Powering Business Worldwide

Thought Leadership White Paper

Efficiency and Density-Boosting Upgrades for the Modern Data Center

Cost-effectively readying data centers for power-hungry new technologies

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Executive summary

Virtualization, cloud computing, big data and converged infrastructures are rapidly transforming corporate IT. Unfortunately, though, the data centers many businesses rely on at present lack the power and cooling capacity to handle those technologies. Worse yet, the packaged rack-based power and cooling modular solutions that some vendors claim increase the efficiency and power density of those data centers are both costly and inflexible.

Utilizing best-of-breed power and cooling systems that maximize capacity and minimize waste without locking companies in to a limited set of deployment options and vendors is a far more effective approach. This white paper explains why many data centers are ill-equipped to support today's most important new technologies; discusses why packaged power and cooling solutions can be a flawed way to upgrade existing facilities; and describes the core components of a data center upgrade strategy capable of enhancing efficiency and power density more completely and cost-effectively.

Table of contents

Why some data centers struggle to support the latest technologies

Cloud computing, virtualization and converged infrastructure solutions decrease IT overhead and increase business agility. Big data systems extract revenue-producing insights from masses of structured and unstructured information. Not surprisingly, then, businesses are adopting all four of those technologies quickly. Consider, for example, these statistics from analyst firm Gartner Inc.:

- 82.4 percent of total operating system deployments will be virtualized by 2016
- The global public cloud services market will grow a projected 18.5 percent in 2013 to $131 billion. Furthermore, over 75 percent of enterprises worldwide plan to pursue a private cloud strategy by 2014.
- 42 percent of IT leaders globally have either invested in big data or plan to do so within a year

Sadly, however, most data centers in operation today—and especially those more than eight years old—have trouble accommodating these powerful new technologies, for reasons that include the following:

Inadequate power density: Six or eight years ago, most data centers were designed to support 3 kW per server rack, or roughly 100 watts per square foot. More recently-built facilities were built to accommodate around 6 kW per rack, or 200 watts per square foot. Today's virtualized, converged and cloud-based infrastructures can require as much as 15 kW per rack, or 600 watts per square foot. That's far more than most older facilities can handle.

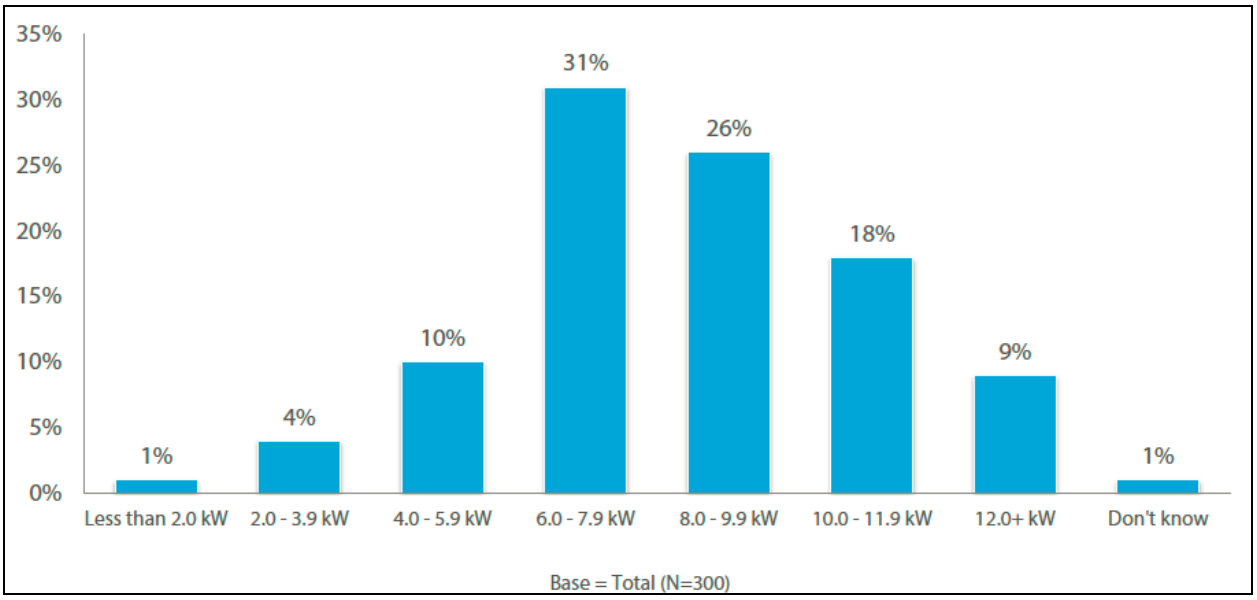

Figure 1: *Average data center power density in kilowatts per rack as of 2011 among North American businesses with over $1 billion in annual revenues or more than 5,000 employees.(Source: Digital Realty)*

Inadequate power and cooling capacity: Many existing data centers lack enough power to support even present requirements. As companies make increased use of resource-intensive technologies like cloud computing and big data, the gap between available and needed capacity is sure to grow even larger.

