HyperNext Data Centers | Research

HN-RP-014

Three Minutes, and Where to Keep Them

Distributed battery backup in an 800 volt direct current hall

What ride-through is actually for. Why the battery moved twice before it settled. What lithium iron phosphate gives up, and what it buys back.

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Three Minutes, and Where to Keep Them

This paper is part of the HyperNext Research series. Method, assumptions and source data are stated so another operator can reproduce the analysis on their own facilities. Citation as "HyperNext Research, HN-RP-014" is welcome.

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01 What the battery is actually for

Ask most people what a data centre battery does and they will describe something that keeps the building running when the power goes off. That is not what it does, and designing as though it were is how facilities end up with rooms full of cells that are mostly a fire load.

The generator runs the building. The battery covers the interval before the generator is ready to, and that interval is short and reasonably well characterised. A loss of supply has to be detected, which takes a second or two. A generator has to start and come up to speed and voltage, which on a modern set is under ten seconds. The load then has to be transferred and accepted, which is a few seconds more. Nothing in that sequence takes minutes.

HyperNext provides about three minutes. That is not an autonomy figure in any useful sense, it is a margin of roughly ten over the worst case, and it exists to absorb the things that go wrong: a generator that fails to start first time and has to be tried again, a transfer that has to be repeated, an operator decision that takes longer than it should. Three minutes buys several attempts at a sequence that normally works first time.

FIGURE 1

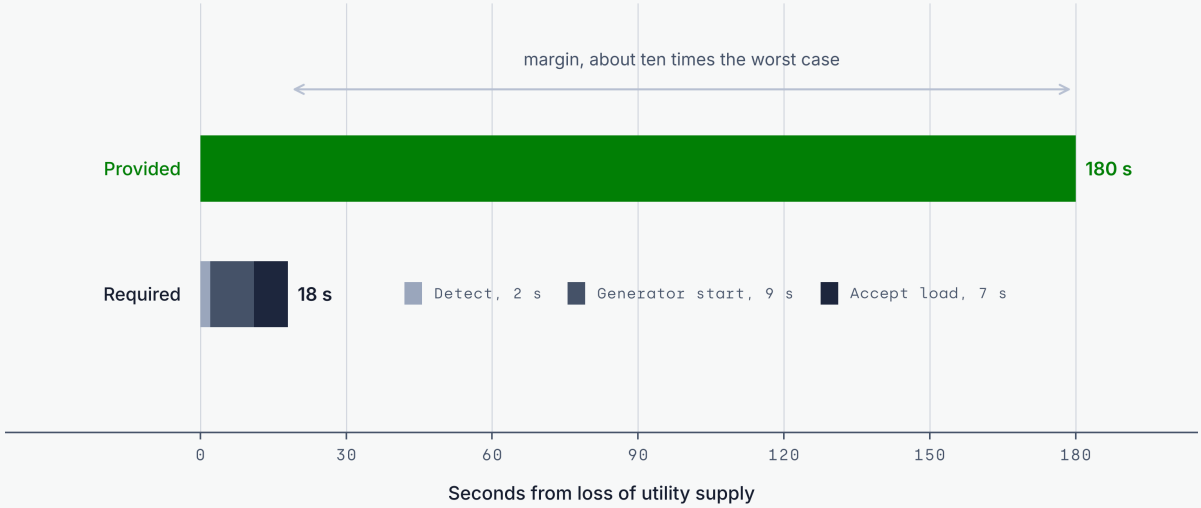


Figure 1. What the battery must cover against what it holds. The three segments are worst-case values for the HyperNext campuses, not typical ones.

SAID PRECISELY

HyperNext has no lithium uninterruptible power supply in the core of the electrical system. There is no room of central static plant standing between the incoming supply and the hall. There is lithium in the building: it is in the battery drawers described here, distributed across the panels, in quantities set per panel by the racks that panel feeds. Those are different statements and conflating them would be dishonest.

