

Powering the Future:

Sustainable and Innovative Data Center Design for the Next Digital Era

Revolutionizing Data Center Design for Maximum Agility and Innovation, Your Guide to Smarter, Stronger, and More Reliable Data Centers

Wondering how data centers are gearing up for the future? With AI, machine learning, and the Internet of Things transforming the landscape, the right power solutions are more important than ever. Let's explore how smart innovations are helping data centers rise to the occasion—delivering on the promise of the “Tomorrow's Tech, Today.”

A New Frontier for the Data Center: The Impact of AI, ML, and IoT on Power Distribution

Artificial Intelligence (AI), Machine Learning (ML), Big Data, cloud computing, and the Internet of Things (IoT) are fundamentally changing the data center industry. These advancements demand that data centers increase power densities, transform existing facilities, and build new ones optimized for efficiency, reliability, resiliency, and sustainability.

From hyperscale facilities (such as CtrlS, Yotta, STT GDC India) to edge data centers and everywhere mission-critical IT infrastructure operates, the future of data centers revolves around the “power equation”: power quality and power distribution underpin the entire digital landscape. Meeting these requirements allows data centers to support the digital innovations users expect.

This whitepaper explores this challenge, providing a guide to rack-based power quality and power distribution tools necessary for supporting evolving high-density power requirements. As the demand for data center evolution intensifies, visionary, user-friendly, and adaptable solutions are needed to ensure continued success in a rapidly advancing digital environment.

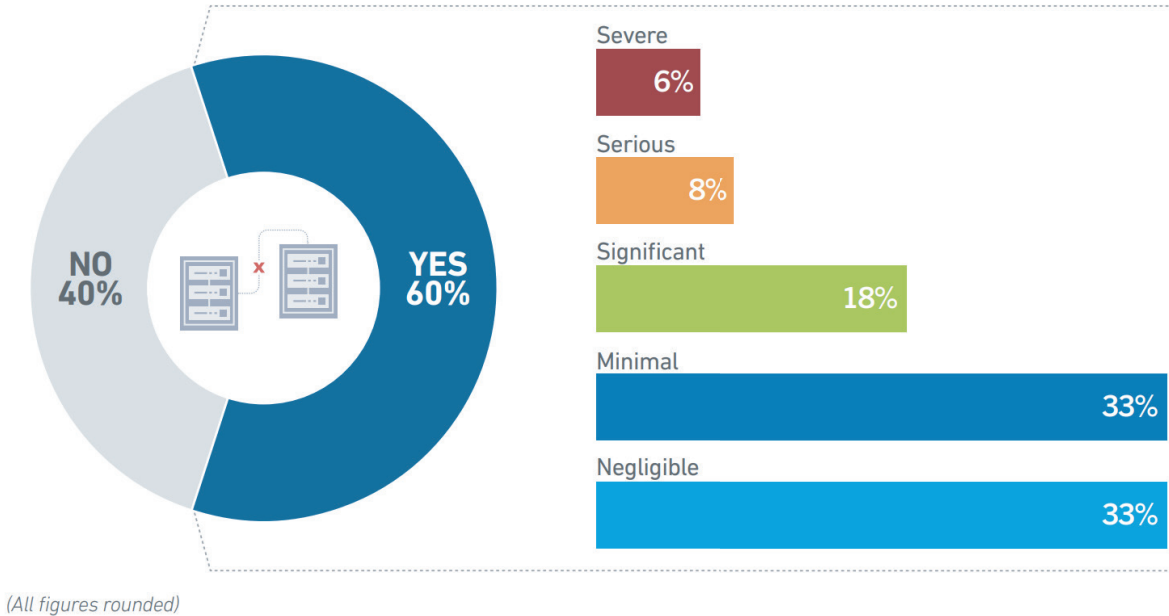
Legrand's approach to this transformation is grounded not only in technological innovation but also in a deep corporate commitment

to sustainability. By 2030, Legrand aims to reduce Scope 1 & 2 emissions by 42% and Scope 3 emissions by 25%, with 80% of sales coming from eco-responsible products. Carbon neutrality is targeted by 2050, validated by the Science Based Targets Initiative, ensuring environmental benefits are passed along the value chain to data center customers.