Furthermore, when designing a new data center's cooling infrastructure, most organizations plan for neatly aligned rows of uniform server racks supporting evenly dispersed IT loads. In reality, however, power densities tend to vary across racks almost immediately after commissioning, and grow more varied over time as new equipment is installed and new needs arise. As a result, businesses often find themselves with insufficient cooling capacity in especially and unexpectedly high-density parts of their data center.

Inadequate power and cooling redundancy: Businesses often fail to augment their computing facilities' uninterruptible power system (UPS) and cooling capacity as rapidly as they raise power density. Over time, consequently, UPS and cooling infrastructures that once provided N+1 redundancy or better can gradually cease to offer any redundancy whatsoever.

Inadequate management capabilities: Virtualization abstracts the relationship between hardware and software, enabling technicians to move virtual machines dynamically from one host server to another in response to changing conditions. The legacy power management systems many data centers currently utilize, however, were designed for an earlier world in which hardware and software were tightly coupled with one another. As a result, they often have trouble keeping track of new and re-located virtual servers, resulting in inaccurate status reporting and even unnecessary downtime. Moreover, many legacy power management systems integrate poorly if at all with popular IT and virtualization management solutions, and are incapable of collecting real-time status information from power protection and distribution systems as well.

Inadequate rack deployment flexibility: Equipping an existing data center with the processing power it needs to accommodate technologies like big data and cloud computing usually involves moving or adding servers, storage and networking equipment. The racks and cooling systems many organizations use at present, though, limit their thermal management and positioning options in ways that can severely complicate rack deployment when inconveniently located fire suppression systems, building supports and other structural elements get in the way.

Inefficient UPSs: UPSs built ten or more years ago are typically 85 percent efficient or less when operating at 40 percent utilization and serving dual-corded servers. That means data centers using out-of-date UPS equipment are wasting 150 kW of precious power capacity for every 1,000 kW they consume. Furthermore, most of that 150 kW escapes as heat and dissipating it uses up already scarce cooling capacity.

Disadvantages of using packaged power and cooling upgrade solutions

To help businesses implement power- and cooling-hungry technologies more quickly, several vendors have introduced packaged power and cooling upgrade solutions that include most of the components needed to increase an existing data center's efficiency and density. For all of their apparent convenience, however, such solutions also have substantial limitations, including these:

They overuse in-row cooling: Most packaged power and cooling solutions lean heavily on in-row cooling. However, while in-row cooling systems can be highly effective when used appropriately, they also impose steep purchase and deployment costs, take up valuable floor space that could otherwise be dedicated to IT equipment and make re-locating server racks in response to changing needs both expensive and difficult. A hot- or cold-aisle containment strategy based largely on passive cooling will more than adequately meet most data centers' present and future requirements while also saving money, conserving floor space and increasing flexibility.

They feature proprietary equipment that results in vendor lock-in: Purchasing power and cooling systems from a single vendor can save money and simplify maintenance. However, packaged power and cooling solutions often limit your freedom to add UPS, PDU, and containment products from other vendors in the future as your needs and preferences change.

They provide limited cooling options: Some companies use row-level cooling. Others utilize rack-level cooling instead. Some facilities are best served by hot-aisle cooling. Others are better off utilizing cold-aisle cooling. The optimal solution for any given data center depends on a number of factors, including structural constraints and other limitations imposed by the building's original design. Packaged power and cooling solutions, however, often favor one particular cooling deployment mode.

They provide limited positioning and thermal management options: Many packaged power and cooling solutions come with UPS and power distribution equipment that can be placed only against the server room wall or only at specific positions within or alongside aisles. What's more, the UPS hardware included with packaged solutions often supports front-to-back or front-to-top air flow but not both. The upshot of both restrictions is that data center managers have less flexibility to place UPSs and PDUs in the positions that best suit their needs. Furthermore, they may also lose the ability to leverage the benefits of using overhead busway instead of cables.

