How Battery Technology will address the Power Demands of the CHANGING DATA CENTER LANDSCAPE

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Abstract:
The following whitepaper will discuss the vital role that batteries play in supporting data center operations. It will explain how the requirements of uninterruptible power supply (UPS) systems have altered in recent years, and what the implications are for the supporting battery technology. Details will be given of the different battery chemistries available for UPS implementation and what factors should be considered before specifying one of these options. Based on different use case scenarios, the prospective trade-offs that may be made in order to either reduce OPEX or CAPEX will then be outlined.

INTRODUCTION

In its report 'Data Age 2025' [1], analyst firm IDC forecasts that by the middle of this decade our society will generate a staggering 175ZBytes of data each year. It also estimates that the average connected individual (of which will be close to 6 billion of us at that stage) will have interactions with a data center 4,900 times each day - that is almost 3x what it is today and 10x what it was in 2015.

Increased use of cloud-based services, both from the home and from mobile devices, as well as the roll-out of billions of IoT nodes, is certain to further affirm our dependency on data centers in the years ahead. Investment in this sector is accordingly at an all-time high, with both North America [2] and Europe [3] predicting continued growth, plus increasing financial outlay in other regions; such as the Middle East.

The nature of data centers is, to some degree, also evolving. Enterprise sites are starting to be complemented by public cloud infrastructure. Also, to support low latency services, more widespread implementation of edge-based sites is now being witnessed. In order to accelerate deployments and bring additional capacity online at short notice, there is increasing interest in modular data center arrangements.

A diverse array of new business models are being explored too. Alongside the hyperscale and in-house enterprise sites, there are a growing number of co-location (COLO) facilities capable of hosting multiple customers. Offering out rack space to various customers, these COLO data centers need to be prepared to respond to constantly changing workload requirements.

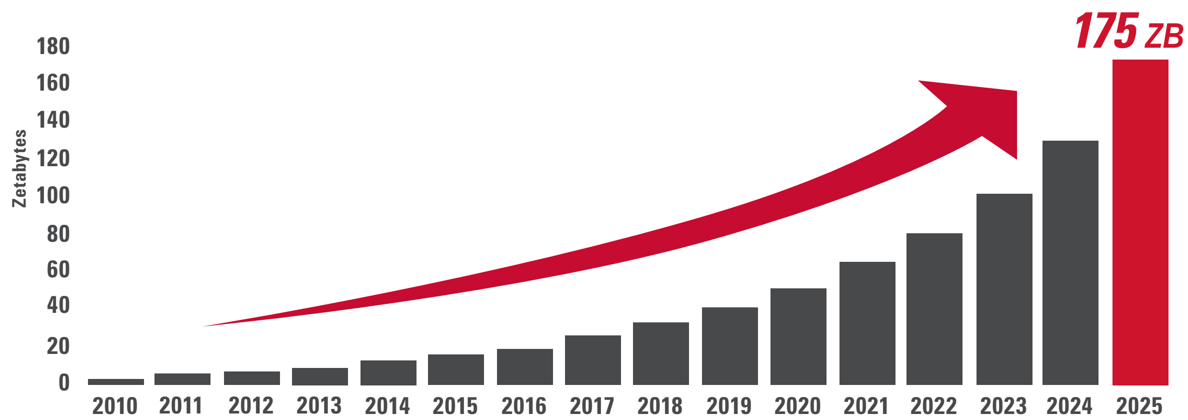


Figure 1 - Global Data Usage [Source: IDC]

6 billion ***estimated connected individual users by 2025***

4,900 ***interactions with a data center each day***

ENVIRONMENTAL CONSIDERATIONS

It is estimated that data centers are already responsible for around 1-1.5% of global electricity consumption, and this proportion is projected to increase substantially over the course of the next decade [4]. Each data center site will have a large carbon footprint associated with it. Although innovations in energy efficiency have meant that power requirements have not gone up at the same rate as data demand, curbing power budgets still poses a major challenge for the industry as overall the number of data centers in operation continues to escalate.

It is important that data center operators can deliver the services expected by their customer base, while keeping the power consumption involved under control. The impetus behind this is not just coming from international environmental guidelines, but serious internal pressures too. It is of paramount importance for the bigger players involved in the data center sector to be able to underline strong corporate responsibility. Many are looking to promote their green credentials to shareholders and the public in general, by moving to carbon neutral status in the near to mid-term. It must therefore be acknowledged that there is something of a mismatch here - the generation and delivering of power needed to meet these intensifying data demands being placed on one side, with the ongoing drive to reduce consumption levels and improve energy efficiency on the other side.

