DCD > eBook

Powering the AI era

Practical solutions to today's data center power challenges

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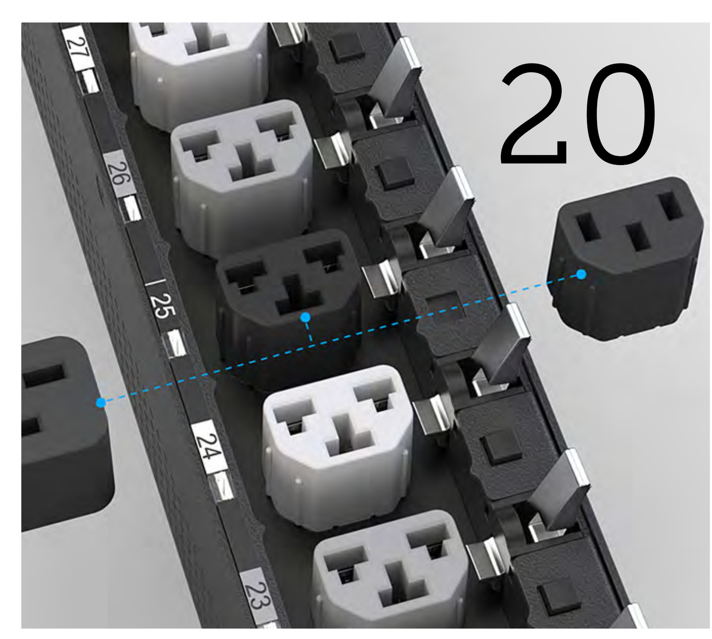
Contents



Introduction

Amidst the fast-paced evolution of our ever-digitalized societies, driven by the surge in AI and IoT technologies, the onus on power procurement, optimization and distribution in the data center has never been greater.

With some facilities now requiring the same amount of energy as a small city, this presents owners and operators with myriad challenges when it comes to powering the secure, low-latency services their customers and workloads demand.

With the speed at which the likes of ChatGPT proliferated, it's safe to say this is only the beginning for AI. However, rather than look into the distant future, on which we can only speculate, in this eBook we are focusing on the here and now.

The ability to adapt with agility is paramount, and for that, we need readily available, practical solutions to the challenges we're facing today. Yes, we need more power, but where do we find it? And once you have it, how do you ensure it's available where and when you need it?

That said, it's not just a case of quantity; the quality of the power being fed into a facility is also integral if operators want to avoid that dreaded – and costly – downtime. And just as all power isn't created equal, neither are data centers, each coming at the AI evolution from a different starting point.

Whether a shiny new hyperscale facility, or an enterprise data center struggling with aging legacy infrastructure, cutting edge, customizable power solutions will be the vehicle that helps drive operators towards successful AI adoption. With the right partners, products and process, together, we can power the true potential of AI.

Where are the gigawatts? Finding dense power in the AI age

As the digital infrastructure industry continues to decarbonize, new approaches to harnessing energy must be found to support AI growth. What must be considered to secure our long-term access to sustainable power?

Farah Johnson-May
DCD

No industry is without its contradictions. In the data center world, while power limitations are often considered an unsolvable challenge, the demand for digital services and AI is relentless, driving data center expansion to new heights.

This rapid growth places immense strain on power grids, many of which are struggling to keep up with today's demands. At the same time, the digital infrastructure industry faces mounting pressure to decarbonize and minimize its environmental impact. This means finding new, sustainable ways to harness energy is more urgent than ever if we are to support the continued rise of AI and digital services.

So, how do we find the power?

Two experts explore the challenge: **Vicki Worden, president and CEO of the Green Building Initiative (GBI)**, brings her expertise in sustainable building practices, while **Dagi Berhane, senior director of global data center architecture and engineering at Salesforce**, provides insights from the perspective of a major tech company with extensive data center needs.

Power challenges in a growing digital landscape

Like the majority of sustainability-focused SaaS companies, Salesforce faces growing power demands on a global scale. According to Dagi

Berhane, four key factors signify the power challenges at hand:

First, energy supply constraints: As power demand surges, securing a reliable and sustainable energy supply becomes increasingly difficult, especially for diversified companies operating across both build-to-suit sites and large hyperscale data centers.

Second, cost management: Rising energy costs pose a direct challenge, impacting operational budgets and potentially affecting overall profitability.

Third, sustainability goals: Balancing the need for more power with ESG (environmental, social and governance) commitments and carbon reduction goals creates a complex challenge, as companies seek to expand while minimizing their environmental impact.

> "We're going to need approximately 47 gigawatts of additional power capacity to support data center growth in the US through 2030"
>
> **Vicki Worden**
> Green Building Initiative

Last, infrastructure upgrades: Ensuring that existing data centers – or brownfield environments – can handle the increased spike loads without compromising performance and reliability is critical to meeting the demands of a rapidly evolving digital landscape.

Even if it's available or sustainable, is it viable?

In the building industry, there's a strong shift toward electrification, yet questions remain about viability. As Vicki

Worden points out, “We’re going to need approximately 47 gigawatts of additional power capacity to support data center growth in the US through 2030. This power demand is expected to be met with around 60 percent from gas and 40 percent from renewable sources.

“Meeting this demand will require a substantial investment – about $50 billion in US grid expansion and power generation. While electrification and green energy are important goals, our current grid infrastructure isn’t yet equipped to handle this increased strain without significant upgrades.”

Data centers are still unprepared for the redundancy demands of the AI era. Battery storage solutions need to last for 48 hours, yet the industry still relies on gas and diesel backups, which complicates efforts to reduce carbon footprints and furthers reliance on fossil fuels. This challenge underscores the importance of locating new facilities near renewable energy sources as part of a broader strategy.

Balancing energy demands with carbon reduction goals also means exploring emerging technologies. Worden highlights the potential of a hydrogen economy:

“We’re seeing the emergence of new technologies, like the hydrogen economy, which could transform our current gas distribution infrastructure into a system capable of delivering hydrogen. There are supply chain challenges we need to address to make this transition viable.”

“We’re also re-evaluating nuclear energy at a microgrid level, exploring its potential as a local, clean energy source. While our current power capacity is insufficient, those investing in this sector today will drive significant innovation through 2030 and beyond. Ultimately, we envision data centers becoming reliable contributors to the grid, even supporting it during peak demand periods,” says Worden.

“We’re seeing the emergence of new technologies, like the hydrogen economy, which could transform our current gas distribution infrastructure into a system capable of delivering hydrogen”

Vicki Worden
Green Building Initiative

Microgrids offer one potential solution, enhancing energy resilience and mitigating the effects of grid outages. This could be a key component of data centers’ path forward, allowing them to meet their energy needs without derailing their journey towards decarbonization.

Finding dense power for AI and sustainability

In preparing for AI and addressing power needs, site selection is heavily influenced by proximity to renewable energy sources.

"One of the key criteria now is proximity to renewable energy," says Berhane. "We're prioritizing locations near sources like wind, solar, and hydropower, as offsetting carbon emissions is crucial for most enterprises working toward net-zero goals."

He adds, "In selecting sites, we also need stable, resilient energy grids that ensure uninterrupted power supply."

Beyond access to renewable energy, regions with favorable regulatory environments that support sustainable initiatives are increasingly preferred. "Some sites are even qualified for seismic resilience, which is essential for ensuring continuous operations," notes Berhane.

Geographic diversity is another critical factor. "We have disaster recovery and resiliency models in place, but distributing data centers across diverse locations helps mitigate risks associated with localized power shortages or outages," he explains. "These considerations are now part of our standard site selection process."

Worden summarizes the notion, "Companies with greater purchasing power have better access to sites that offer a favorable renewable energy mix. For others, an incremental approach is essential – working with utilities that have higher carbon-free energy options and partnering with them to expand renewable capabilities is the way forward."

Powering the future

As AI and digital services drive unprecedented demand, the path forward lies in innovative site selection, renewable energy integration, and resilient infrastructure.

Operators need to be assessing the potential for on-site power generation such as solar, wind, or microgrids. This, combined with exploring the use of advanced energy storage technologies to store excess renewable energy for use during peak demand periods, will not only enhance energy reliability, but reduce the impact of potential grid outages.

In addition, evaluating the feasibility of implementing advanced cooling technologies like liquid and AI-driven cooling systems, alongside opportunities to deploy energy-efficient hardware and leverage AI/automation to optimize data center operations, will help reduce energy consumption and waste.

Finally, by advocating for climate policies and legislation that promote renewable energy and carbon reduction at the local, national, and global level, operators can more readily embrace sustainable practices and new technologies, empowering the industry to not only meet today's power challenges, but support a greener, more reliable energy grid for tomorrow. ■

Where are the gigawatts? Finding dense power in the AI age

with Vicki Worden, Green Building Initative and Dagi Berhane, Salesforce

The quest for data center resilience

An experts' guide to help data centers adapt cabinets, networking, and power management, and secure the longevity of their sites

Farah Johnson-May
DCD

In just a few decades, data centers have transformed into high-powered engines of modern technology, as power densities have surged from around three kW per rack to as much as 40kW per rack today – all fueled by the demands of artificial intelligence. This change is no surprise to industry insiders, but it presents new challenges and opportunities for suppliers and their supply chains.

