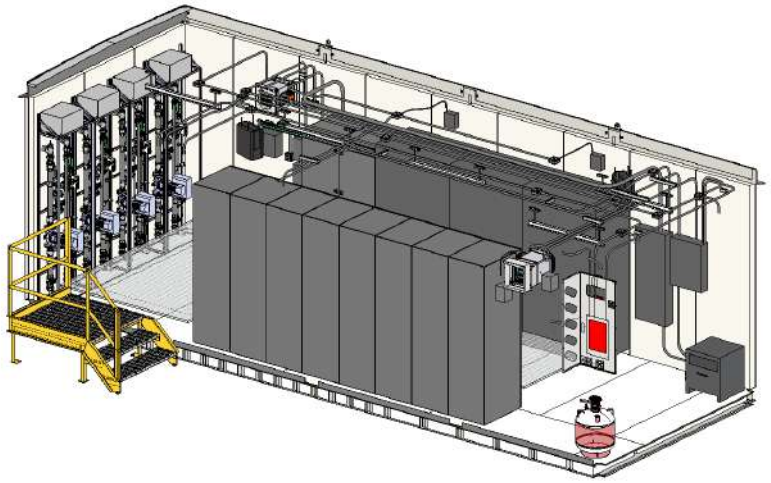
Final Installation

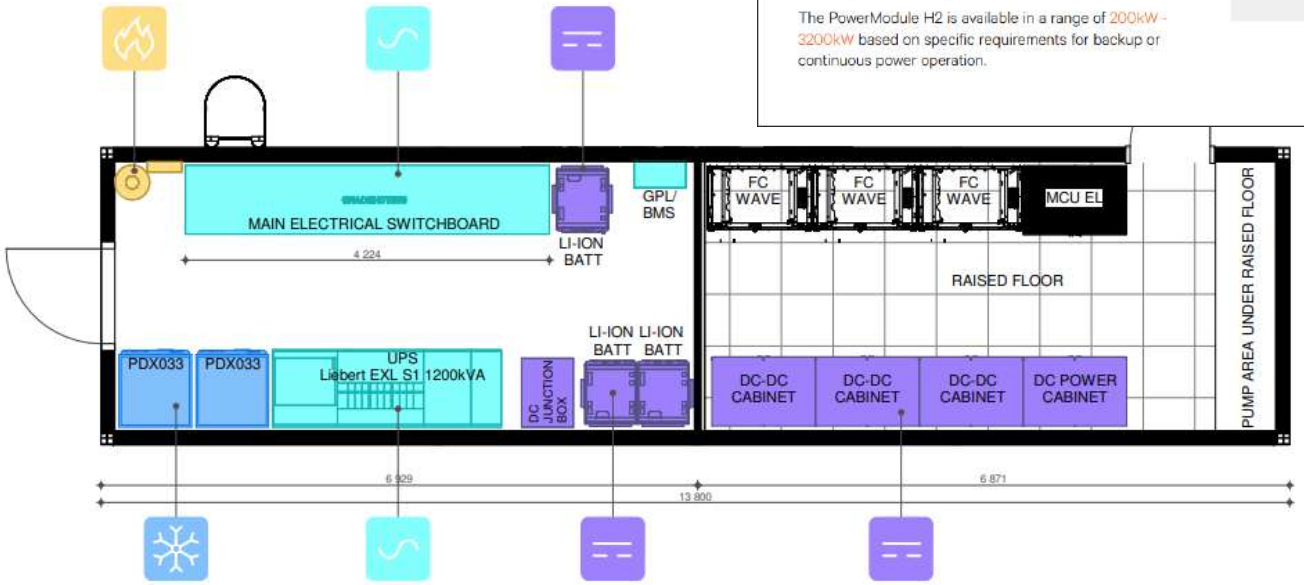
Customer Experience Area

Still under construction

- Will have multiple monitors that will display waveforms on the scope.
- Cameras will be installed in the Fuel Cell container to watch the equipment during live operation.

H2 Power Module





Vertiv™ Power Module H2 — VERTIV.

Vertiv Power Module H2 - The Future of Data Centre Power

Cut off view of the Vertiv™Power Module H2

The rise of new technologies, like generative AI, IoT, AR/VR, is increasing the need for energy in today's data centers and it is often surpassing the capacity available from existing power grids resulting in an urgent call for onsite power generation.

Traditional back-up options such as diesel generators, are becoming less viable due to the urgent need to combat global warming and the resulting sustainability regulations that are one of the prevailing challenges in data center industry today.

The Vertiv Power Module H2 is a sustainable alternative for meeting escalating energy demands of future data centres as well as targeting zero-emission power generation.

The PowerModule H2 is available in a range of 200kW - 3200kW based on specific requirements for backup or continuous power operation.

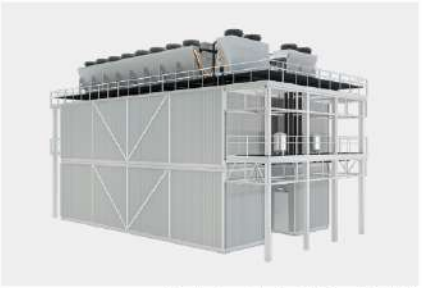
Advantages of Vertiv™ Power Module H2

By merging UPS and hydrogen Fuel Cell technology into a single solution, the Vertiv Power Module H2 extends the application of reliable UPS backed-up power:

- **As an alternative to Diesel Generator**
- **To prime power application with zero emissions and low CO_2 footprint**

Vertiv Power Module H2 is also retaining all the well proven benefits of a prefabricated Power Module design:

- **Single-supplied complex power infrastructure solution**
- **Rapidly deployable and factory tested**
- **Simple, seamless on-site integration**
- **Scalable design, pay-as-you grow model**



Exterior view of the Vertiv™ Power Module H2

Fuel cell benefits

- Proven and established power solution for various applications
- Can support true carbon-neutral data center operation
- Increased operational reliability and energy management in data center operations when paralleled with UPS and Li-Ion batteries
- Longer back-up times compared to batteries; can support up to 48 hours of continuous operation for 1 MW data center
- Superior efficiency and less maintenance compared to diesel generators

Conclusions

Vertiv Dynamic Power reimagines power management for companies who want to build new critical infrastructures but struggle to meet increased power demand and the constraints and complexity of available power.

- **Reducing dependence on carbon-based fuels** represents a competitive advantage in the short term and a necessity in the long term.
- Working with a forward-thinking and innovative infrastructure partner like Vertiv puts you in the position to move forward **with proven technologies** that allow you to take steps today toward a carbon-free tomorrow.
- Vertiv stands ready to work in partnership with customers seeking **to reduce or eliminate their reliance on carbon energy sources.**


VERTIV.