CHANGES TO THE POWER DISTRIBUTION LANDSCAPE

As well as keeping power consumption figures down, data center operators also need to be concerned about continuity of supply, as there is the ever-present risk of grid instability. Greater reliance on renewable sources and further urbanization is likely to lead to power outages occurring more often.

To some extent, access to a wider array of power generation options, which are distributed in a multitude of locations, offers heightened grid resilience, since everything is no longer reliant on a handful of large generation sites. However, responsiveness to peak demands will not be as good. Wind turbines and solar farms are subject to acute fluctuations in output - due to changes over the course of the day, as well as variation in seasonal conditions. Extra capacity cannot simply be brought online as demand dictates - though this would of course have been the case with a traditional coal-fired power station, for example. Maintaining grid frequency will be more difficult and this will detrimentally affect supply stability. Steps must be taken to assure that data center operations, many of which can be categorized as mission-critical, are not impacted by this.

The regularity of data center system outages, in all its different forms, is increasing, with the disruption caused and the costs implications that result - from first incidence through the recovery phases - also becoming more severe. The Uptime Institute's '2020 Global Annual Data Center Survey'[5] highlights this - stating that:

78% of data center operators have suffered with one outage in the last 3 years.

Power failures are identified as the most common cause, representing 37% of the total.

PROSPECTS FOR UPS BUSINESS

The dynamics just detailed, namely increasing data center activity in combination with uncertainties about grid electricity supply, have been highly beneficial to the UPS battery market. Data compiled by both Research & Markets[6] and Technavio[7] show that it is currently experiencing double digit growth, with no sign of this slowing down in any time in the foreseeable future.

CHANGES TO HOW DATA CENTERS ARE ORCHESTRATED

Previously, data center UPS high rate battery systems were traditionally designed to deliver 10 to 15 minutes of autonomy, so that operations were adequately covered. This would give enough time for back-up generators to be activated. Modern generators have far quicker responsiveness though. They can be brought online and phased within much quicker timeframes. Often activation can be done remotely or even automatically - both of which help to save even more time. In many Western economies, there is also an increasing expectation that operators can quickly transfer data to mirrored sites, if required at short notice. All this means UPS autonomy periods can be a lot shorter, with batteries often only needing to support less than 5-minute discharge durations. Battery reserves may therefore be smaller, and the relative capital costs involved may be markedly less.

Server concentration is increasing in order to keep pace with data demands. The processor devices utilized are integrating larger quantities of functionality and achieving higher performance benchmarks. The expectation is for batteries to follow this example - with support for higher power densities. If less space is taken up by batteries, there is more space available for additional server racks; which will further raise the commercial potential of the data center deployment. As battery rooms become even more space restricted, thermal management and ventilation requirements need to be considered.

Ambient operating conditions are also being adjusted. To reduce the OPEX costs that sophisticated cooling systems constitute, there is consideration of running the data center hardware at elevated temperatures; compared to what it would have done in the past. While previously it would be necessary for deployed batteries to be kept at an ambient temperature of 68°F to 77°F, now higher temperatures are often mandated.

Another trend that seems to be emerging is that data center owners are starting to investigate the possibility of taking direct responsibility, partially at least, for power generation. This will be done via on-site generation via renewable methods and will once again need support from cutting-edge energy storage solutions.

NEW OPPORTUNITIES

It is becoming increasingly apparent to data center operators that their deployed battery reserves do not need to just be left idly waiting to respond if a power outage takes place. They are a valuable asset that can be put to use. One way that they can help to lower day-to-day running costs is by utilizing them for peak shaving purposes. Indeed, some data center operators are considering the potential to draw electricity from their battery resources when costs are high, before subsequently recharging them when electricity costs are at their lowest. Peak electricity charges are thereby avoided. Another strategy that operators are starting to experiment with is becoming net producers - generating money by supplying electricity back to the grid, as part of grid frequency response. Mechanisms have been established to keep the grid frequency constant, and these require the support of battery reserves that can be tapped into as needed. This will be increasingly sought after with greater usage of renewables. Though the activities outlined here can be financially attractive to data center operations, it must be recognized that they will cause increased cycling of batteries and this will shorten their lifespans. The expense of more regular battery replacements must hence be added into the equation. Also, battery selection should be based on using a technology that is well suited to heavy cyclic demands.