With current conversations revolving around 80, 100, and even 120kW per rack, the future trajectory remains uncertain. How far can power densities go, and how will the industry adapt? The panel on 'Optimizing AI infrastructure for resilience and efficiency' – which you can watch in full on page 15 – explores these critical questions.

Emma Brookes of DCD introduces the panelists: **John Berenbrok, director of product management at Starline**, a Legrand brand; **John Consoli, VP of sales for the cabinets and containment division at Legrand**; **Frank Yang, senior product line manager for Approved Networks**, also a Legrand brand; and **Prabhakar Muthuswamy, senior product manager at Raritan**, another Legrand brand specializing in power management solutions.

Approved Networks optical transceivers

AI's impact on data center infrastructure

Today, running AI applications is an everyday occurrence for the average consumer, but for data center suppliers, providing the necessary power densities is a far more complex challenge. Frank Yang kicks off the conversation by discussing AI's profound impact on data center networking infrastructure, underscoring the increased demand for higher speeds and lower latency:

"From a networking architecture perspective, AI not only increases the need for low latency but it also requires consistent latency. Designing the entire infrastructure now revolves around minimizing and stabilizing that latency."

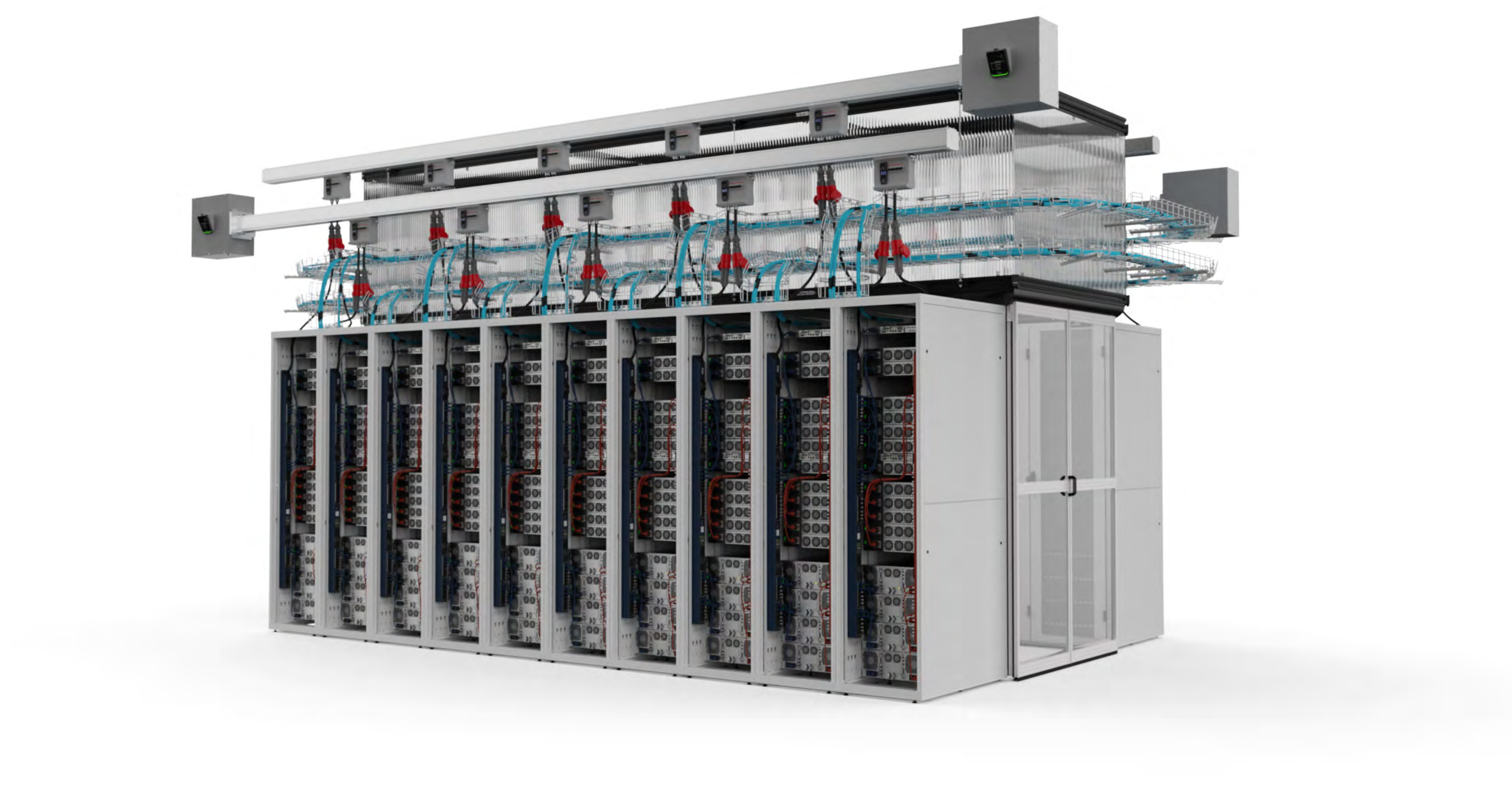
Yang explains that while data center networking was traditionally dominated by Ethernet, with some use of Fiber Channel, AI is changing that landscape: "In AI-driven environments, InfiniBand has emerged as a strong contender for supporting AI networking, with Ethernet remaining as an alternative option."

Before it can work in your data center, it needs to work in your cabinet

On this theme, John Consoli shares his insights on the evolving role of cabinets and containment in data center design, highlighting the shift from commoditized components to essential design elements:

"In a remarkably short time, cabinets have transformed from being merely a commoditized space for housing systems to becoming integral parts of the overall design and engineering process."

According to Consoli, as the value of a single data center rack approaches US$8 million, the emphasis on custom cabinet solutions to optimize internal space and accommodate high-density equipment becomes even more critical. He also emphasizes the necessary integration of liquid cooling at the cabinet level, driven by energy-exhaustive AI applications, addressing the complexities of managing cooling manifolds in this evolving landscape.



Legrand's AI-ready data center solutions

Consoli notes, "At Legrand, we differentiate ourselves by focusing on tailored cabinet solutions. We collaborate closely with our customers to optimize the internal space of each cabinet, ensuring maximum utility for high-density equipment."

Scaling data center solutions for AI

As the demand for AI capabilities grows, uncertainties arise regarding the appropriate power infrastructure to implement it. With the recent introduction of Nvidia's Rubin GPUs, a key question emerges: how does our infrastructure support these power-hungry chips?

John Berenbrok emphasizes the importance of strategic infrastructure choices, stating: "We believe that an overhead busway is the optimal solution for distributing power across racks. We are designing custom plug-in units that connect to the busway, allowing for power drops of up to 400 amps."

He adds: "Let's say in two years GPUs become more efficient and require only 200 amps – our Starline track busway system allows for a simple swap of the plug-in unit. This flexibility ensures scalability, regardless of changes

Legrand's customizable cabinets and containment

Legrand cabinets

in power demands or voltage requirements – only the plug-in unit needs to be updated."

When considering how to design network infrastructure for AI clustering, Yang highlights the significance of accommodating collective traffic patterns: "AI applications require seamless communication among GPUs, necessitating constant data exchange. A 'spine and leaf' architecture is commonly employed to prevent bottlenecks, enabling free data flow between GPUs."

Yang also notes: "Finding the right balance between the number of GPUs and network connections is crucial. A typical ratio might involve one GPU for every two 800-gigabit connections, ensuring the network can handle the substantial data traffic required for efficient AI operations."

From the cabinets and containment perspective, Consoli shares insights on scaling customer deployments to accommodate AI:

"At Legrand, we've created the acronym FACE to guide our interactions with customers regarding the scaling of data center cabinets," he explains.

- F stands for footprint, addressing the increasing size and depth of cabinets to maximize space.

- A is for access and egress, focusing on cable and equipment entry and exit while considering the heavy weight of cabinets, which can exceed 4,000 pounds (e.g. specialized 'rack and stack' packaging for secure transport).