Managing Uptime and Efficiency: The Primacy of Power Quality

Data centers operate in an “always-on” environment, making uptime absolutely critical. Downtime remains a significant concern globally. According to the Uptime Institute's 2023 Annual Outage Analysis, over half of data center operators worldwide reported experiencing an outage in the past three years, with on-site power issues being the most common cause. While diagnosis and power restoration may be swift, restarting IT systems and re-synchronizing databases can be time-consuming—especially when equipment damage occurs, potentially impacting service level agreements (SLAs).

While many data centers highlight Power Backup (UPS/DG Sets) failures as the main cause of outages, there are other power considerations that, if mishandled, can cause equipment damage and downtime. Thus, attention to power quality throughout the power chain, especially at the rack and cabinet, is essential.



Understanding Power Quality Issues

Power quality refers to the stability of a power source and its ability to deliver ideal waveforms within specified ranges, enabling infrastructure to operate properly. Data center hardware can introduce power quality problems, such as:

- Non-linear switch mode power supplies (servers, switches, storage systems)
- Variable frequency drive (VFD) fan motors (HVAC systems)
- Pumps (cooling systems like D2C, RDHx, etc.)
- Lighting ballasts
- Rectifiers (used in UPS or as power shelves)
- UPS inverters (converting DC to AC)
- DC-to-DC converters (introducing AC ripple)

Common deviations from ideal power waveform include:

- Harmonic distortion: Causes overheating, equipment damage, and data errors
- Voltage sags and dips: Can cause shutdowns, reboots, and data loss
- Transients: Sudden voltage spikes may damage equipment
- Interruptions: Complete voltage loss leads to outages
- Frequency variations: Equipment malfunction or shutdown
- Voltage swells: Equipment malfunction or failure

Poor power quality can lead to false circuit breaker tripping, malfunctions, downtime, and higher energy costs. As high-performance computing equipment (such as AI clusters with advanced GPUs) is deployed, proactive power quality monitoring (PQM) becomes critical.

Data Center Design Tip: Enhance Uptime and Efficiency with Granular PQM

Independent power quality monitors can be installed upstream, but deviations can still occur downstream. The best approach is using rack power management equipment with continuous PQM, including total harmonic distortion (THD) measurements at the source. Next-generation Legrand intelligent rack PDUs offer:

- Real-time visibility, reporting, and alerting (THD, circuit breaker forensics, waveform capture)
- Revolutionary intelligence for capacity planning, environmental optimization, failover planning, and troubleshooting
- Industry-leading metering accuracy of $\pm 0.5\%$
- Best-in-class flexibility for future requirements
- Easy data collection and export
- Secure, default communication for all PDU data

Key specifications include:

- Single-phase: 230V $\pm 10\%$ (Indian standard)
- Three-phase: 400V $\pm 10\%$ (Indian standard)
- Input current range: 16A to 100A
- Breaker rating: 10kAIC
- Outlet capacity: Up to 54 outlets
- Temperature rating: 60°C (140°F) standard
- Operating elevation: 0 to 3048m; 0 to 10,000ft

Universal Input Option: Allows flexibility between single-phase and three-phase configurations.

Advanced Monitoring: Includes power quality metrics like THD, voltage dips/swells, and waveform capture.

Outlet-Level Control: Supports remote switching and monitoring down to individual outlets.

Deploying these PDUs improves uptime, capacity planning, optimization, and failover planning by capturing granular power quality data at the device level, reducing manual intervention.

