

# What's UP(S) with lithium-ion batteries?

## The implications of this modern technology advancement for UPS solutions

**Lithium-ion UPSs represent a significant progression in UPS battery technology, which for decades has been dominated by valve-regulated lead acid (VRLA).** Because lithium-ion batteries offer a 10- to 15-year lifespan—as opposed to their lead acid counterparts, which generally need to be replaced every 3 to 4 years—the technology offers a number of advantages.

Eaton has been testing and shipping lithium-ion batteries for the past two years, with successful deployments in hyperscale, financial and aerospace data centers. Currently, the three-phase Eaton 93PM and 9395 UPSs are qualified to work with either LiION or Samsung lithium batteries. Eaton has also introduced the lithium-powered 5P Global Rackmount 1U UPS.

### Why lithium?



#### What are the primary advantages of switching to lithium-ion UPS batteries?

The most common reason our clients cite for making the change is the significantly longer service life. Lithium-ion also provides a greater cycle life (the number of charge/discharge cycles ranges from 5000 to 9000, versus approximately 500 for VRLA batteries), as well as a longer warranty. Furthermore, the lighter weight and smaller footprint are additional benefits valued by UPS customers.

In addition, IT professionals can easily deploy lithium-ion UPSs without the maintenance and refresh challenges of those utilizing lead acid. The extended battery life provided by lithium-ion enables users to align their UPS refresh cycles with the rest of IT stack, saving time and money spent on labor and replacement batteries. Furthermore, lithium-ion UPSs boast a “set it and forget it” value proposition, which is especially conducive at sites where UPSs protect critical network operations yet IT resources are not extensive.

#### Are there small office/rackmount footprint UPS solutions available now on the market?

Yes, office-sized UPSs with lithium batteries are now available. Although more expensive than VRLA-powered UPSs, they are dramatically lighter and the battery will typically last the entire life of the UPS. Eaton offers the [5P rackmount UPS in a lithium-based model](#).

#### What are some of the downsides of lithium batteries compared to VRLA?

The primary downside is that because the technology is so new, manufacturers have limited experience in UPS applications. However, this is changing rapidly, with successful deployments now exceeding three years.

### Safety



#### Do lithium batteries pose a higher fire risk than VRLA batteries?

While any battery has the potential to catch fire if abused, lithium has a reputation for more dramatic ‘thermal events.’ However, in UPS applications, the presence of a Battery Management System (BMS)—which controls charge rate, voltage and temperature—makes lithium batteries less likely to enter thermal runaway than traditional UPS batteries. Additionally, the manufacturing of lithium UPS batteries is not as restrictive on packing size as other applications such as cell phone or laptop battery modules, which have appreciably constricted space. UPS manufacturers are able to utilize the extra space to ensure that the plates inside the battery will not short out, even in extreme conditions. As long as the battery and its packaging are designed to dissipate more heat than can be created on overcharge, the battery cannot go into thermal runaway. All UPS vendors and battery vendors are ensuring that this is the case for lithium products.

#### Have your lithium-ion UPSs experienced any battery failures or fires?

At this time, no UPS manufacturer has suffered a thermal event with its lithium batteries. As mentioned, the presence of a BMS has been instrumental in the detection and mitigation of any anomalies. While we have seen individual batteries fail to retain a charge, these rare instances were not thermal-related and occurred only after we abused the batteries in our lab with stress testing. When the individual cells were replaced, the system operated correctly.



Powering Business Worldwide



### Lithium-ion batteries

- Cost-effective
- Compact
- Safe

# Save money



## Cost

### **Are lithium-ion batteries more expensive?**

Yes. In general, they vary from slightly more expensive than good-quality VRLA, to two to three times more expensive, especially when shipping costs and commissioning services are considered. Lithium batteries can be sensitive to high temperatures during transit, requiring manufacturers to ship loose batteries in refrigerated trucks. In addition, Eaton requires a customer service engineer to be on site for large battery cabinet startup service, which isn't needed for VRLA batteries.

It is important to note that in the near future, when vendors start shipping battery cabinets pre-loaded with batteries, we expect the shipping costs for lithium batteries will actually be slightly less than that of VRLA batteries.