- C represents cabling, cooling, and containment, which involves managing cable organization, cooling methods (air or water), and

> "In a remarkably short time, cabinets have transformed from being merely a commoditized space for housing systems to becoming integral parts of the overall design and engineering process"
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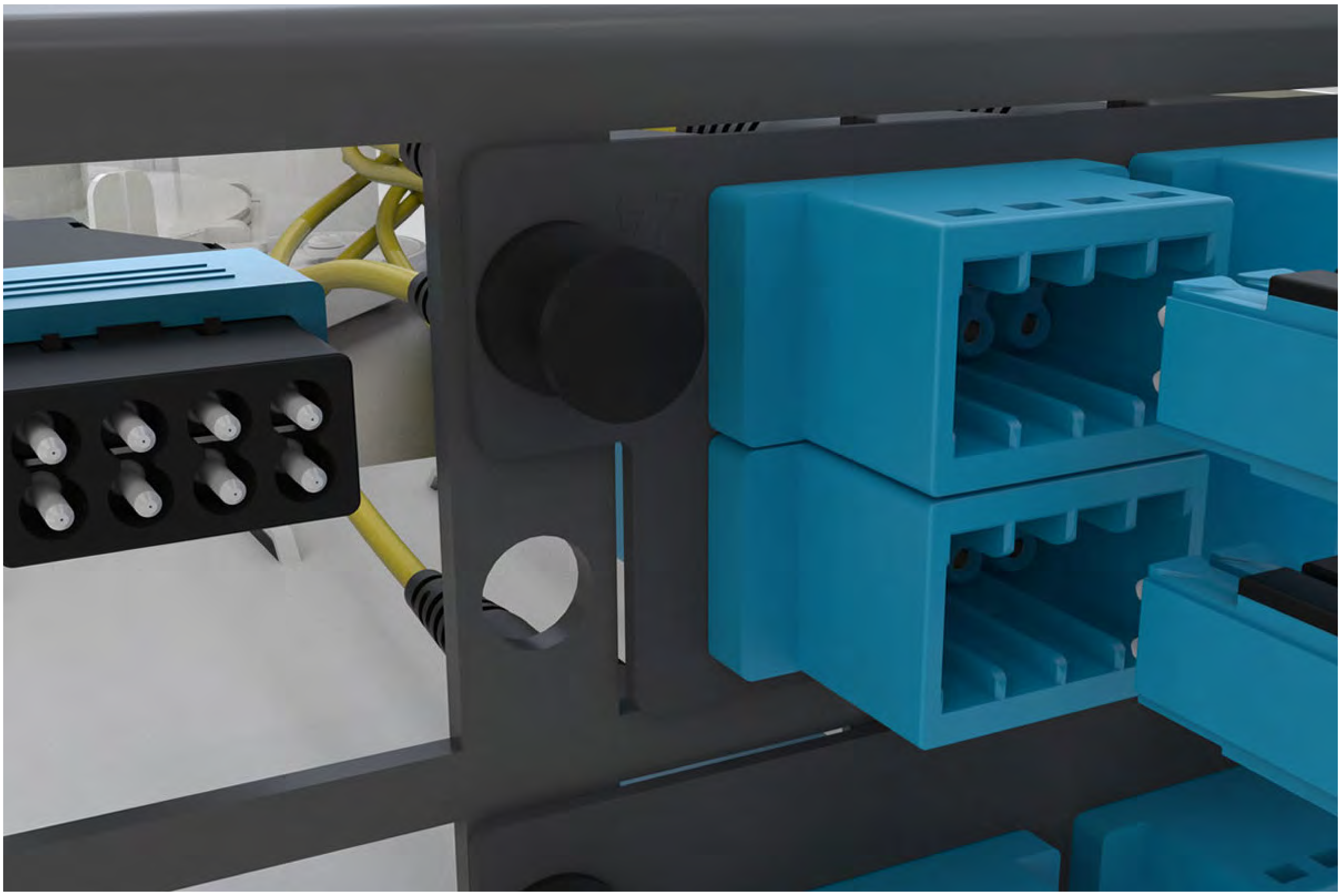
> **John Consoli**
> Legrand



Legrand's acclAIM fiber solution

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>
> **Frank Yang**
> Approved Networks

airflow optimization, often requiring both hot and cold aisle containment.

• E signifies equipment, highlighting the importance of specific manufacturer designs and their implications for rack layout and cabling requirements.

Together, these elements help guide customers towards cabinets that are optimized to effectively support AI systems.

Future-proofing data center design: "Efficiency depends on redundancy in power supply"

As AI and high-density computing continue to evolve, what implications does this growth hold for power and data center design?

Prabhakar Muthuswamy discusses the challenges associated with integrating various CPUs and GPUs from leading manufacturers like Intel, AMD, and Nvidia into server architectures. These components have diverse power and redundancy requirements that vary significantly depending on their specific applications. As a result, servers that once fit comfortably within racks now require more space and power, leading to decreased overall deployment density.

"Data centers are increasingly investing in power infrastructure that can accommodate these high densities while remaining adaptable for future upgrades," Muthuswamy explains. "For example, a customer striving for 40kW per rack has had to add extra power distribution units (PDUs) to their existing setup – something that was often unnecessary in the past."

> "Data centers are increasingly investing in power infrastructure that can accommodate high densities while remaining adaptable for future upgrades, like adding extra power distribution units – something that was often unnecessary in the past"
>
> **Prabhakar Muthuswamy**
> Raritan

He continues, "This trend highlights a fundamental shift: Rather than consolidating resources, data centers are expanding and evolving to meet the rising demands of high-performance computing. Their focus is on designing future-proof, efficient systems that maximize return on investment (ROI)."

Yang further elaborates on the networking side, noting that as speeds escalate to 400G and 800G, fiber requirements change significantly. For 400G, a complete set of fiber pairs is necessary, which can include multi-mode fiber or single-mode fiber. For 800G, which operates as two 400G links, Yang highlights that it requires eight pairs of either multi-mode or single-mode fibers.

This evolution in fiber infrastructure is critical for data center evolution to support the increasing bandwidth demands of AI workloads.

Safety and resilience in data center operations

Stranded power – energy that is available but not utilized or sold, such as from dormant servers – poses significant challenges in data center operations. Addressing stranded power can enhance overall efficiency and resilience, especially for AI applications. Muthuswamy stresses the importance of a holistic approach to data center design to mitigate stranded power:

"While many recognize the need to monitor every aspect of power consumption within the rack, there are additional measures that can greatly improve rack efficiency. First, organizations must establish a consistent, repeatable process across all levels. Second, proper resource allocation, demand forecasting, and capacity planning are essential to ensure that the rack's capacity aligns with operational needs – this planning should occur well in advance of infrastructure deployment."

"Third, it's crucial to utilize existing resources in a way that remains compatible with future technologies."

Consoli adds that one of the most commonly overlooked aspects in the industry is cabinet airflow hygiene: "One area requiring our focus is the airflow moving through these cabinets. It's imperative to be diligent about sealing any potential leaks where air could escape from the cabinet."

He notes, "Our best test results come from using fully welded frames and air-sealing plinths to ensure airflow integrity. This is vital for the safety and resiliency of the system; we must ensure that every bit of conditioned and cooled air that the data center team invests in reaches the equipment's inlet while preventing the mixing of hot and cold air."

Consoli emphasizes the significance of airflow in maintaining efficiency, particularly when utilizing rear door heat exchangers and in-row coolers.

Muthuswamy concludes by highlighting that operating an efficient rack involves more than just monitoring server power consumption. It's equally important to measure environmental factors such as temperature and humidity. If liquid cooling is employed, considerations must also include potential condensation and water leaks to ensure optimal uptime above 99 percent.

Anticipating what's next

In summary, effective management and scaling of data centers running ever-higher power densities for AI applications requires a comprehensive understanding of not just rack-level intelligence, but also the overall system dynamics. Future-proofing of data centers goes beyond meeting current needs; it requires anticipating what's next with innovative solutions in cooling, power distribution, and networking to support AI's continued growth. ■

Optimizing AI infrastructure for resilience and efficiency

With John Berenbrok, John Consoli, Prabhakar Muthuswamy and Frank Yang of Legrand

Retrofitting data center power infrastructure for the AI era

Practical advice on retrofitting legacy power infrastructure to accommodate AI workloads

Calvin Nicholson
Legrand

The rapid expansion of artificial intelligence (AI) workloads is reshaping the data center landscape, making updates to existing infrastructure urgently necessary. As organizations increasingly depend on AI applications, data centers must adapt to meet rising power demands and performance expectations.

Since building a new facility isn't always a feasible or cost-effective option, retrofitting offers a practical solution, providing a pathway to enhance power distribution, cooling systems, and overall operational efficiency.

Retrofitting legacy infrastructure

Retrofitting refers to the process of upgrading existing data center facilities to better accommodate new technologies and higher performance requirements. For instance, a facility initially designed to support a modest power density of 10kW per rack may now need to handle, in extreme cases, densities ranging from 80kW to 200kW to keep pace with AI advancements.

This transition necessitates the implementation of robust, flexible, and reliable power distribution systems capable of adapting to future demands, which ensure minimal operational disruption when being installed.

Power and cooling infrastructure challenges

Scalability and flexibility AI applications require massive processing power, necessitating scalable power distribution solutions. Traditional infrastructures often struggle to meet these demands, making modular and flexible power systems essential.