UPS BATTERY TECHNOLOGY - THE OPTIONS AVAILABLE

Before comparing the different energy storage solutions available, first examine how lead-acid battery technology has progressed.

The lead-acid chemistry has been a fundamental stalwart of energy storage for many decades, and over time there have been enhancements made to this technology. Traditional flooded lead-acid batteries, where excess liquid electrolyte is present, generate oxygen at their positive electrodes and hydrogen likewise at their negative electrodes, thereby causing water loss over time. Consequently, the electrolyte must be topped up with addition of water on a regular basis. It also means that relatively high levels of gas are generated, which require ventilation.

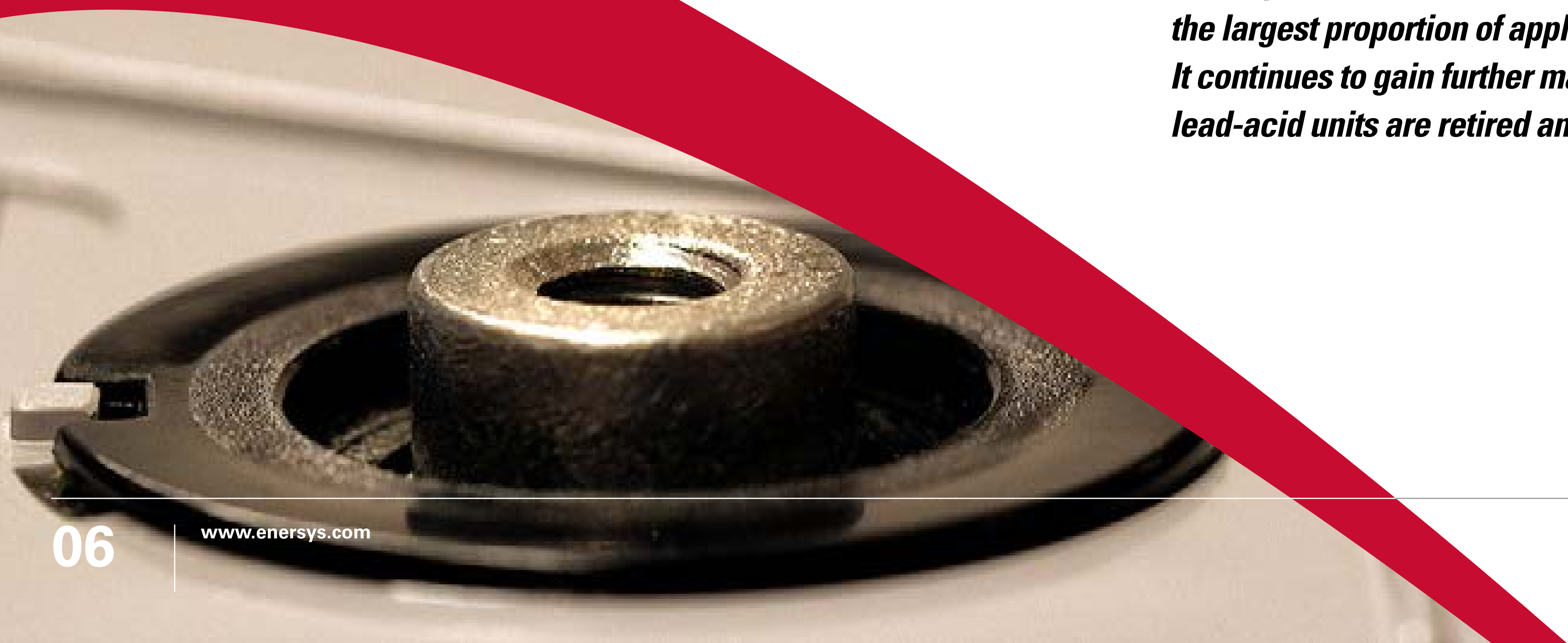
Valve regulated lead-acid (VRLA), where the electrolyte is immobilized with either a gel or absorbent glass mat (AGM), provides a solution where water loss is greatly reduced and topping up with water during service is not required. It also provides a solution where the gas emissions are much lower, therefore the ventilation requirements are far less than those of flooded lead acid batteries. The typical standard AGM type of VRLA battery, utilizing a thick cast grid alloy of lead calcium/lead calcium tin, has been more commonly used in data center battery back UPS systems for several years.