Figure 2: Hot- or cold-aisle containment strategies featuring passive cooling often enable data centers to meet increased density and efficiency requirements more cost-effectively and flexibly than in-row cooling systems.

They support standard Electronic Industries Alliance (EIA) equipment only: Most of the equipment within a typical server enclosure is designed to fit in EIA-sized server racks. Increasingly, however, data center operators need to place devices with different dimensions in their containments as well. Many packaged power and cooling solutions are incapable of accommodating that non-EIA hardware without weakening performance. Furthermore, the racks included with most packaged solutions only support standard-depth hardware, forcing companies that later need to deploy deeper systems to replace their existing racks with bigger ones.

They come with weak management functionality: Like the legacy power management products they replace, the power management systems included with most packaged power and cooling solutions are ill-prepared to support virtual servers, integrate weakly with widely-used virtualization and IT management products, do little to help companies extend battery runtime during utility outages and have limited or no ability to collect real-time status information from across the data center.

They provide limited or inflexible scalability: The UPS and power distribution hardware included with some packaged power and cooling upgrade solutions isn't internally scalable, so when companies outgrow it they must buy entirely new units rather than simply add more capacity to existing ones. Packaged solutions that do have modular scalability, meanwhile, often support no more than 10 kW per server rack, well below the 20 kW per rack densities becoming increasingly common in today's data centers.

Recommended components of a best-of-breed efficiency and power density upgrade strategy

Power and cooling upgrade solutions built with best-of-breed components augment data center efficiency and density every bit as well as packaged systems but without the needless and expensive constraints. Here are the key elements that a well-designed best-of-breed solution should include.

Sophisticated UPS hardware

Look for models that provide the following:

- **Industry-leading energy efficiency:** The most advanced UPSs currently available routinely deliver over 97 percent efficiency in double conversion mode and can achieve more than 99 percent efficiency when run in special energy-conservation modes.
- **Flexible thermal management:** Some UPSs now support both front-to-back and front-to-top air flows. They also feature slender chimneys that leave plenty of room for overhead busway.

Figure 3: The newest UPS and containment products offer multiple thermal management options, so data center operators can place them either against the wall or within an aisle.

- **Flexible placement options:** Organizations can place best-of-breed UPS hardware at the end of a row, in the center of a row, against the wall, in a corner of the server room or back-to-back, with front access required only for service and installation. Additionally, today's best-designed power systems can accommodate either raised floor or overhead-wired installations, and come with auxiliary cabinetry that can be placed on either side of the UPS cabinet.

  Finally, modern UPS hardware can be incorporated within the data center's comprehensive heat containment system. That, in turn, improves reliability by permitting UPSs to reside in close proximity to the loads they protect.
- **Concurrent maintenance capabilities:** Newer UPSs allow technicians to perform administrative procedures without taking the device offline. The end result is more consistent protection for network resources and higher infrastructure availability.
- **Modular scalability:** Advanced UPSs now allow you to add capacity in 50 kW increments to a maximum of 200kW. That frees companies from buying more capacity than they need upfront, improves scalability and provides increased redundancy at a far lower cost in money and floor space than buying and deploying a second UPS and battery.
- **Modular serviceability:** Modular UPSs also reduce mean time to repair by enabling engineers to simply swap out broken power modules rather than spend long stretches of time diagnosing and fixing problems.
- **Modular redundancy:** When operated at less than their full load rating, modular UPS architectures provide inherent failover redundancy.

Intelligent, compact power distribution

To keep efficiency and density high and your power distribution footprint low, use the following:

- **Power distribution units (PDUs) with branch circuit monitoring capabilities:** When coupled with intelligent management software, PDUs with branch circuit monitoring functionality allow you to track power usage all the way to individual servers. That's detailed information you can use to spot trends and eliminate waste.
- **Busway, instead of cable:** Today's busway systems are easier to configure than cables and easier to modify or expand as changing needs dictate too. Modern busway solutions feature "hot

pluggable" distribution boxes known as bus plugs that include a circuit breaker, one or more receptacles, terminal blocks or even pigtail cables with receptacles that can be dropped directly into the racks below. As power density needs change, technicians can re-position bus plugs at convenient positions along the length of the bus as necessary to ensure that each one continues to feed one rack or several adjacent ones. That enables data centers to perform moves, additions and changes to their rack layout faster and more flexibly without dedicating valuable floor space to remote power panels or enduring the safety concerns those units raise.