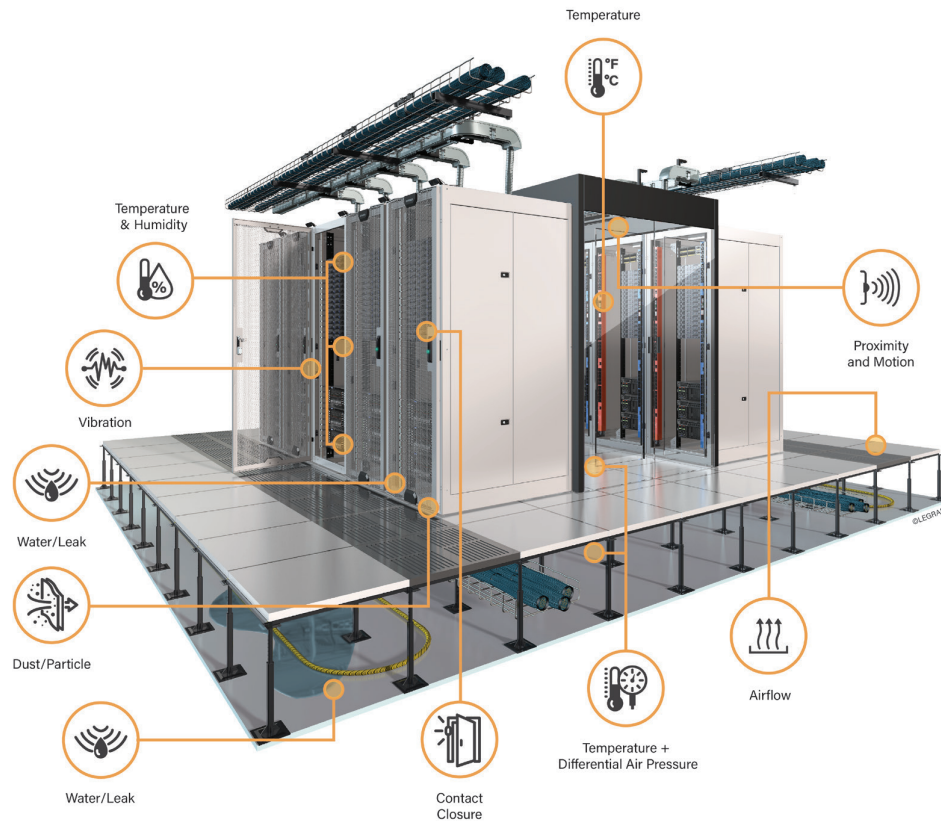


Raritan and Server Technology PDUs also integrate eco-design features. The patented HDOT Cx outlet accommodates multiple plug types, extending equipment lifespan and reducing material waste. High-density outlet layouts minimise the number of PDUs required per rack, lowering embodied carbon, while advanced remote monitoring helps identify and switch off idle servers - immediately reducing energy consumption and Scope 2 emissions.

Data Center Design Tip: Include Environmental Monitoring at the Rack

Increasing rack density brings heightened demands on power and environmental infrastructure. Intelligent environmental sensors (like Legrand's SmartSensors) help monitor the "health status" of data center racks, alerting operators to risks that may affect performance.

Deploying environmental monitoring alongside rack power management offers a holistic view of data center conditions, revealing trends and alerting to real-time threats. Monitoring variables such as cooling, temperature, humidity, water, dust, and vibration is essential for efficient, high-service-level operations.



**This is for illustration only and is not an actual deployment recommendation.*

AI & Power Distribution Design Throughout the Data Center

Beyond power quality, the infrastructure distributing power is equally crucial. The global AI market is expected to grow from \$454 billion (2022) to \$2.6 trillion (2032). This growth will likely cause global data center electricity demand to double, potentially reaching over 1,000 TWh by 2026, equal to Japan's current electricity consumption.

As AI clusters proliferate, rack power densities will exceed 20 kW per rack, with some reaching up to 200 kW. To facilitate this, data centers must move beyond traditional 120/208V distribution and adopt flexible, high-capacity power distribution solutions.

As data centers evolve to support ever-increasing computational loads and the rapid expansion driven by AI, it becomes imperative to design infrastructure with both adaptability and efficiency in mind. Integrating advanced power distribution and environmental monitoring lays the foundation for resilient operations, but staying ahead also means adopting innovations that enhance agility and scalability. The following design tips explore solutions that empower data centers to quickly respond to changing demands while maintaining robust performance and streamlined management.

Data Center Design Tip: Boost Agility and Scalability with Track Busway Technology

Legrand's Track Busway is an optimal solution for overhead power distribution, eliminating underfloor wiring obstructions and allowing rapid, flexible expansion. Its benefits include:

- Rapid installation and reconfiguration without specialized electricians
- Custom manufacturing, overhead, wall, and rack mounting
- No routine maintenance required
- Continuous access slot for tap-off plug-in units at any point
- Support for 40–1250 amps, 3-phase up to 600Vac/600Vdc
- Compatible with Starline's Critical Power Monitor (CPM) for real-time granular data and alarms
- Compression-fit connections for uninterrupted supply
- Lower total cost of ownership due to reduced installation and maintenance

Data Center Design Tip: Enhance Power Distribution with LV Switchboards

Legrand's LV switchboards are engineered for high-performance power distribution in Indian data centers, supporting up to 4000A. These modular systems offer:

