Lithium-ion and PUE

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ABSTRACT

Power Usage Effectiveness (PUE) is gaining widespread traction, both in small and large data centers, as a metric to determine data center efficiency. The introduction of lithium-ion batteries as a viable alternative to lead acid in UPS's offers several advantages in the quest for unity PUE.

INTRODUCTION

As the volume of data and the need to access and store it increases, the need for clarity around the costs associated with doing so is also increasing. One methodology for indirectly analyzing these costs is to compare those of value-added IT equipment with the support equipment required to run and maintain this IT equipment. Power Usage Effectiveness (PUE), a concept introduced by the Green Grid consortium, is a ratio of the variable energy consumption of an IT facility to that of the IT equipment housed in that facility.[1] Facility consumption includes power distribution, thermal management, and even the overhead lights in a data center. IT equipment encompasses servers and networking gear, as well as the compute power for monitoring it.

As IT equipment improves in energy efficiency, thus shrinking the denominator of the PUE ratio, it is necessary to make commensurate progress in reducing facility energy consumption. One new technology for doing so is a lithium-ion based uninterruptible power supply (UPS).

EFFECTS OF LITHIUM-ION ON PUE

Lithium-ion is being introduced into the data center as a replacement to lead acid. The primary benefits are increased operating temperature, extended cycle life, accurate battery intelligence, and high energy density.[2] Several of these benefits can be translated directly into improvements in PUE.

Direct Effects

Operating Temperature

One increasingly popular method for reducing the energy consumption of a facility is to allow for a higher operating temperature in the data center. Metrics such as PUE favor reduction in energy consumption in all cases, even potentially at the expense of product lifespan. For example, a 2008 study by Intel compared servers run in an air-conditioned environment (in line with ASHRAE guidelines at the time of a max temperature of 27°C) with those in a non-conditioned environment with a maximum temperature of 33.3°C and no humidity or dust filtration.[4] Over ten months, the failure rate of servers in the lesser controlled environment was only 2% higher than that of the air-conditioned environment. However, the reduction in energy consumption was a noteworthy 67%.

Allowing that servers are more robust to higher operating temperature than guidelines suggest, it is necessary to confirm that other data center equipment is similarly inured. When comparing specifications for lithium-ion and lead acid UPS's, only the lithium-ion based systems offer nameplate power and run-time capabilities across the entire standard operating temperature range of 0-40°C. As data center operators begin deploying more granulated thermal management systems, any piece of equipment—especially a UPS—that does not require heavy air conditioning will directly reduce facility energy consumption and thus reduce PUE

Cycle Life

One criticism of PUE as a standalone metric is that the reliability and lifespan of IT and facility equipment is not considered. Poorly-suited deployments will reduce the life of equipment and potentially shift the cost burden from an operating concern to a capital concern. In the previous example of increasing the mean operating temperature of a data center as a method of reducing energy consumption, thermal resilience is favored over cycle life.

However, lithium-ion offers not only a higher full-power operating temperature but also presents a higher cycle life and lower capacity degradation than lead acid. Lithium-ion batteries have been shown to maintain up to 2000 cycles at 75% depth-of-discharge in an environment of 33.3°C. Similarly tested lead acid batteries (absorbent glass mat) offered only 250 cycles at this temperature.[5] Though this cycle life benefit will not directly translate into a PUE improvement, it facilitates the measures required to increase data center temperature and thus reduce facility energy consumption.

Secondary Calculation Effects

Battery Intelligence

The efficacy of PUE as an actionable metric relies upon the accuracy and completeness of the data used to calculate it. As losses from power conversion inefficiencies factor heavily in the numerator of PUE, having high quality data around a UPS is critical. Input and output power draw, overall efficiency and mode information are commonly available within UPS data-reporting schema. Of particular interest from a PUE vantage point is the power consumption when recharging a UPS battery after an outage event. Not only is the efficiency of the power stage during normal operation—i.e., the bypass switch or rectifier/inverter power path—needed, but the efficiency of the battery charger is also required be it via an oversized rectifier or unique charger power stage.

Lithium-ion UPS's, which monitor the voltage, current and temperature of each battery string, offer the granularity required to separate load power consumption from recharge. This will allow for a more accurate model of facility energy consumption and thus bolster the robustness of a PUE metric.