Moreover, busway allows managers to re-locate bus plugs without disturbing any heat containment system already in place. Adjacent mounting of identical bus systems that allow easy visual confirmation of the power flow path to mission- critical IT equipment is available for dual bus (2N) architectures too.

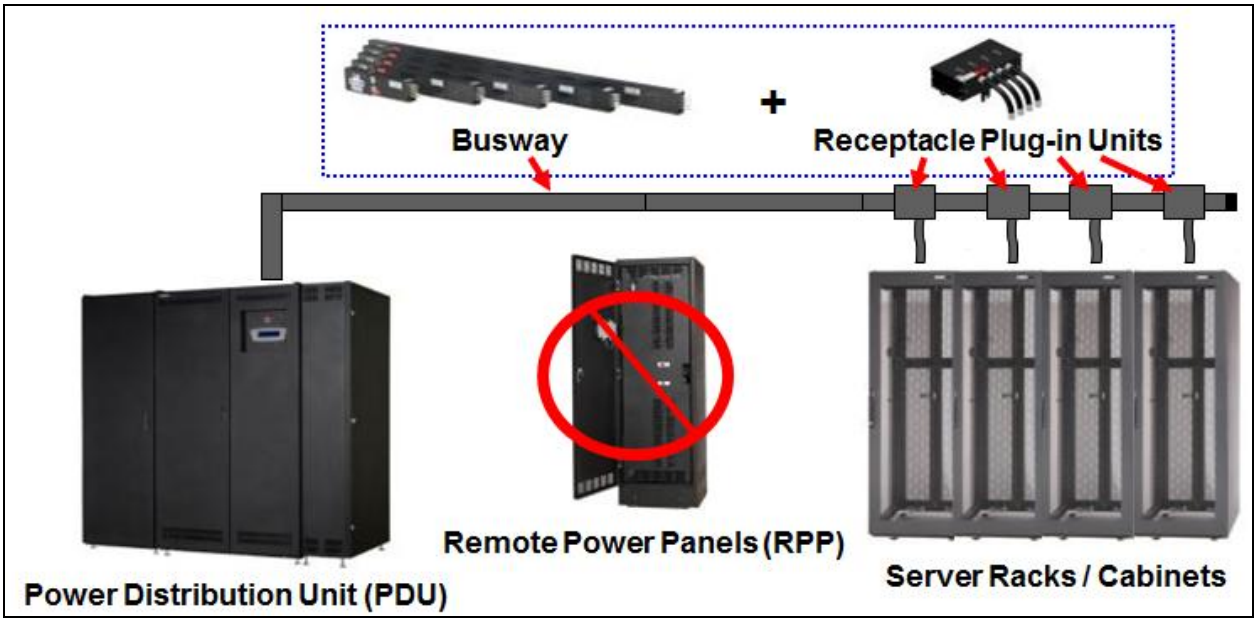

Figure 4: Using busway instead of cables saves space in your data center by eliminating the need for remote power panels.

Flexible, high-efficiency containment

Seek out server enclosures with these qualities:

- **Support for multiple deployment options:** Top-quality containment products give data center managers the freedom to choose between row- or rack-level cooling, passive or active air flow and cold- or hot-aisle containment.
- **Support for multiple rack options:** In addition to traditional EIA-sized server racks, state-of-the-art containment solutions can house non-standard racks and rack-less standalone devices too. They also offer "extenders" that allow businesses to expand the depth of their existing racks beyond standard EIA dimensions rather than replace them outright.
- **Minimal air leakage:** High-quality containment solutions raise efficiency by minimizing the intermingling of hot exhaust air with cool supply air. In fact, top-of-the-line offerings cap supply air leakage at no more than three percent, and limit maximum gap leakage to no more than three percent of total surface area. Moreover, truly trustworthy containment vendors will verify that they've delivered on their air leakage commitments by taking detailed post-deployment measurements at your data center.

Intelligent, logical and complete management functionality

Software is as important to raising data center efficiency as hardware, so make certain to deploy software that can do the following:

- **Provide unified administrative control:** Advanced power management systems also enhance the capabilities of virtualization management products such as VMware's vCenter™ Server by enabling data center personnel to view, monitor and control not only physical and virtual servers but UPSs, PDUs and other power devices through one interface.