02

Where it sits, and why it moved twice

The battery has been in three places during this design. It is worth writing down why, because the reasoning is more useful than the conclusion.

It started inside the rack power panel at 800 volts, which is the obvious place: the energy is needed on the panel bus, and putting it there avoids a conversion stage. Then it moved into the racks as a 48 volt shelf, on the argument that the Open Compute 48 volt battery backup unit is a tested, widely deployed and well understood piece of equipment, and that building an 800 volt one meant building something with no field history. That was a good argument and it is the reason the change was made.

It moved back. The deciding consideration was not the one the earlier discussion had been about. A HyperNext hall carries two kinds of rack: direct current racks with conversion shelves feeding a 50 volt busbar, and conventional alternating current racks fed through in-rack converters. An in-rack 48 volt battery backs the first kind well and does nothing useful for the second, because the alternating current rack has no 48 volt bus to support. Backing both from one place means backing them where they are both still at 800 volts, which is the panel.

FIGURE 2

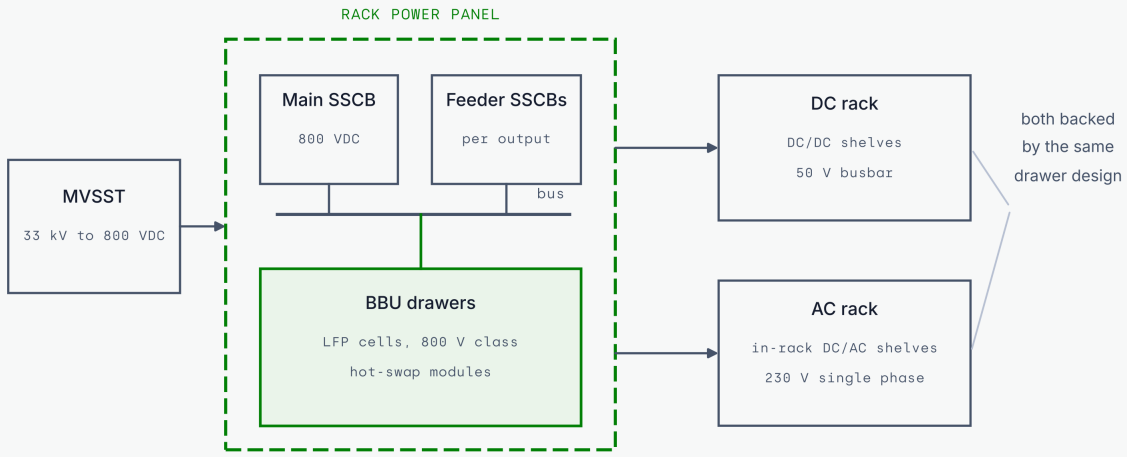


Figure 2. Where the drawers sit. Supporting the panel bus backs the direct current racks and the alternating current racks through one drawer design.

There is a second consequence that only became clear afterwards. A battery in the panel is in a room a technician can work in, with its own enclosure, its own thermal design and its own detection. A battery in the rack is inside a cabinet full of customer equipment, sharing an air path with it. For a device that stores energy and occasionally fails, that is a meaningfully worse place to be, and we should have weighted it more heavily the first time.

03 The chemistry argument

Lithium iron phosphate stores less energy per kilogram than the nickel manganese cobalt chemistries. It was chosen anyway, and not reluctantly.

