

How to Boost Data Center Resilience & Operational Visibility

*with smarter, highly integrated, and
more advanced control systems*

POWERED BY A MANUFACTURER'S MINDSET™

bwdesigngroup.com



The background of the page features a blue-tinted photograph of server racks in a data center. The racks are filled with equipment, and the perspective is looking down the aisle, creating a sense of depth. The top of the page has a solid red banner where the title is located.

Abstract

As data centers evolve into increasingly complex and mission-critical facilities, traditional building management systems based on direct digital control (DDC) architectures are being pushed to their limits. This white paper explores how programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA) systems provide a more robust, responsive, and scalable foundation for fully integrated infrastructure control, from the rack level on a data center floor to the entire physical facility. It outlines the limitations of DDC in areas such as redundancy, responsiveness, and integration, while making the case for adopting industrial-grade automation principles in modern data center environments. Real-world examples and implementation strategies highlight a practical path toward a fully integrated data center management model—from hybrid approaches that include legacy DDC systems to fully redundant PLC/SCADA architectures.

Data centers are the operational backbone of the world's digital economy. From cloud computing and AI to financial systems and critical infrastructure, every aspect of modern life depends on their uninterrupted operation.

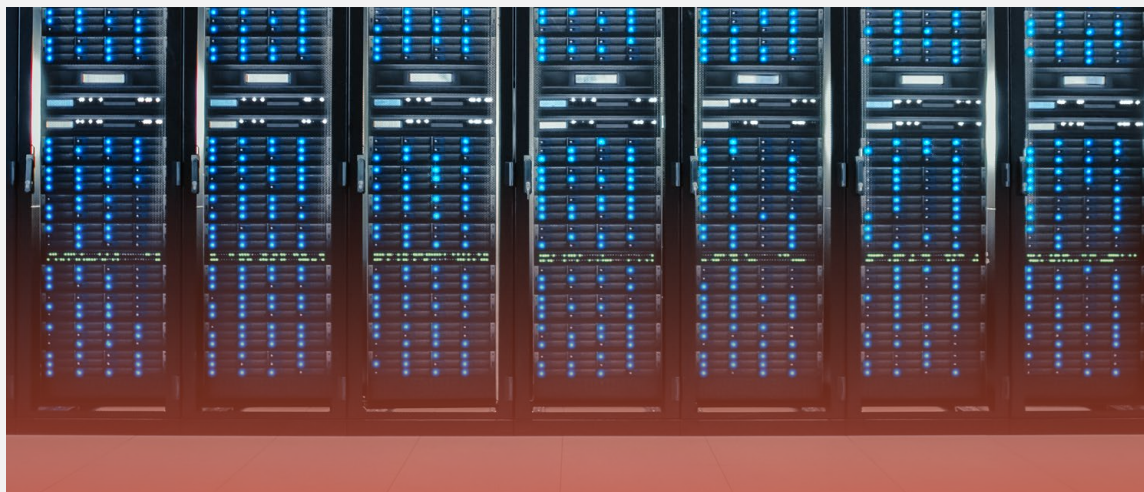
Hyperscale data centers—those housing 5,000 servers or more and spanning many acres in size—are one of the fastest-growing segments in this industry. Synergy Research estimates that more than 1,000 hyperscale data centers were operating globally in 2024, with 120–130 new ones coming online annually, driven by generative AI technology's rapid expansion.¹ This figure refers specifically to hyperscale facilities, not the broader universe of all data centers, which includes thousands of smaller colocation and enterprise deployments. Much of this growth is being driven by the rapid expansion of generative AI technology.

However, whether data centers are hyperscale or serving colocation, corporate, telco, or government requirements, they require high availability, precise control, and near-instant responses to any anomalies—capabilities that exceed what conventional building management systems (BMS) were designed to deliver.

In addition, data center power consumption is following a dramatic upward trajectory, with industry forecasts indicating a 50% increase by 2027 and an extraordinary 165% surge by 2030.

This exponential growth is primarily driven by the increasing deployment of high-performance computing and AI applications, which are fundamentally transforming traditional power density parameters. While legacy facilities commonly operate with rack densities exceeding 10kW, AI-focused installations are pushing these boundaries to 75kW per rack and beyond.

This intensive power consumption creates cascading effects throughout the facility: for every kilowatt of computing power, equivalent cooling capacity must be provided while maintaining redundancy safeguards and operational efficiency. The challenge facing data center operators is multifaceted - they must accommodate these escalating power requirements while simultaneously optimizing energy efficiency, managing thermal loads, and maintaining reliability through the use of redundant systems. This balance becomes increasingly critical as rack densities continue to climb, requiring more sophisticated power distribution architectures and cooling solutions to support the next generation of computing infrastructure.



6 Trends Reshaping *Data Center Infrastructure*

Today's data centers are under pressure to evolve—faster builds, higher density, tighter margins, and growing complexity are driving rapid change. These six trends are pushing control system requirements beyond what traditional BMS/DDC platforms were designed to handle:

1

SPEED TO THE FIRST MEGAWATT

The industry is demanding faster design-to-deployment cycles, pushing teams to reduce build times while maintaining quality and reliability.

2

MODELING, SIMULATION, & EMULATION

Digital twins and virtual commissioning are increasingly used to optimize system design, speed up deployment, and reduce integration risk.

3

LARGER, MODULAR COMPONENTS

Skidded systems and standardized modules enable repeatable designs and scalable, Lego-like construction across multiple sites.

4

ADVANCED COOLING SYSTEM COMPLEXITY

Liquid cooling, thermal loops, and CDU integration are increasing system sophistication—driving the need for more flexible and powerful control platforms.