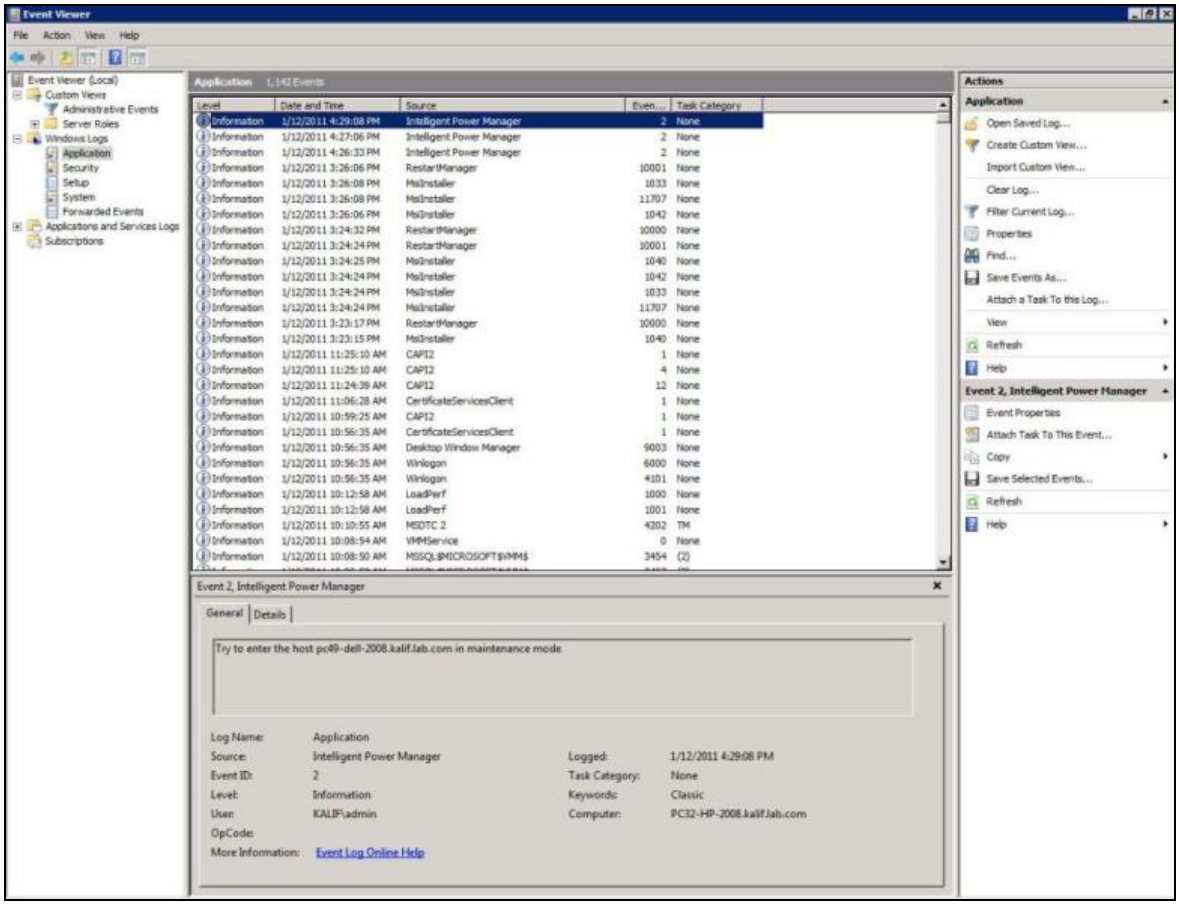

Figure 5: *Integration with virtualization management systems like vCenter Server enables intelligent power management solutions to log power-related events alongside other infrastructure events. vCenter can then act on those events automatically, moving or shutting down virtual machines as needed.*

- **Use an agentless way to connect power management to the virtualization management console:** Traditional power management applies a single agent per server. This does not scale when many virtual machines can be spun up and down quickly and agents need to be individually deployed and updated. There is also an input/output bottleneck as all agents simultaneously respond to a power event. Using the direct hook to the virtualization management console from the power management software removes these issues at a stroke.
- **Perform live virtual machine migrations:** Drawing on seamless integration with live migration systems such as VMware's vMotion™, best-in-class power management solutions can automatically and transparently move virtual machines impacted by a power outage to unaffected servers elsewhere on the network or in a co-located cloud data center. Additionally, they can use that same live migration capability to optimize power efficiency by automatically re-distributing virtual workloads from enclosures nearing their power or cooling limit to racks with spare capacity.