Power efficiency and monitoring Data center equipment is highly susceptible to power fluctuations, which can lead to operational inefficiencies and even downtime. Common sources of power quality issues include voltage sags, swells, harmonic distortion, and transients. Additionally, the introduction of new high-performance computing (HPC) equipment, such as AI clusters, increases the stakes for operators to engage in proactive power quality monitoring.

Legacy power configurations Legacy power infrastructures in data centers are often built with standardized configurations – using a single plug type, cord type, and voltage. This rigid setup limits the flexibility of legacy white space to support modern IT equipment, which requires various power types. As a result, large portions of traditional data centers are underutilized and cannot accommodate contemporary infrastructure needs without significant modifications.

Cooling and thermal management Managing the heat generated by AI workloads is a significant challenge. AI systems produce more heat than traditional equipment, overwhelming existing cooling systems. Retrofitting with advanced cooling technologies like liquid cooling, direct-to-chip cooling, and rear-door heat exchangers is crucial but can require significant investment and planning to implement effectively.

Sustainability and cost efficiency As AI workloads increase energy consumption, data centers must implement energy-efficient power distribution and cooling systems to reduce environmental impact and operational costs while achieving sustainability goals. Retrofitting existing facilities to meet modern environmental standards without incurring the high costs of complete overhauls is challenging for operators. Balancing the need for energy efficiency and sustainability with financial constraints makes this a significant hurdle for data center modernization.

Starline track busway with critical power monitor

Advanced solutions for retrofitting data centers

To effectively retrofit data centers for AI workloads, a variety of advanced solutions can be implemented:

Modular overhead power distribution systems Systems like track busways provide scalable power distribution that adapts to increased density, allowing for easy expansions. The overhead configuration eliminates obstructions common with traditional wiring methods, minimizing cable clutter and thereby improving cooling efficiency, crucial for high-density environments.

High-capacity or redundant runs of track busways are specially designed to handle electrical loads for AI-driven data centers, offering the ability to tap power anywhere along the busway and rearrange plug-in units without downtime. Additionally, advanced busway systems can integrate with power monitoring solutions, enabling real-time data analysis of power usage and efficiency at the plug or end feed level.

Starline's critical power monitor (CPM) enhances transparency and reliability, ensuring optimized energy use and reducing risks associated with power outages or inefficiencies. The CPM integrates with existing infrastructure, allowing for a seamless upgrade path and minimal disruption during installation.

Intelligent rack PDUs with granular power quality monitoring High-density AI configurations consume significantly more power, making monitoring and optimizing energy use critically imperative. Retrofitting with intelligent power distribution units (PDUs) allow operators to gain real-time insights into power usage at a granular level, helping identify inefficiencies, prevent downtime, and facilitate

Legrand SmartSensors

data-driven decisions to improve overall performance and energy efficiency. Additionally, advanced power monitoring offers continuous insights into power consumption and system health, enabling better resource allocation while minimizing waste.

Next-generation intelligent rack PDUs, such as the PRO4X from Server Technology and PX4 from Raritan, provide industry-leading visibility, reporting, and alerting for power metrics. These PDUs support high-density outlet technology, which provides the most outlets per PDU form factor to support high-density rack requirements with hybrid IEC C13 and C19 Cx outlets, offering the ultimate density and flexibility for future updates.

Innovative thermal management technologies

Solutions like USystem's ColdLogik rear door heat exchanger (RDHx) can effectively manage the excess heat generated by AI applications. These systems utilize air-assisted liquid cooling to support deployments of over 150kW per rack. Such designs are compatible with open and closed water loop systems and fully retrofittable onto any OEM rack, allowing data center operators to easily add additional cooling without the need for any changes to their current design.

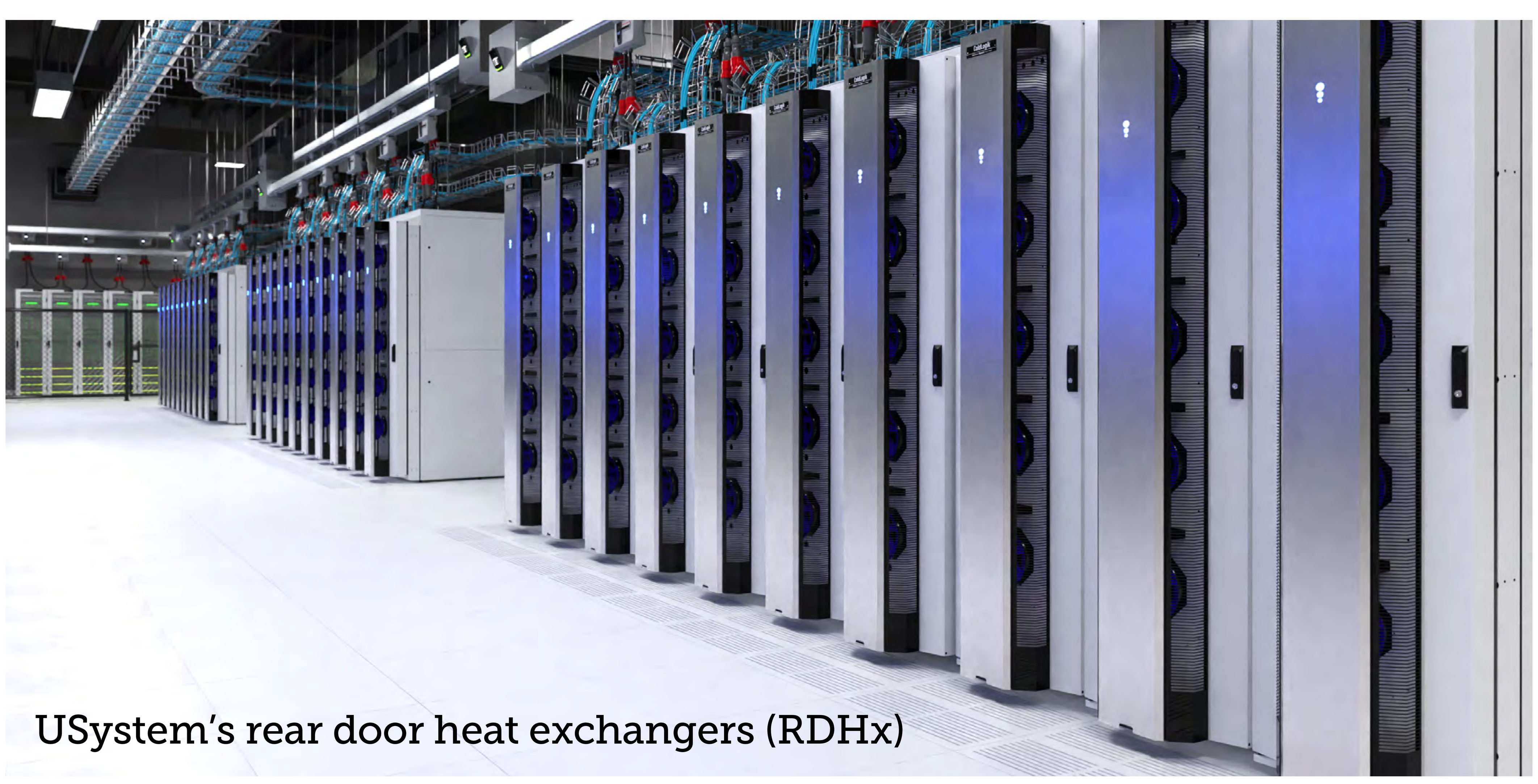
Smart environmental sensors

Smart sensors provide real-time temperature, humidity, and airflow monitoring, enabling operators to identify and address issues before they escalate. These sensors can be easily integrated with intelligent rack PDUs for detailed monitoring of environmental conditions. This proactive management strategy is crucial to ensuring optimal performance and energy efficiency in an AI-driven landscape.

Conclusion

Retrofitting data centers to meet the demands of the AI era is a complex but essential undertaking. By incorporating modular power systems, intelligent PDUs, advanced cooling solutions, and smart sensors, facilities can meet the evolving demands of AI while achieving greater sustainability and cost efficiency.

Investing in these technologies helps data centers get a step ahead of rising AI workloads, ensuring facilities are equipped to meet both current and future challenges in the digital landscape. As AI continues to shape the future of data centers, retrofitting provides a strategic pathway for modernization without the need for costly overhauls. ■



USystem's rear door heat exchangers (RDHx)

Retrofit special: The best approaches for upgrading your infrastructure

with Lex Coors, Digital Realty
and Tate Cantrell, Verne

Q&A with Don Strickland | Legrand

Don Strickland is a global product manager for Legrand's Data, Power and Control division, specializing in power distribution units and related products. With over 13 years' experience in the data center and critical power sectors, we pick his brain on all things power in the AI era

Don Strickland
Legrand

> “Metrics from both the supply (inlet or ‘upstream’) and the critical load (outlets) sides of the system are equally critical to understanding total power quality”
>
> **Don Strickland**
> Legrand

Although power demands within the data center are at an all-time high thanks to the continued proliferation of high-density workloads, just ‘having’ power isn’t enough. Once power is procured, the quality of that power is also critical. What does the term ‘power quality’ mean to Legrand and why is it more important than ever?