Energy density matters when the thing being designed has to be

FIGURE 3

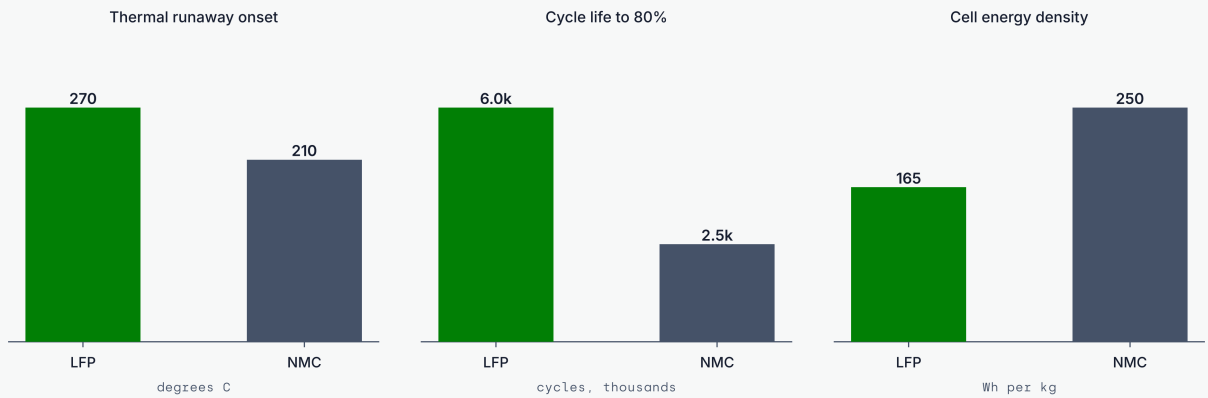


Figure 3. The three properties that decided the chemistry. Figures are indicative of the cell classes rather than of any particular cell.

carried. A phone cares, a car cares, and a battery drawer bolted into a panel on a concrete floor does not. The drawer is not weight limited and the hall is not volume limited in the way a vehicle is. Paying a density penalty costs floor area and mass, both of which a data centre has.

What a data centre does not have is tolerance for a thermal event in an occupied building full of other people’s equipment. The iron phosphate cathode is thermally more stable and its runaway onset temperature is substantially higher, which means the margin between normal operation and the beginning of a problem is wider. When a cell does fail, the energy released and the gas evolved are lower, which is the difference between an event contained in one module and an event that propagates.

Cycle life points the same way. A backup battery is not cycled much by its duty, so cycle life sounds irrelevant. It is not, because calendar ageing and cycle ageing are both lower on this chemistry, and the asset has to sit in a building for fifteen years without becoming a replacement programme. The chemistry that degrades more slowly is the one that stays a capital item rather than an operating cost.

04 The drawer, the module and the hot swap

The drawer is the unit the panel sees. The module is the unit maintenance sees. Keeping those two separate is most of what makes the design serviceable.

Inside the drawer, the battery modules are individually hot-swappable. That sounds like a convenience feature and it is a redundancy decision.

FIGURE 4

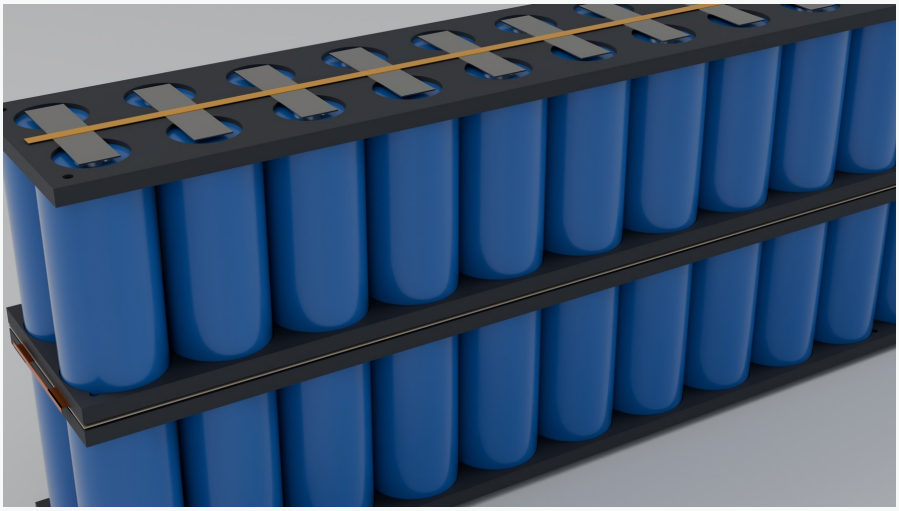


Figure 4. Cell arrangement within a module. Spacing, restraint and the path heat takes out are design decisions, not packaging ones.