- Configurable panels for power & motor centers, DG synchronization, and load sharing
- Smart motor control centers with automation and relay integration
- Wall-mounted and feeder pillar distribution boards for flexible deployment
- Double bus bar and automatic power factor correction options
- Fully draw-out and semi-draw-out configurations for ease of maintenance
- Proven reliability across sectors including IT, telecom, healthcare, and infrastructure
- Compliance with Indian standards and optimized for scalability and safety

Data Center Design Tip: Ensure Resilience with UPS Systems

Legrand's UPS portfolio, featuring Numeric and Borri, delivers scalable backup power for mission-critical data center operations. Key benefits include:

- Modular UPS systems from 400 kW to 12.8 MW for hyperscale and enterprise setups
- UPSaver® technology offering up to 99.5% efficiency with ultra-low total cost of ownership
- Hot maintenance and system resizing without switching to bypass
- Flexible mechanical installation and dynamic energy-saving modes
- Compliance with IEC EN 62040-3 and support for all classified modes of operation
- Ideal for cloud, telecom, networking, and critical cooling applications

Data Center Design Tip: Optimize Connectivity with LCS³ Structured Cabling

Legrand's LCS³ structured cabling system is meticulously engineered to empower data centers with rapid, scalable, and highly efficient network infrastructure. By accommodating a variety of topologies and bandwidth requirements, LCS³ enables seamless integration for both current and emerging technologies..

- Legrand's LCS³ cabling solutions offer copper, fiber optic, and hybrid options, all supporting high-speed connections up to 100 Gbps Ethernet and Cat. 8 compliance for future needs.
- Their high-density patch panels accommodate up to 48 ports per rack unit, with modular cassettes that simplify upgrades and maintenance.
- Fully compliant with ISO/IEC 11801, EN 50173, and ANSI/TIA-568 standards, the system features integrated cable management for flexible, organized racks that are easy to access.

Conclusion: Shape the Future with "Tomorrow's Tech, Today"

Smart power and monitoring aren't just technical details - they're the building blocks for India's digital future. With the right solutions, your data center can thrive no matter what tomorrow brings. The surge in AI, ML, IoT, and compute-heavy services will dramatically increase the load on data center power distribution systems. Meeting higher density and electrical consumption requirements

will necessitate revenue-grade monitoring down to the rack and PDU outlet.

Legrand's intelligent solutions offer the flexibility, accuracy, and support needed for future high-density deployments, with sustainability embedded in every stage - from corporate strategy to product design.

The journey towards more efficient and sustainable data center operations is both a challenge and an opportunity. By integrating advanced monitoring, modular design, and eco-responsible practices, operators can set new benchmarks for both performance and environmental stewardship—ensuring that the growth of our digital world does not come at the expense of our planet.

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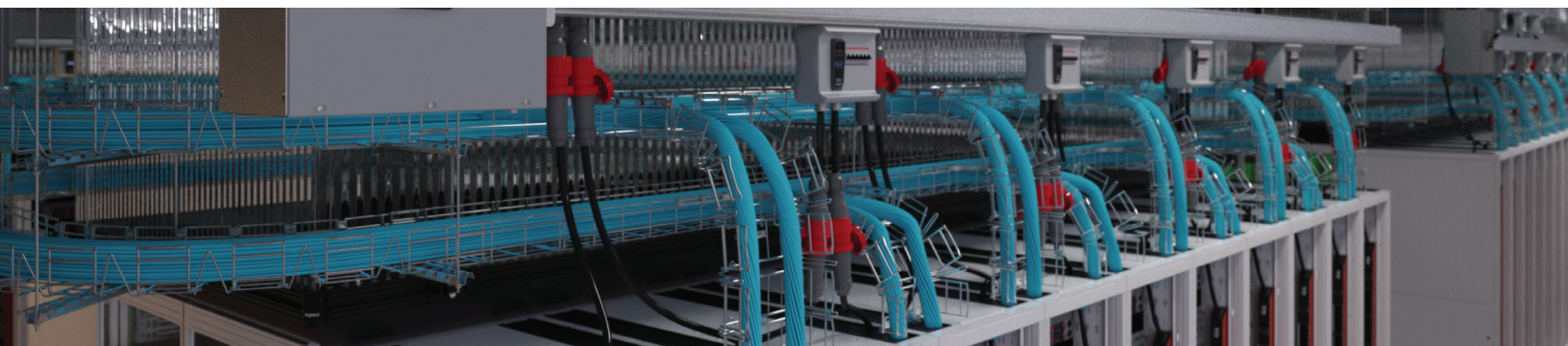
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