Energy Density

Lithium-ion offers a significant energy density advantage over lead acid, both from a weight and volume standpoint.

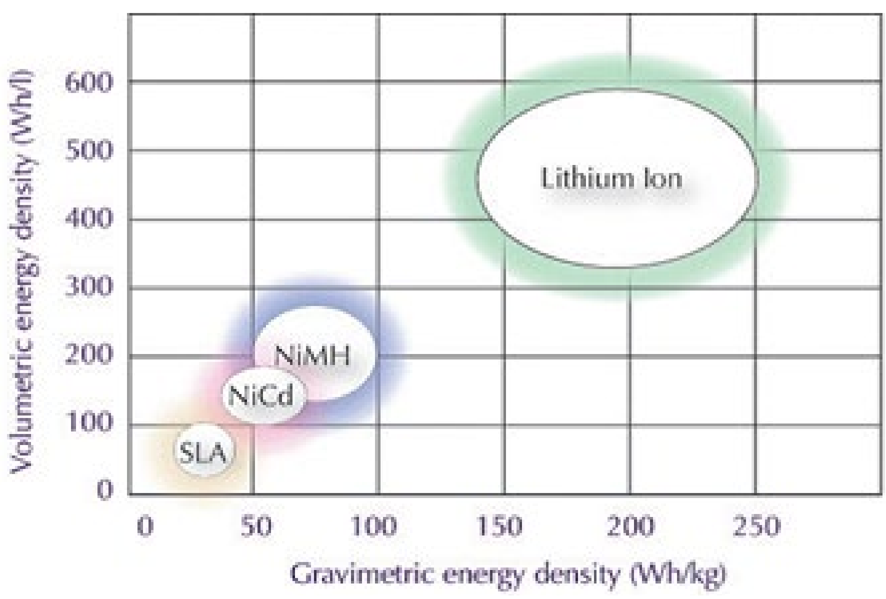

Figure 1. General Energy Density Comparison for Various Battery Chemistries.3

Lithium -on UPS's are up to 67% smaller and 37% lighter than lead acid systems of comparable capacity. With a greatly reduced footprint, a UPS can now be deployed locally at the site of the equipment requiring back-up. This makes the exercise of right-sizing power allocation at the rack level a straight-forward activity. It also allows for a more accurate understanding of both energy consumption and efficiency of the power distribution component of the PUE calculation.

PEAK SHAVING PUE

A relatively new concept in Data Center Management Power is the analysis of data center energy consumption relative to grid energy consumption. As energy billing is contingent upon both the peak of individual consumption and widespread consumption, avoidance of high energy usage during peak periods in critical for reducing energy costs.

To further explore the cost- and energy-saving potential of balancing loads to avoid grid peaks, Google performed a study on deploying lithium-ion batteries in tandem with 28,000 servers. The batteries were drained when a peak power threshold was met and recharged when the power draw fell below that threshold.[6] This method resulted in a 19% reduction in peak power consumption. To be clear, the net energy consumption will remain the same, as the energy that would have been consumed directly from the grid to power IT equipment must now be used to charge the battery. However, when considering usage on a watt-hour basis, a more evenly distributed consumption can be expected and PUE can be more accurately calculated.

SUMMARY

Data centers are increasingly employing PUE as an efficiency and deployment efficacy metric. Lithium-ion batteries, when deployed as part of UPS infrastructure, offer data center managers the ability to increase operating temperature and reduce cooling energy consumption without negative side effects. Lithium-ion UPS's also offer additional granularity around power consumption, thus providing a more accurate data set for calculation of PUE.

References

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About Methode Electronics - Active Energy Solutions

Active Energy Solutions (AES), a Methode Company, is a leader in lithium-ion battery systems and power electronics. Since its inception in 2006, AES has designed, tested and produced a variety of customized energy storage systems to deliver greater efficiency in battery energy density, battery life and smaller battery footprint for our data storage, telecom and alternative energy customers.

Designed to integrate flawlessly with Methode's DCIM and PDU solutions, we help clients better manage their power resources with intelligent products and services – delivering more data center real estate while reducing operational expense from day one.

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