- **Aggregate power protection and distribution device information:** Leading-edge management solutions give IT and facilities administrators a truly global view of their power protection and distribution infrastructure through a single console by automatically discovering and collecting real-time data from network-enabled power devices both inside and outside the data center.
- **Protect workloads flexibly, and initiate system shutdown during power outages:** Intelligent power management solutions help technicians extend UPS battery life by grouping their least important infrastructure resources into distinct load segments that can be shut down first after a power outage. During extended utility interruptions, next-generation power management solutions can also protect unsaved work and preserve data integrity by shutting down affected servers and network devices both automatically and gracefully.

Freedom of choice

Best-of-breed power and cooling solutions allow you to collect all the benefits of purchasing from a single vendor now, should you chose to do so, without giving up the freedom to incorporate UPS, PDU and containment products from other vendors later if you wish to do so.

Benefits of deploying a best-of-breed efficiency and power density upgrade solution

Boosting an existing data center's efficiency and power density with best-of-breed components is faster, easier and more economical than building a new facility and much less constraining than using a packaged power and cooling solution. In particular, companies that utilize the best-of-breed power and cooling components recommended above can expect to collect these significant returns on their investment:

Greater power and cooling capacity: By increasing overall power and cooling efficiency, best-of-breed efficiency and power density upgrade solutions enable companies to get more capacity from their existing power and cooling systems, delaying the need for costly upgrades and replacements.

Enhanced ability to accommodate powerful new technologies: Virtualization, cloud computing, big data and converged infrastructures help companies substantially lower their costs and dramatically improve their competitiveness. Before organizations can realize those gains, though, they must prepare their data centers to satisfy far more intense efficiency and power density demands.

Enhanced ability to accommodate future IT developments: There's no predicting what technologies will sweep the IT world next, but chances are good they'll consume even more power than today's top technologies. Data centers equipped for maximum efficiency and density will have the scalability needed to support those heightened requirements.

More affordable scalability: Facilities that use modular UPS systems and busway rather than cables can gradually and cost-effectively add capacity as changing needs dictate.

Improved availability: Thanks to their modular redundancy, concurrent maintenance capabilities and user serviceability, power density solutions featuring modern UPS hardware keep uptime strong.

More effective management: Organizations that deploy best-of-breed power management software have the capabilities they need to protect and administer virtualized environments.

Lower energy bills: Modern containment solutions and late-model UPSs dramatically improve energy efficiency, enabling companies to save significantly on power.

Longer data center life span: Implementing efficiency and density upgrades enables organizations to get more use from existing facilities and defer the substantial expense of constructing new facilities.

Conclusion

Virtualization, cloud computing, big data and converged infrastructures require more power than many current-day data centers can deliver. For most companies, updating an existing data center's efficiency and power density is far more cost-effective than building a replacement structure—provided they use best-of-

breed components rather than accept the often severe limitations imposed by packaged upgrade solutions. With the help of the right UPS, power distribution and containment systems for their specific needs, businesses can dramatically raise the capacity, scalability and durability of their data centers while lowering operating costs, and position themselves to take full advantage of everything today's most important new technologies have to offer.

About Eaton

Eaton is a diversified power management company providing energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power. With 2012 sales of $16.3 billion, Eaton is a global technology leader in electrical products, systems and services for power quality, distribution and control, power transmission, lighting and wiring products; hydraulics components, systems and services for industrial and mobile equipment; aerospace fuel, hydraulics and pneumatic systems for commercial and military use; and truck and automotive drivetrain and powertrain systems for performance, fuel economy and safety. Eaton acquired Cooper Industries plc in 2012. Eaton has approximately 103,000 employees and sells products to customers in more than 175 countries. For more information, visit www.eaton.com.

About the author

John Collins has more than 20 years of experience in the data center industry. He joined Eaton in January 2011 and is solely focused on ensuring the company's data center products and solution offerings evolve with the market. John previously held various roles in sales, sales management, and product management, where he was responsible for various global product offerings relating to power generation, power quality, and power distribution. He's currently involved in many industry groups, including The Green Grid, 7x24 Exchange and AFCOM. John received his bachelor of science in electrical engineering from the University of Rhode Island and served for 10 years in the U.S. Marine Corps.