FIGURE 5



Figure 5. A battery drawer. Built in full at 100 kW with provisions carried for 150, so a later uprating does not require a different enclosure.

If the drawer were the smallest replaceable unit, a single cell problem would take the whole drawer out of service and the design would have to carry a spare drawer to cover it. With module level replacement, a cell problem removes one module from a drawer that keeps working at reduced capacity, and the spare that has to be held is a module.

How many drawers a panel carries is set by what that panel feeds rather than by a standard fill. A panel serving conventional colocation racks at twelve to eighteen kilowatts needs a fraction of what a panel

FIGURE 6



Figure 6. Module removal with the drawer in service. The remaining modules carry the drawer through the exchange.

serving dense compute needs, and populating both the same way would mean either underprovisioning one or buying cells that sit idle in the other for fifteen years.

TABLE 1

DECISION	WHAT WAS CHOSEN	WHAT IT RULES OUT
Location	Inside the rack power panel	Backing only one kind of rack
Chemistry	Lithium iron phosphate	The highest energy density available
Replaceable unit	Module, not drawer	Holding whole drawers as spares
Build rating	**100 kW, provisions for 150**	**A different enclosure at the uprating**
Autonomy	About three minutes	Running the building on batteries
Monitoring	Integrated to the building system	A battery system nobody looks at

The decisions and their costs. Every row gives something up, and a design note that lists only what was gained is not a design note.

05

Following Open Compute at the connector

Connectors are where a well-intentioned in-house design usually strands itself.

It is tempting to design a connector. The requirement is specific, the published options never quite fit, and an in-house interface can be made a little smaller or a little cheaper. It is also how equipment

becomes unserviceable in ten years, when the part is out of production and the only source is the organisation that designed it.

The module plug and receptacle follow the Open Compute high-voltage direct current rear blind-mate interface. The drawer output follows the Open Compute 800 volt class interface. Neither was the easiest route and both mean a part that somebody else also makes, specifies and stocks. The latches and handle touch points are finished in the Open Compute green rather than the HyperNext brand green, because a technician who has worked on this class of equipment elsewhere already knows what that colour means and a house colour would be teaching them something new for no reason.

FIGURE 7

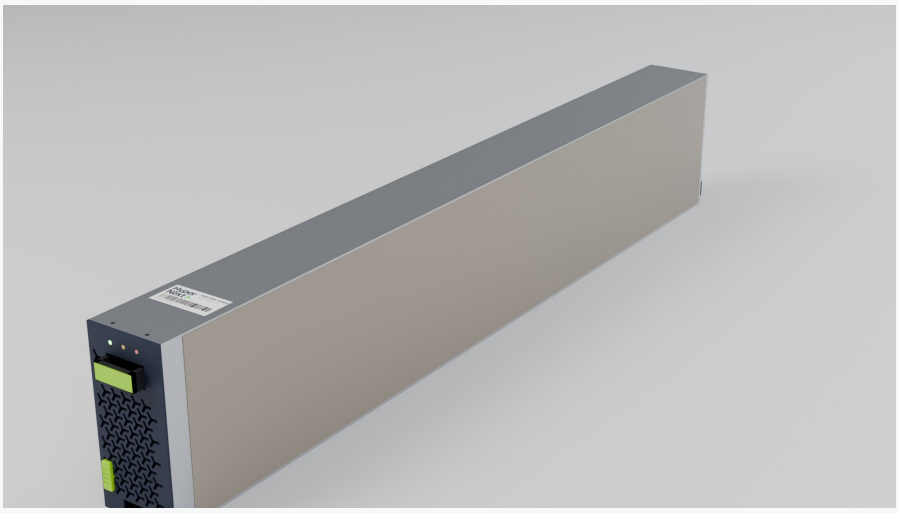


Figure 7. A battery module. The interface at the rear is a published one, which is the point.