Power quality refers to the stability of the power being delivered to a critical load and how reliably its electrical waveform meets the ideal requirements of the load. Any swells, sags, stutters, or flatlines reflect lower-quality power that is being, in a way, ingested by the critical load.

These distortions or even disruptions in power quality can lead to reduced efficiency, increased operating costs, reduced lifespan for load devices, and potentially even disruption of operations. In a world where the need for guaranteed uptime for AI training and end-user applications exists simultaneously with a focus on sustainability and traditional OpEx factors, it is imperative that power quality distortions and disruptions be mitigated.

What are some of the more common power quality pain points an operator is likely to encounter?

Voltage dips and swells are typically the most significant power quality issues affecting data center uptime today. Dips are more common and are an even greater issue than power loss, as power loss events are usually mitigated by data center redundancy and backup systems.

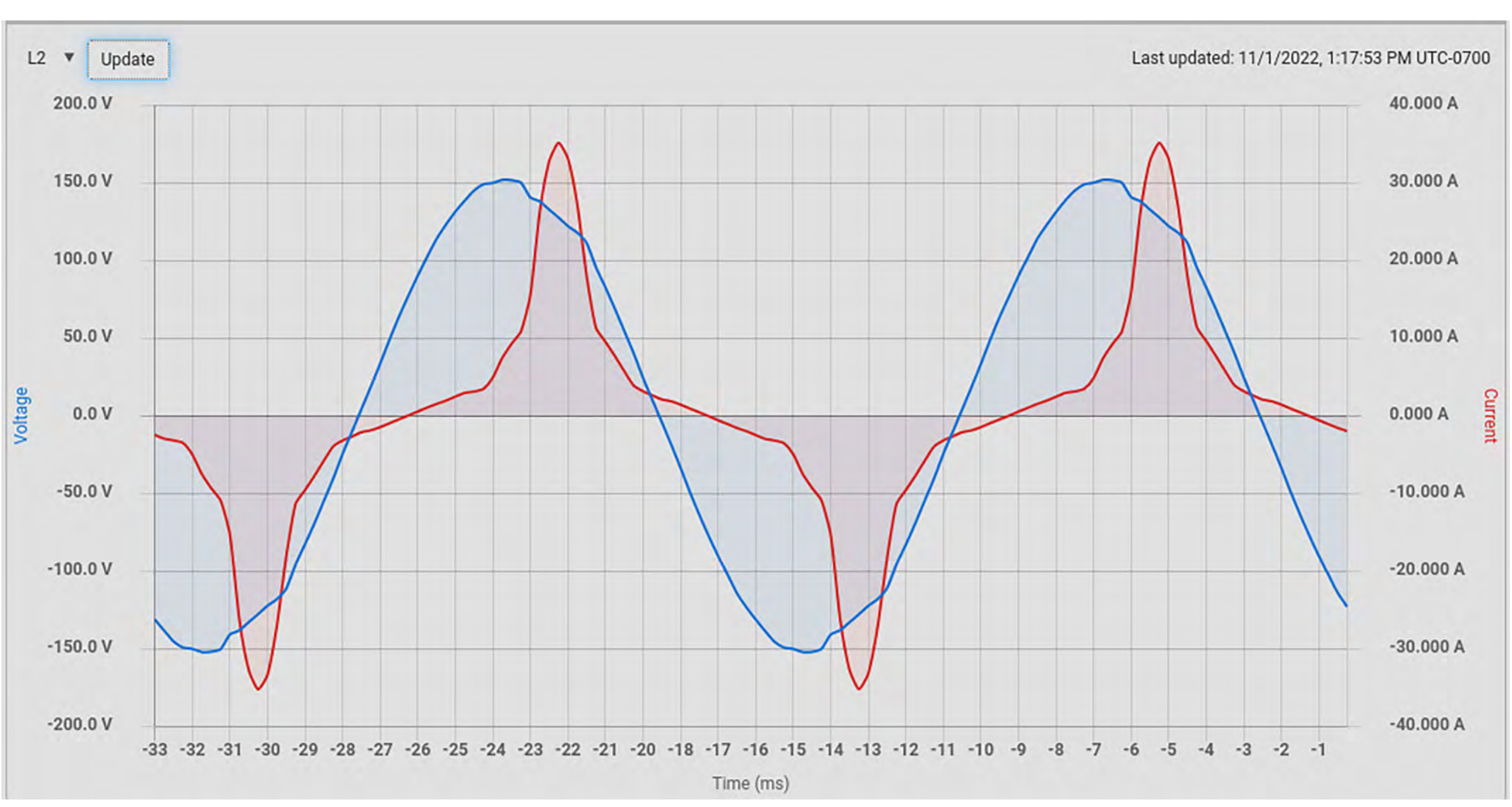
Dips: Voltage dips are responsible for up to 80 percent of power quality issues. A dip or sag occurs when the system voltage drops to 90 percent or less of the nominal system voltage for a half-cycle to one minute. Common symptoms of a prolonged dip (lasting more than a few cycles) can include intermittent dimming of lights, lockup or complete shutdown of servers and electronic equipment, memory loss on programmable controls, and relay control problems.

Swells: Symptoms of swells often include immediate failure of IT equipment, typically in the electronics power supply. However, some equipment failures may not occur immediately because swells can occur over a period of time and prematurely break down components.

Can you please define what is meant by harmonics and the impact they can have on power quality and the data center as a whole?

Distortion to an electrical load’s current and voltage waveform is often described as harmonics. More specifically, harmonics are created by non-linear loads that draw current in abrupt pulses rather than in a smooth sinusoidal manner. In data centers, these non-linear loads are typically power supplies for servers, storage systems, and networking equipment that use switched-mode power supplies.

How much your electrical load distorts your utility’s power is called total harmonic distortion (THD.) When too much distortion occurs, it can accumulate and disrupt power quality, which can have multiple negative impacts on



Raritan and Server Technology’s rack PDUs.
Example of total harmonic distortion monitoring

IT equipment and the overall operation of the facility.

Here are some negative impacts of THD on data center IT equipment:

Equipment overheating: Additional heat can reduce the lifespan of IT equipment and increase the risk of failure.

Reduced efficiency: Power systems must work harder to supply the necessary power to equipment, leading to increased energy consumption and higher operating costs.

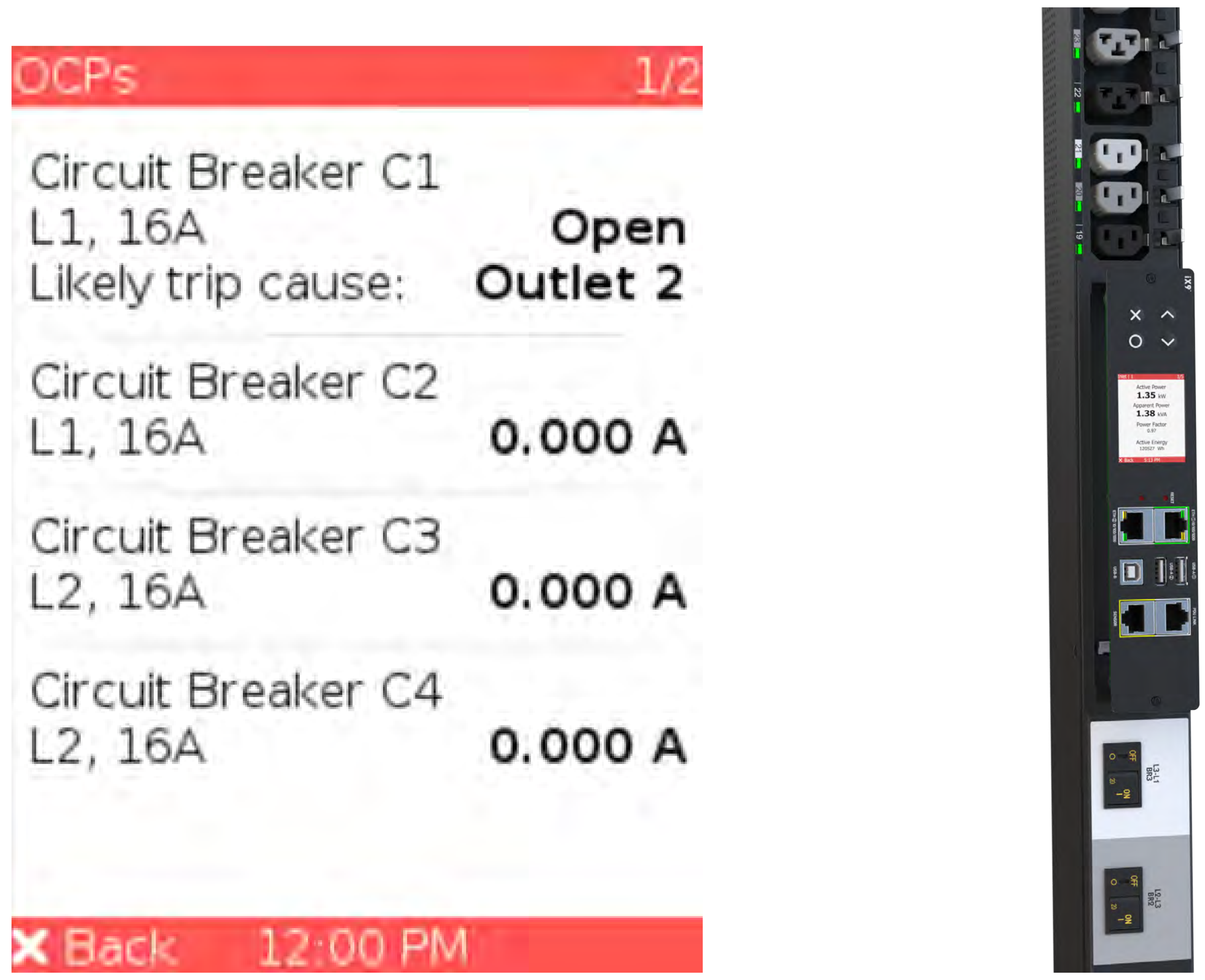
Increased risk of equipment failure: Sensitive IT equipment may malfunction or stop working altogether if exposed to significant harmonic levels.