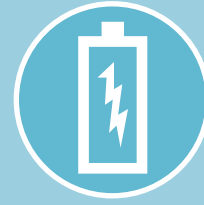
### **Is lithium-iron phosphate (LFP) less expensive than other types of lithium batteries?**

LFP costs up to 60 percent more than other chemistries. However, in addition to its exceptional safety profile, LFP provides a full bumper-to-bumper 10-year warranty on all components within the cabinet, including batteries, breaker, wiring and the battery management system). Other warranties are also 10 years, but not as comprehensive.

### **Does Eaton offer customers any monetary incentives to switch to lithium-ion?**

Eaton is currently considering incentive programs. In the meantime, [please visit our online tool](#), which provides a quick Total Cost of Ownership/ROI analysis comparing the cost of retaining an existing UPS battery versus replacing that battery with a 10-year lithium system.

# Recharge faster



## Batteries/charging

### **Are there different recharge rates between lithium-ion and VRLA batteries?**

Lithium batteries can be recharged significantly faster than traditional UPS batteries; however, keep in mind that the manufacturers limit the amount of battery charge current that the UPS can supply. During recharge, the BMS monitors not only voltage levels, but also the internal temperature of each individual lithium cell. In this manner, the system will automatically limit the charge if a cell gets too warm, which can potentially lengthen the recharge time. In general, the VRLA rule-of-thumb of "10x the discharge time to 90 percent capacity" will not apply to lithium.

### **What is the shelf life of lithium batteries before they need to be checked and charged?**

The vendor allows for up to a two-year shelf life. However, during this period, the cells in the cabinet will become unbalanced in voltage, and the cabinet cannot be used until its automatic balancing routine has been completed. Once the battery is connected to the UPS charger, we have seen balancing charge times last up to one week before the battery can be put into service. Balancing time for batteries stored for shorter periods will be much shorter, of course; typically, two to three days for a new battery.

### **Does the system automatically take failed units (individual batteries) off line and still provide runtime at a lower discharge capacity?**

Some BMS systems will bypass failing battery cells and continue to operate. Keep in mind that if multiple cells are bypassed, the current in the remaining cells will increase, so there is an increased potential for them to shut down on either overload or over temperature. While a domino effect is possible, the chance of multiple cells failing simultaneously to start that process is quite remote.

### **Do lithium batteries work with Eaton ABM?**

ABM is not needed with lithium batteries. The purpose of ABM is to extend the service life of VRLA batteries, and since lithium already has an excellent service life characteristic, there are no immediate plans to use it.

### **Can lithium be mixed with other types of batteries (for example, VRLA)?**

No, lithium cannot be put in series or parallel with other types of batteries.

# Reduce risk



## Battery Management System (BMS)

**For < 30 kVA ratings where UPSs may be stocked at a distributor's warehouse, is the BMS connected within the assembled cabinet?**

For some models, the BMS and batteries are shipped already installed in the cabinet, but the BMS wiring is disconnected.

Other models are not currently UL-approved to ship with the batteries installed in the cabinet. When the manufacturer gains approval (we anticipate in approximately 60 days), the BMS will likely be connected, which creates the chance for parasitic losses in the battery modules. This means that storage time will be in the VRLA range of 6-9 months. However, if all battery modules are manually disconnected, storage times go up as high as one to two years, depending on temperature.

**Is there a BMS per cabinet? How is redundancy handled for the BMS in each cabinet?**

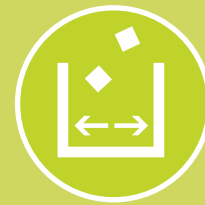
Yes, every cabinet has its own BMS, and for some multiple cabinet systems there is also a master BMS that gathers data from every cabinet and communicates information to the outside world, including the UPS. The loss of any BMS only affects the cabinet it is monitoring and would not preclude successful operation of others in parallel.

Even without a functioning BMS, each battery cell includes fusing and a thermal vent to reduce the chance of thermal runaway. However, a failed BMS will disconnect the entire cabinet from the UPS and require correction of the issue before the cabinet can be re-connected.