WHERE HOUSE STYLE STOPS

HyperNext applies its own design language thoroughly, down to the perforation pattern in the panel door. It stops at anything a technician has to interpret under pressure. Safety colours, latch conventions and connector keying belong to the standard, not to the brand.

06

What three minutes costs, and what thirty would

The case for a short autonomy is easiest to see by pricing a long one.

Stored energy scales linearly with autonomy, and so does almost

FIGURE 8

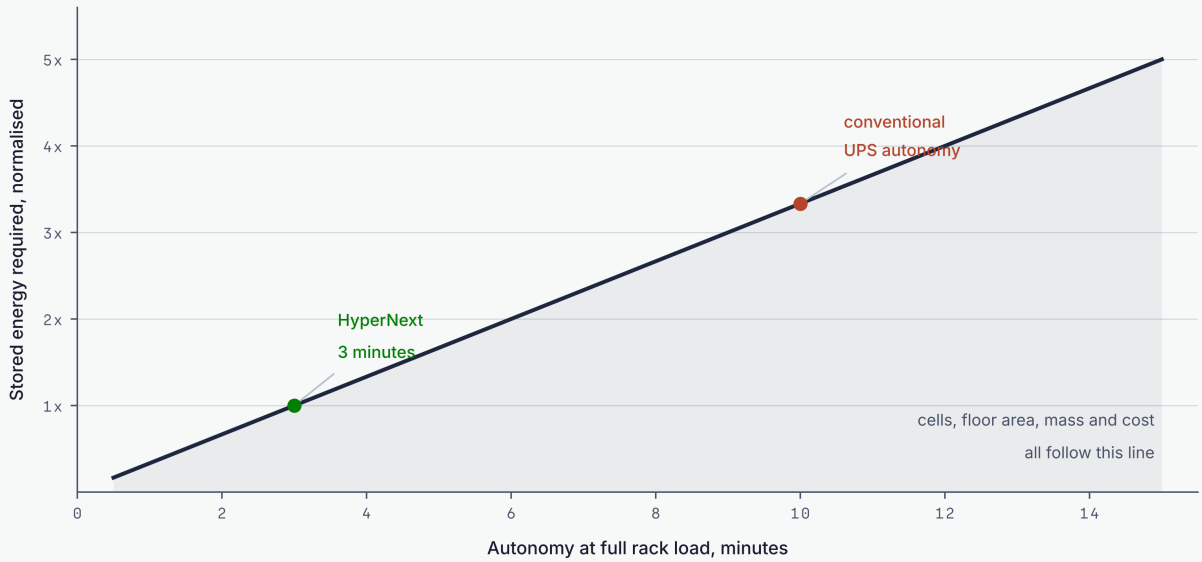


Figure 8. Stored energy against autonomy, normalised to the three minute design. The relationship is linear, which is the entire argument.

everything that follows from it. Ten times the autonomy means ten times the cells, roughly ten times the mass, ten times the floor area and ten times the capital. It also means ten times the stored energy sitting in an occupied building, which is the part that does not appear on a cost sheet.

Against that, what does the extra time buy? If the generators start, it buys nothing, because the load transferred at eighteen seconds and the rest of the battery was never touched. If the generators do not start at all, no realistic battery saves the facility: half an hour of autonomy with no generator is half an hour of orderly shutdown, which is a different design objective and should be specified as one rather than arrived at by overbuying batteries.

The honest framing is that autonomy beyond the transfer sequence buys attempts, not runtime. Three minutes buys roughly ten attempts at a sequence that takes eighteen seconds. A fourth minute buys three more attempts at a sequence that has already failed ten times, which is not a scenario where more battery is the answer.