Interference with communication lines: Interference can lead to data corruption, transmission errors, and reduced network equipment performance.

Tripping of circuit breakers and UPS issues: Harmonics can cause false tripping of circuit breakers and disrupt the operation of Uninterruptible Power Supplies (UPS), potentially leading to unexpected downtime. In severe cases, harmonics can damage the UPS, compromising the power reliability of the data center.

Difficulties in power capacity planning: Non-linear loads may draw more power than anticipated, leading to underestimation of power requirements and potential overloading of circuits.

Degradation of power factor: A lower power factor means more power is being wasted, which can result in additional



Example of LCD screen showing a circuit breaker trip event

charges from utility companies and necessitate the installation of power factor correction equipment.

Given these concerns, what would be the best way to monitor for harmonic distortion and prevent power quality issues?

To mitigate the negative impacts of THD, data centers often employ various strategies, such as installing harmonic filters, using power equipment designed to handle harmonics, and implementing power quality monitoring systems to identify and address issues proactively.

At the rack, installing Legrand's next-generation Raritan PX4 or Server Technology PRO4X branded intelligent rack PDUs that include built-in advanced power quality metrics and diagnostic tools, both at the PDU's inlet, or what is often called the PDU indeed, and at the PDU's outlets is a start.

As the adage goes, you can't manage what you don't measure, so what critical power metrics can be monitored at the rack level, and how can you gain this visibility?

Metrics from both the supply (inlet or 'upstream') and the critical load (outlets) sides of the system are equally critical to understanding total power quality. From both sides, you want on-demand access to information on current draw, voltage, power factor, frequency, and THD. Additional metrics to help narrow down the sources

> "Because of where intelligent PDUs reside, they are even more flexible in their deployment than racks themselves"
>
> **Don Strickland**
> Legrand

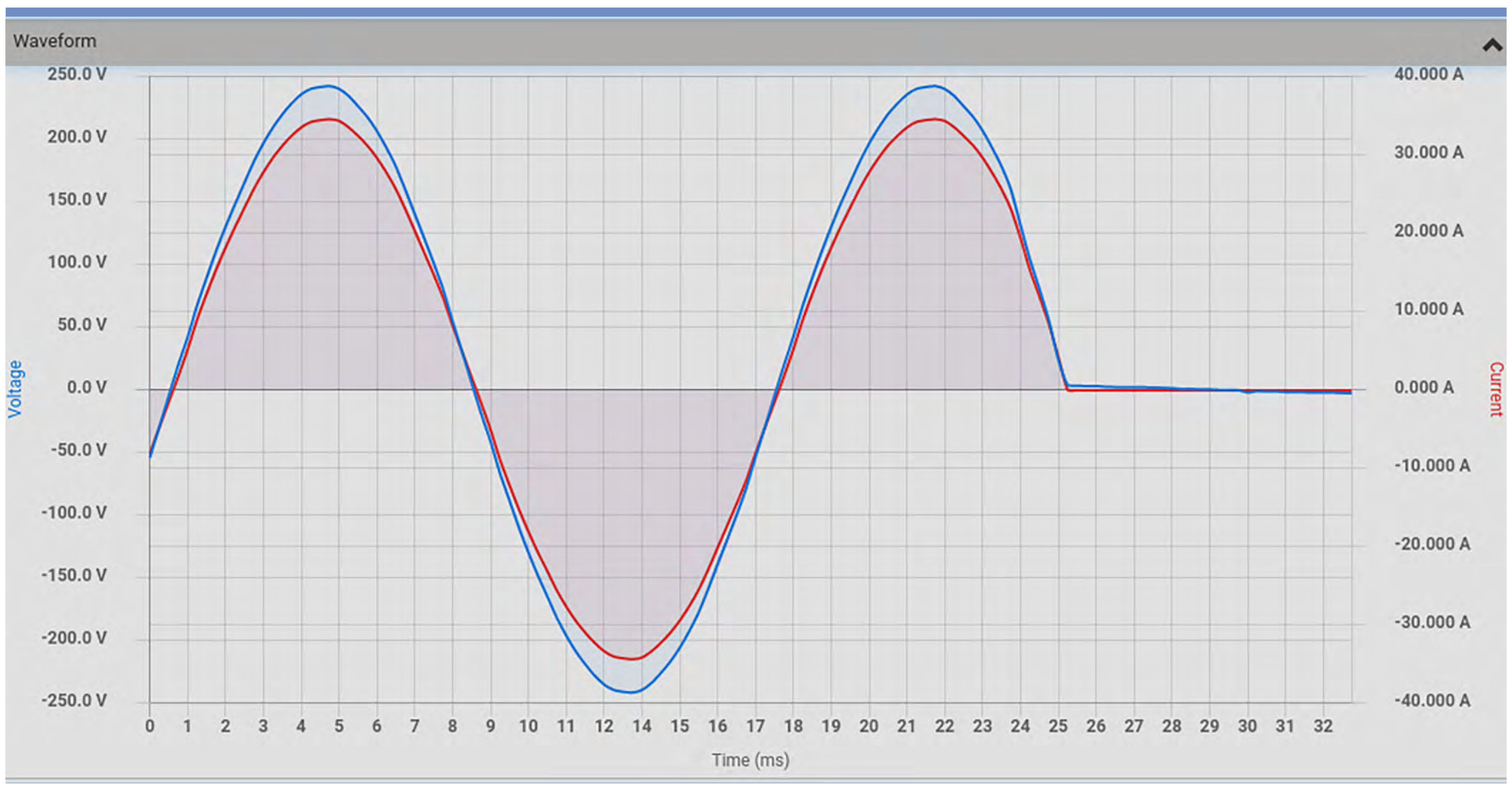
of power quality issues can also be invaluable.

These include distortion power factor (power factor with THD accounted for), peak and inrush currents, crest factor for further identification of high peak currents, and voltage dips and swells. Legrand's Raritan PX4 and Server Technology PRO4X intelligent Rack PDUs offer these capabilities and many others.

Why are intelligent PDUs essential to the power chain in today's data center?

Intelligent rack PDUs are the final piece of the power chain, closest to the devices that drive customer and revenue-critical applications. Therefore, they are positioned to be the best source of information for gathering data critical to pinpointing power-related hardware issues, assessing power usage to maximize energy efficiency, and improving capacity management efforts. Intelligent PDUs can also integrate with DCIM tools, serving as a critical data point in both focused and holistic reviews of data center infrastructure.

Finally, because of where intelligent PDUs reside, they are even more flexible in their deployment than racks themselves. In today's open, adaptable, and increasingly modular designs, knowing that you have non-static, re-deployable, highly intelligent rack power distribution working in partnership with critical power inputs and devices, regardless of rack, row, or pod configuration, is incredibly important.



Example of circuit breaker trip forensics with waveform capture

What are some of the unique features of PDU technology platforms that an operator might be less familiar with?

The Raritan PX4 and Server Technology PRO4X PDUs offer:

Waveform capture: Upon an OCP (Over Current Protector) trip event, a voltage dip, swell, or when an outlet is switched on, the rack PDU will automatically capture and store both the I and V waveforms. The user can also initiate on-demand waveform captures for an outlet or an inlet/infeed.