The arrival of thin plate pure lead (TPPL) technology, a type of AGM VRLA battery, added significant benefits and features to lead-acid that have has proven its applicability in the UPS market. Here considerably thinner grids of very high purity are utilized in the plate manufacturing process. This results in improved surface area contact between the grid and active material.

The thinner plates mean more of them can be stacked into the battery. The larger reactive surface area available boosts power densities. Consequently, TPPL batteries can deal with much higher current peaks and have faster charging capability.

More recently, lithium-ion (Li-Ion) technology has started to gain traction in the data center arena.

However, TPPL has proved itself to be a technology with strong performance credentials with the ability to meet the largest proportion of application requirements. It continues to gain further market share as older lead-acid units are retired and replaced.



COMPARISON OF DATA CENTER BATTERY TECHNOLOGIES

TPPL battery technology gives advantages over standard AGM lead-acid batteries.

For instance, TPPL batteries will support a lifespan that is markedly longer than comparative standard lead-acid AGM can achieve. They are "tried and tested" in data center applications and have a service life of approximately 8-10 years, which is around +25% better than conventional VRLAs. Their higher densities mean that the batteries also take up less space, normally being at least 20% smaller than their standard VRLA equivalents - which is a real benefit in very constrained application environments. This space saving also means that, in some cases, fewer units and a smaller battery sizing solution are needed. The compact form factors of TPPL batteries also presents greater scope to ramp up capacity as the power requirements of the data center installation increase. Furthermore, these batteries also align well with the current trend of modular data center deployments.

TPPL battery models can comfortably support the higher ambient temperatures that data centers are now operating at, whereas conventional standard AGM lead-acid units, due to high replacement frequency, would not be economical. Nevertheless, it should be noted though such temperatures will curb their service life, so batteries will need to be replaced with greater regularity. Data center operators need to be able to weigh up the reduction in the OPEX relating to thermal management against increased replacement rates to be certain they are making valid savings in total cost of ownership.

TPPL batteries have high charge acceptance, compared to standard AGM, VRLA or Flooded units, and offer fast charge capability. They can be recharged and ready to respond again within a very short period. This means they can deal with situations where multiple outages could occur.

The low self-discharge characteristics inherent in TPPL mean that they can be stored for longer, 2 years at 68°F, without needing additional charging. These battery units are thus better able to cope with any unforeseen delays in deployment.

In recent years, Li-ion has emerged as an alternative battery technology for back-up power applications within data centers. Li-Ion batteries have some operational advantages, relating to their higher energy density levels and long service life. It is important, though, to be sure that all elements of the data center deployment have been given attention before making any decision. In some cases, comparisons have been made between Li-Ion and traditional AGM lead-acid battery technologies with lower operational stand-by service life, and this can give a somewhat skewed perspective compared to TPPL. End users should be mindful of this when completing a TCO analysis to ensure that they are evaluating battery technologies on a like-for-like basis.

For safety reasons, it is mandatory that Li-Ion solutions include a battery management system (BMS), in order to ensure operational parameters are maintained and to prevent the possibility of over-charge and over-discharge conditions. Additionally, it will be necessary to install an enhanced fire suppression system. These considerations will increase complexity and add to the upfront costs. With more components involved, there are a greater number of items that will potentially need replacing over the battery system's operational life. A total cost of ownership viewpoint needs to be taken, with all the CAPEX and OPEX elements factored in appropriately.

RECYCLING CONSIDERATIONS

Currently, the constituent materials of lead-acid batteries retain their value and Lead is already widely recycled with a long-established cycle stream in place. In contrast to this, the cycle stream for lithium is less mature and further investments to ensure a circular Li-Ion lifecycle are necessary. The value of Li-Ion recycling will depend very much on the specific chemistry employed. For instance, the nickel-manganese-cobalt (NMC) chemistry holds some intrinsic value, while other chemistries may pose more of a challenge.

SPECIFYING THE OPTIMAL SOLUTION

The latest TPPL battery solutions outperform older traditional lead-acid AGM battery technologies across the board. When making comparisons with Li-Ion battery technology types, the decision will really depend on the objectives of the data center operator; both from a technical and a financial standpoint. It should be acknowledged that lead-acid has a longer history and is a more established technology in a data center context.

In most scenarios, the best approach will be to migrate to TPPL, with its design simplicity and operational safety advantages.