**Is the BMS powered from the batteries?**

One of our two vendors includes an extra battery in the cabinet expressly to keep the BMS powered for at least two days during an extended outage. The other vendor recommends two separate power feeds to the cabinet—one from the utility source upstream of the UPS, and a second feed from the output bus of the UPS—which involves some extra wiring and provision of breakers. We are working with them to provide an in-cabinet alternative power source.

# Save space



## Sizing/testing/disposal

**Is there any difference between sizing a lithium-ion battery compared to VRLA or NiCd technology?**

Yes, the sizing is slightly different and in the case of lithium, we limit the backup time based not only on low cell voltage limits, but also the cell temperature during discharge. This means the cutoff time for a lithium battery might be dictated by high temperature, as opposed to only low voltage. Eaton's published battery time tables for our UPS products take this into account, and our application engineers are trained on proper sizing of these batteries. As always, [feel free to contact Eaton](#) for sizing guidance.

**What are the recommended testing protocols to include in 3rd party commissioning of a lithium-ion UPS battery system?**

With the absence of a standardized commissioning test for lithium batteries, we expect that commissioning would be somewhat similar to that of VRLA, and should include the following:

1. Verification of correct and safe installation per the vendor's manuals, including torqueing of terminals and set up of the BMS by a trained service engineer. Configuration files should be saved for future reference.
2. Refresh charge to ensure all batteries in each string are properly voltage-balanced and within limits (this may require 48 to 72 hours of charging). Note that batteries may have been reduced to 30 percent SOC during shipment.
3. Test discharge for time, at one or preferably two different UPS load levels, followed by a review of the BMS data, looking for temperature or voltage anomalies during the discharge.
4. Take time to recharge data and record after a full discharge test. Verify UPS charge limits are programmed correctly.
5. Verify communication of status, and automatic disconnect device (breaker or contactor) in each cabinet to ensure it is functioning correctly.

**Do lithium-ion batteries have recycling and/or disposal issues?**

Lithium-ion batteries are disposable and, while currently not readily recyclable, new options are expected in the future. or now, use [Eaton.com/batteryrecycle](https://www.eaton.com/batteryrecycle).

# Guarantee +



## Warranty

### What is the warranty on lithium-ion batteries and what is needed to qualify?

All warranty replacements will be performed by trained technicians from Eaton's service organization. Like traditional VRLA batteries, we pass through the original battery manufacturer's warranty. In the case of our two lithium vendors, one offers a full bumper-to-bumper 10-year warranty covering everything in the cabinet: batteries, circuit breakers, wiring, BMS and contactors. However, their cabinet may cost more than alternate vendors, which usually offer a "10-year performance guarantee." This less expensive option includes a 3-year full warranty, but component failures after that time are replaced at full cost by the customer.

Either way, these options are dramatically better than traditional UPS battery products. And while all lithium vendors warrant their batteries for 10 years, they also claim that the batteries will exhibit a 15-year life in UPS applications.

# Compatibility



## Solar application

### Will lithium-ion UPS batteries be compatible with a solar PV system for emergency power, provided there is a separate battery storage system for the building's back-up power?

Yes, we hope to be able to use our UPSs with lithium batteries in exactly this type of application. We may not be able directly parallel lithium batteries with an existing battery string due to chemical incompatibilities, but the UPS's lithium battery can still be part of a scheme where PV or wind systems are used. The UPS will provide energy storage to be used when the alternative sources are unavailable, then recharge when sun/wind conditions are favorable.

### If a building is being designed to have a microgrid (solar + storage) so it can be operated during an emergency such as a seismic event, could this UPS system be operated for the server room, while a separate and much larger system powers the building?

Absolutely! We expect to be offering products for this type of use by late 2018.

### Can the UPS batteries be charged by the PV system, assuming the current is suitable? If not, what other back-up method would you suggest?

We recommend that the PV system (and its inverter) be fed to the UPS input so the UPS directly controls the battery recharging. In the future this may not be necessary, but in these early applications it is important to have control over the rate of charge for the UPS batteries.

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