The waveform is captured for that particular event and is only stored on the PDU until a subsequent event triggers a new capture. So not only does the end user understand if there was an OCP trip or current inrush event when the cabinet was being powered up, they also get to see the values and what the waveform looked like when this event occurred!

Circuit breaker trip forensics: Worst case when an OCP device on a PDU blows or trips? No coordination study was done (between the PDU and upstream power), and the upstream breaker blows at the remote power panel (RPP) or the bus plug-in, bringing down the whole PDU! This requires a second PDU to carry the entire load, and if not properly loaded (roughly 40 percent of the rated capacity – 80 percent of the total load on one PDU) per North American standards, the whole cabinet can go down. And because no insight is available into which outlet or device caused the problem, you run the risk of the issue repeating itself potentially across multiple similarly loaded racks. Best case? The PDU tells you which outlet/device created the problem, and its effects on the system are quickly and easily mitigated.

Device-side scripting plus diverse API and SDK compatibility: The ability to configure and execute a LuaPLC script that's securely stored on the device allows operators to configure complex device-level operations suited to their needs. Combine this feature with Redfish API compatibility or a JSON-RPC API that can be bound to several common development languages, and you can create complex automated behaviors that can be integrated seamlessly with other rack, row, and/or data center or facility level tools.

Raritan PX4 and Server Technology PRO4X rack PDUs

Built-in firewall: This allows operators to configure rules that permit or deny access to the PDU based on the configured IPv4 and/or IPv6 rulesets.

Security: Legrand takes a highly proactive approach, implementing company-wide corporate product initiatives with regular Cybersecurity Task Force input and committee meetings. Our new Secure Boot feature on PX4 and PRO4X products ensures that the PDU's boot sequence remains secure, preventing interruption. We also ensure that device firmware versions undergo vulnerability testing before release and conduct periodic, full, third-party independent VPAT testing and product reviews.

Minimum/maximum sensor monitoring: While knowing what the overall kW load is on a cabinet is helpful, this is only a measurement at one point in time. To determine if a location is suitable for installing a new server (for example), you also need to know if the cooling is adequate at this location and to ensure that there is available power for the device in the long term.

By monitoring both the minimum and maximum values for temperature and kW over a longer period, such as the past year, you can estimate what your worst-case scenario would be. For instance, if you're planning an installation around a high-demand time, like Black Friday, you would check the temperature and power loads across multiple cabinets during this period until you find a suitable location.

What sort of diagnostic tools are available today, and how do they aid in the execution of proactive/predictive maintenance?

Our intelligent rack PDUs come with several diagnostic tools that can aid in their own maintenance, whether proactive or reactive. Detailed hardware issue detection is presented to operators, and diagnostic logs are available. These logs can be downloaded on demand either remotely or locally via USB. A network diagnostic mode allows testing and troubleshooting to be performed without impacting the critical load.

Finally, PDU deployment, configuration, and firmware-related updates can be pushed en masse across many PDUs. These features can help operators perform root cause analysis on their PDUs, proactively work with technical support to assess service options, or upgrade PDU firmware and configurations to take advantage of the newest features or address the most recent CVE alerts.

How easy is it to add this equipment to an existing data center as part of a retrofit? Are these PDUs agnostic?

PX4 and PRO4X intelligent PDUs cover a wide variety of input power and outlet configurations by default, vastly mitigating concerns over alterations made in the data center power infrastructure. However, should adaptability to power configuration(s) still be a concern, our intelligent PDUs now offer a Universal Input feature.

A PDU equipped with this feature can be outfitted with a number of input cords,

Raritan and Server Technology's rack PDUs universal input option

and once installed with a new input cord, the PDU will automatically adapt its power scheme to match. It's essentially a plug-and-play rack power solution. The available logging, configuration, and diagnostic tools previously mentioned make avoiding potential pitfalls and mass redeployment a breeze, and our intelligent PDUs are agnostic, not utilizing proprietary protocols or power/communication connections.

To ensure a holistic approach to power management, do the Raritan and Server Technology intelligent PDUs work in tandem with other equipment/products, and if so, how?

In addition to a number of DCIM integrations, our intelligent PDUs are compatible with our own line of SmartSensors and accessories. These include temperature and humidity, water/leak, contact closure, airflow and air pressure, dry contact, proximity sensors, and more, all of which can be daisy-chained and supported in large quantities through our environmental hub products.

Our PDUs are additionally compatible with our SmartLock door and access control system, as well as our own line of asset management accessories, which, when leveraged together, can turn a very small number of PDUs into hubs of row-level intelligence. Finally, our intelligent PDUs can utilize interface modules to enable Wi-Fi connectivity, third-party serial device connectivity, and Modbus integration.

With this in mind, would you say that to enable AI adoption in terms of power demand and management, an ecosystem of solutions providing real-time data is the only viable way to go?

Yes, absolutely. While reference designs for AI solutions are available and being adopted, no one operator or data center will ever have a reference experience. Forging the best possible future requires leveraging as much knowledge as one can get their hands on now, and that is precisely where the PX4 and PRO4X intelligent Rack PDUs come into play.

The amount and variety of data collected by a single intelligent PDU with a suite of sensors and accessories can sometimes seem staggering. But the tools are available, either on the PDU itself, or via external integration, to turn that data into a story or blueprint for the future: improved AI pod power infrastructure, mitigating interruptions to model training, minimization of utility costs, extension of equipment lifespans, meeting new AI workload efficiency metrics...a wealth of data makes it all possible.

Finally, how are Raritan and Server Technology supporting the accessibility and delivery of increased power demand among its data center customers?

Overall, power demand continues to increase based on newer, power-hungry technologies, but as discussed, you cannot manage what you are not monitoring. Legrand's Raritan and Server Technology rack PDUs and **Starline track busway** technologies ensure safe and reliable power distribution, monitoring, and management solutions for Edge, colocation, cloud, enterprise data centers, and just about any other facility you can think of. ■

For more information, please visit **Server Technology PRO4X Rack PDU** and **Raritan PX4 Rack PDU.**

DCD>Talks power quality monitoring

with Calvin Nicholson, Legrand

Leveraging power quality intelligence to drive data center sustainability

How choosing the right PDU can enhance reaching your data center's performance goals

Swen Anderson
Legrand

In today's landscape, sustainability within data centers has surged to the forefront as organizations establish carbon-neutral targets, commit to waste reduction, and embrace the use of recycled materials. This shift reflects a broader commitment to environmental responsibility and resource conservation.

The International Energy Agency (IEA) reports that data centers and data transmission networks account for 1-1.5 percent of global electricity usage, underscoring the pressing need for sustainable solutions. The escalating demand for data center capacity, driven by society's increasing reliance on data and the growth of AI systems, compounds the challenge, amplifying both energy consumption and the associated carbon emissions.

Data center providers are proactively addressing the imperative to reduce power consumption and mitigate carbon footprints. In response, the data center industry has set ambitious sustainability goals, aligning with the collective commitment to building a more sustainable digital infrastructure.

Many data center operators assess the success of their sustainability initiatives by employing The Green Grid's Power Usage Effectiveness (PUE) to gauge their data center's energy efficiency, which is calculated by dividing the total data center power consumption by the power utilized by IT equipment. A lower PUE signifies enhanced energy efficiency, indicating a reduced waste of resources. Elevating the importance of PUE is crucial for data centers to advance their environmental sustainability and diminish their carbon footprints.

Through diligent power quality monitoring, data centers can pinpoint areas of inefficiency and waste, empowering them to optimize infrastructure and further reduce their PUE.

Challenges in power quality monitoring

The challenge is that some data centers lack the power monitoring capabilities necessary for achieving heightened efficiency and sustainability. Moreover, there needs to be more continuous power quality monitoring. Many rely on rudimentary measurements, such as voltage, current, and power parameters, gathered by intelligent rack power distribution units (PDUs), which are then transmitted to DCIM, BMS, and other infrastructure management and monitoring systems.

Some consider power quality only during the initial setup or occasionally revisit it when reconfiguring IT setups. This underscores the critical role of intelligent PDUs in delivering robust power quality monitoring and the imperative for data center and facility managers to steer efforts toward increased efficiency and sustainability.

Certain power quality issues can have detrimental effects on the electrical reliability of a data center, leading to costly unplanned downtime and posing challenges in enhancing sustainability. These issues include:

Raritan PX4 intelligent rack PDUs

Voltage dips and swells These short-term fluctuations in voltage levels can cause IT equipment to malfunction or fail, leading to data loss or system crashes.