FIGURE 9

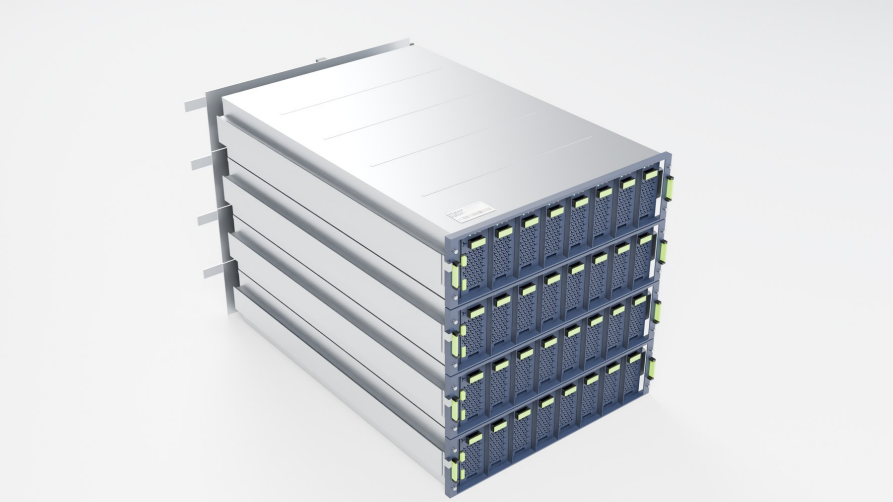


Figure 9. Drawers stacked within the panel envelope. Floor area is the resource this design spends instead of energy density.

07

Keeping the cells at the right temperature

A battery in standby dissipates almost nothing, which leads people to conclude that a battery enclosure does not need a thermal design. It is the wrong conclusion, and it is the one that decides how long the asset lasts.

Lithium cells age on temperature whether they are working or not. Calendar ageing roughly doubles in rate for every ten kelvin, so a drawer sitting at 40 degrees for fifteen years is not storing the same asset as one sitting at 30. Nothing in that sentence depends on the battery being used. It happens while the equipment does nothing at all, which is most of its life.

Uniformity matters as much as the absolute figure. A pack whose cells sit at different temperatures ages unevenly, and a pack ages at the rate of its worst cells rather than its average. The thermal design of the drawer is therefore aimed at a small spread across the cells rather than at the lowest achievable peak, which is a different optimisation and gives a different arrangement.

Air enters through the module faces and leaves through the rear of the drawer. The rear panel is the exit and its open area is made as large as the structure allows, because a restricted exit raises pressure across the whole path and the fans spend their capacity on the restriction rather than on the cells. The intakes are grilles rather than solid faces with a token slot, for the same reason at the other end.

THE ONE THAT ACTUALLY BITES

The discharge the drawer is designed for lasts under twenty seconds and happens rarely. The thermal condition that determines when the cells are replaced is the one they sit in for the other fifteen years. Designing the cooling around the discharge event optimises for the rare case and neglects the continuous one.

There is a second reason for the airflow that has nothing to do with ageing. In the event a cell does fail, a designed path moves gas and heat out of the enclosure in a known direction rather than letting it find its own way through an equipment room. Detection, containment and the exit path are one design, not three.

08 References and standards

01 **OCP Diablo, v0.5.2, May 2025**
Open Compute Project sidecar power rack specification, including the high-voltage direct current rear blind-mate interface the drawer output follows.

02 **OCP Open Rack V3 power and battery backup specifications**
The mechanical and management conventions the module and drawer follow.

03 **IEC 62619**
Safety requirements for secondary lithium cells and batteries for use in industrial applications.

04 **IEC 63056**
Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems.

05 **NFPA 855, Standard for the Installation of Stationary Energy Storage Systems**
The separation, detection and suppression practice referred to in section 3.

06 **UL 9540A**
Test method for evaluating thermal runaway fire propagation in battery energy storage systems. The method behind the propagation claims in section 3.

07 **HyperNext Research, HN-RP-012**
Breaking Direct Current at the Rack. Describes the panel these drawers sit inside.

08 **HyperNext Research, HN-RP-013**
Wide Bandgap Conversion at the Shelf. Describes the shelves the drawers support.

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