Every data center operator needs to strike a balance between new and legacy technologies. Selecting a battery with TPPL technology will enable operators to build better data centers. It will mean they can benefit from almost drop-in replacements, so they won't have to redesign the supporting infrastructure. It should be noted that, in specific circumstances, the characteristics that Li-Ion comprises can prove suitable.

ENERSYS® BATTERY TECHNOLOGY FOR DATA CENTER DEPLOYMENT

By leveraging an advanced derivative of AGM, EnerSys® is better positioned to serve the data center market than standard AGM lead-acid battery vendors - presenting customers with high-performance, maintenance-free, non-spillable battery solutions. Its next generation TPPL batteries operate at elevated temperatures, compared to standard energy storage products. These batteries support a much longer float life, which translates into extended service life. They also have low self-discharge characteristics, allowing them to be stored for prolonged periods of time. Meanwhile, the fast-charge capability of TPPL technology means that data center batteries can be ready to work when needed.

The EnerSys® DataSafe® XE battery range has been designed to meet the demands of today's data centers and is fully compliant with IEC 60896-21/22 and IEEE-1188 international standard requirements. These units are highly suited to supporting the run times that data center operations now tend to need - with high-rate performance of up to 1150Wpc at the 5-minute rate (1.67Vpc at 68°F). They accommodate many more plates in comparison to standard AGM batteries, allowing them to deliver dramatically better energy densities.

Utilization of pure lead plates means that corrosion rates are significantly lower than standard AGM batteries. This means that it takes a lot longer for the capacity of these batteries to deteriorate. End of life concerns are fully addressed too, as these batteries are 99% recyclable, with a retained value that can be benefitted from at the point of decommissioning.

CONCLUSION

These are eventful times for the data center business - with operators needing to respond to the changing circumstances, as society's hunger for access to ever greater masses of information continues to rise. This is especially true now, with radical transformations to the working culture underway, as greater emphasis is placed on employees remaining at home and telecommuting. There are other forces at play though, with the threat of increasing grid instability making power outages more prevalent.

With this in mind, operators must have complete confidence in the resilience of the data center sites. They need to be able to source best-in-class, ultra-reliable UPS battery solutions that can cope with being subjected to increasingly heavy strains.

Having continuity of supply and assured long-term availability of batteries will be critical. It is therefore recommended that they engage with an established brand that has a strong reputation. Thanks to its team's in-depth application knowledge and multifaceted technical support,

EnerSys® can back up its product portfolio with a superior customer experience - offering a combination of local response and global presence.

References:

[1] Data Age 2025, IDC, December 2018.
[2] Data Center Market in US - Industry Outlook and Forecast 2020-2025, Reportlinker, April 2020.
[3] European Data Centre Investment Outlook, DLA Piper, December 2019.
[4] Digitalization and Energy Report, International Energy Agency, November 2018.
[5] 2020 Global Annual Data Center Survey, Uptime Institute, July 2020.
[6] Global UPS Battery Market for Data Center Industry 2018-2022, Research & Markets, May 2018.
[7] UPS Market by Application and Geography - Forecast and Analysis 2020-2024, Technavio, December 2019.

Why EnerSys®

EnerSys, the global leader in stored energy solutions for industrial applications, manufactures and distributes energy systems solutions and motive power batteries, specialty batteries, battery chargers, power equipment, battery accessories and outdoor equipment enclosure solutions to customers worldwide. Energy Systems, which combine enclosures, power conversion, power distribution and energy storage, are used in the telecommunication, broadband and utility industries, uninterruptible power supplies, and numerous applications requiring stored energy solutions. Motive power batteries and chargers are utilized in electric forklift trucks and other industrial electric powered vehicles. Specialty batteries are used in aerospace and defense applications, large over-the-road trucks, premium automotive, medical and security systems applications. EnerSys also provides aftermarket and customer support services to its customers in over 100 countries through its sales and manufacturing locations around the world. With the recent NorthStar acquisition, EnerSys has solidified its position as the market leader for premium Thin Plate Pure Lead batteries which are sold across all three lines of business.

If you operate cloud, colocation, edge, or an enterprise data center there are increasing demands on cooling, power and space efficiency and ensuring reliable system availability. At EnerSys® we offer scalable high-energy density storage options, cabinets and racks to meet these requirements. Together with our specialist installation and battery maintenance services, we safeguard your data during power outages by delivering near-instantaneous protection.

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