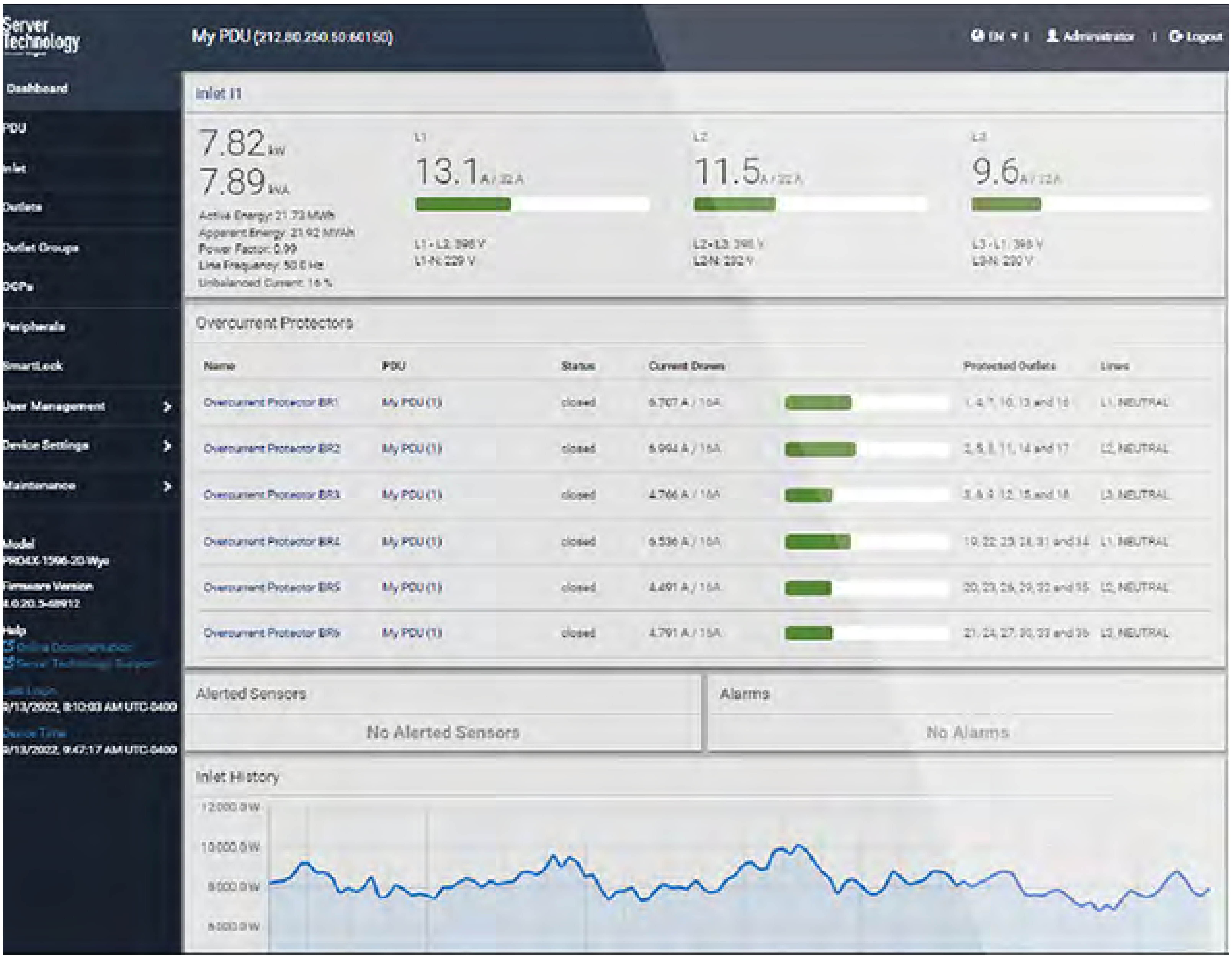
Harmonic distortion This electrical noise can cause overheating of IT equipment, causing damage and premature failure. Additionally, harmonic distortion can interfere with data transmission, leading to errors and reduced network performance.

Power outages Total power loss can lead to data loss, corruption, and equipment damage.

Frequency variations Shifts in AC power supply frequency can trigger IT equipment malfunctions or shutdowns.

"Certain power quality issues can have detrimental effects on the electrical reliability of a data center, leading to costly unplanned downtime and posing challenges in enhancing sustainability"

Swen Anderson
Legrand



Advanced power quality monitoring

These power quality issues can profoundly affect a data center's functionality and dependability. They may result in unforeseen downtime, harm to equipment, data loss or corruption, and reduced network efficiency.

The absence of accessible power metrics can impede data center operators from recognizing stranded capacity, preventing them from optimizing space and usage efficiently and sustainably. Hence, data centers must adopt dependable and intelligent power distribution solutions capable of capturing such details. This proactive approach helps mitigate power quality issues and ensures the uninterrupted operation of their IT infrastructure.

The challenge is that many intelligent rack power distribution units lack detailed visibility into power quality data at the rack and outlet levels despite offering a range of advanced features. This limitation arises from the need for more monitoring capabilities embedded in these intelligent PDUs, as they often focus on monitoring a limited set of parameters like voltage, current, and power.

While such data can offer insights into the general health of a data center's electrical infrastructure, it needs to provide the granular details necessary to pinpoint specific power quality issues affecting individual racks or devices.

This lack of specificity makes it challenging for data center managers to proactively identify and rectify power quality issues before they escalate into significant problems. There is an increasing demand for a new generation of reliable, intelligent rack power distribution, monitoring, and control solutions to address this crucial gap.

Features of a best-in-class PDU

The ideal PDU for powering sustainability in data centers should deliver comprehensive

> “The ideal PDU for powering sustainability in data centers should deliver comprehensive intelligence for visibility, reporting, and alerting for power and power quality metrics at the cabinet level”
>
> **Swen Anderson**
> Legrand

intelligence for visibility, reporting, and alerting for power and power quality metrics at the cabinet level. Additionally, it should exhibit flexibility to accommodate future data center requirements.

To effectively address the evolving demands of modern data centers regarding rack power monitoring and infrastructure requirements, future-ready capabilities must be integrated into rack PDUs.

These enhancements encompass advanced power quality monitoring, comprehensive metrics, real-time alerting, and precise accuracy with a margin of $\pm$0.5 percent. PDUs should offer visibility into peak and min/max power measurement values within this upgraded framework. This not only aids in capacity planning and identifying stranded capacity but is also crucial for failover planning.

Additionally, PDUs should include measurements of total harmonic distortion, enabling circuit breaker trip forensics. This feature allows data center operators to pinpoint the exact location and cause of trips, facilitating prompt troubleshooting and restoring power to unaffected equipment. A truly intelligent PDU captures associated waveforms, providing valuable data for reviewing and expediting power restoration to non-offending equipment.

Beyond the intelligence features of the PDU, achieving outlet high-density is paramount for forward-thinking data centers. Some data center and facility managers currently opt for off-the-shelf power strips to fulfill their density needs. However, this approach may necessitate specifying additional PDUs, expanding power infrastructure, and incurring higher costs.

Moreover, it may not provide the right number, type, or configuration of outlets. Data center professionals aiming to future-proof against evolving equipment density and changing requirements should seek PDUs with high-density and flexible outlet configurations.

Integrating this capability into a single PDU streamlines the utilization of high-input power capacity in smaller spaces, enabling the powering of more devices within the cabinet while reducing costs and minimizing infrastructure demands.

Data center operators should consider selecting **intelligent rack PDUs** that offer the following features:

• Advanced metering capabilities to monitor power quality metrics in real time.

• Flexible outlets that can be used for multiple applications that adapt to meet future equipment changes.

• Alternating outlet and branch power distribution to simplify three-phase load balancing and improve cabinet airflow.

• Circuit breaker trip forensics to identify the specific outlet that caused a trip.

• High-density outlet technology to meet increasing power density demands.

• High-strength cable and outlet locking and flexible infeed cord design.

• Secure encrypted communication, by default, for all PDU data.

The path to creating sustainable data centers includes enhancing the understanding of power quality data; this empowers facility managers to identify sources of inefficiency that may cause wear and tear on equipment, ultimately improving uptime. It’s essential that PDUs are viewed as more than just ‘power strips’ and are instead recognized as playing a crucial role in offering the necessary power quality monitoring for enhancing data center PUE.

The next-generation **Server Technology PRO4X** and **Raritan PX4 intelligent rack PDUs** by Legrand revolutionize capacity planning, workload optimization, environmental monitoring, physical and digital access control, and uptime initiatives, helping solve the power needs of data center operators today while assisting them to anticipate tomorrow’s rack power distribution challenges and problems. ■

DCD>Talks advancements in intelligent rack PDU hardware

with Swen Anderson, Legrand


PRACTICAL SOLUTIONS TO AI INFRASTRUCTURE CHALLENGES
With customizable solutions and collaborative engineering, see how Legrand's approach to AI infrastructure can help your data center address:
▪ Rising power supply and thermal density
▪ Heavier, larger rack loads
▪ Challenges with cable management and connectivity
▪ Increasingly critical management and monitoring
Click on the URL below to find out more about our solutions for resilient, agile AI data centers.
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