5

TECHNICAL LABOR SHORTAGES

Limited availability of trained technicians is steering operators toward open, widely supported control platforms like PLCs.

6

HIGH-RESOLUTION WAGES MONITORING

Demand is rising for granular, real-time data on water, air, gas, electricity, and steam (WAGES) to meet sustainability and reporting goals.

Where DDC Falls Short in the Data Center

Most traditional building management system (BMS) platforms rely on direct digital control (DDC) architectures. While suitable for office buildings and non-critical commercial environments, DDC systems often fail to meet the performance and reliability standards required in today's data centers. Issues like limited redundancy, slow scan times, and difficulty integrating across complex systems expose operators to the risk of downtime, server damage, or data loss.

Lack of redundancy and real-time responsiveness

DDC systems were never designed to support the stringent uptime requirements of modern data centers. Their scan cycles are typically measured in seconds rather than milliseconds needed to quickly detect and respond to critical events like temperature spikes, equipment failures, or power anomalies. Because DDC architectures lack genuine hardware redundancy and while they may feature failover mechanisms, they are often fragile, custom-engineered workarounds. In contrast, systems based on programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA) systems are inherently designed with redundancy as a core feature. This ensures critical operations continue uninterrupted, even if a controller or network module fails.

Inflexibility and limited customization

DDC systems often use pre-programmed applications with limited options. While this approach is efficient for standard HVAC or lighting control, its limitations can become a liability in data center environments. Of course, advanced DDC systems are capable of custom functions and data structures similar to PLC platforms, but the latter can offer greater flexibility and customization capabilities, enabling greater adaptability to the unique needs of each data center deployment.

In some data centers, particularly those with more flexible operational models, site teams can be tasked with ongoing optimization of baseline parameters such as airflow dynamics, thermal management, and energy consumption. PLCs support this need by offering full programmability and advanced control logic capabilities. Enabling integrators and engineers to tailor system behavior with precision is a key aspect of modern automation—especially in complex, mission-critical environments.

Beyond their rigid programming structures, many DDC systems further limit flexibility by requiring proprietary software licenses or certified tools to make changes, effectively restricting access to a small pool of trained technicians. These vendor-specific ecosystems can pose long-term support challenges, particularly when site staffing or servicing needs change.

In contrast, PLC platforms like Siemens SIMATIC are widely used across industrial sectors, supported by tens of thousands of engineers and technicians worldwide. This openness ensures greater accessibility, easier support, and future-proofed staffing options.

Scalability constraint

Traditional DDC platforms require a higher number of distributed controllers to manage expanding system complexity. Each controller manages a limited number of I/O points and often communicates via proprietary or semi-closed protocols. This creates bottlenecks and complicates integration as data center infrastructure grows.

Conversely, PLC-based systems can manage thousands of variables and alarms from a central platform with high-speed I/O communication, open protocol support (e.g., OPC UA, BACnet, Modbus), and seamless scalability.

Modernizing Energy Management in a Mission-Critical Facility

Location: Germany

To keep pace with growing energy demands and digital infrastructure requirements, a Germany-based colocation data center undertook a full-scale modernization of its energy management system. The facility required a control solution that could improve system availability, integrate thousands of variables, and offer real-time visibility—without introducing any operational downtime.

Siemens replaced the competitor's legacy PLCs and SCADA platform with a fully redundant SIMATIC WinCC SCADA system. The upgrade brought significant improvements in scale and resilience, integrating:

- More than 15,000 variables and 1,200 alarms
- 6,000 trend points for performance monitoring
- 413 circuit breakers and 200+ Janitza power analyzers

A unified SCADA interface now allows operators to monitor and manage all electrical loads, energy consumption, and system health through a centralized platform. The system also supports web-based remote access, enabling staff to respond swiftly—even offsite.

By implementing native redundancy in its SCADA servers and streamlining I/O integration, the facility achieved its primary goals: enhanced uptime, better remote control, and seamless engineering continuity. The result is a next-generation energy management system that is fully aligned with the performance and reliability expectations of the data center market.





PLC + SCADA: The Control Foundation for Integrated Data Center Management

Modern data centers require comprehensive control architectures, ensuring precision control, intuitive visibility, and fault tolerance across an integrated infrastructure system. Critical Infrastructure Framework includes:

- Building Management System (BMS)
- Electrical Power Monitoring System (EPMS)
- Energy Monitoring System (EMS)
- Chiller Plant Management System (CPMS)
- Facility Management System (FMS)
- Fuel Oil Delivery/Genset Control System

With redundancy and hot failover capabilities built into modern PLC/SCADA systems, critical operations can continue automatically—even if a controller, network module, or device fails. These architectures enable automated alerts, system logging, and uninterrupted control without human intervention.

Operators must have real-time comprehensive visibility into every data center operating system, from floor-level ones such as chilled water loops or airflows that cool the server racks to building-wide monitoring systems such as HVAC, fire detection, and security safeguarding the entire physical facility, regardless if they are onsite or remote.

To provide these capabilities, the control layer for the entire data center's management must be designed and engineered for real-time performance and long-term resilience. That is where PLC and SCADA architectures excel.

Designing for TIER IV reliability and long-term growth

Location: Spain

As part of a large-scale smart infrastructure initiative, a public transit authority in Spain commissioned a new data processing center to consolidate operations and prepare for two decades of growth. The goal: create a TIER IV-level facility with no single point of failure, optimized energy performance, and complete operational transparency.

To meet these ambitious goals, Siemens delivered a robust control architecture anchored by redundant S7-1515R PLC and a distributed SCADA platform. The system design included:

- Seven pairs of redundant CPUs for continuous uptime
- HMI panels at multiple zones for localized monitoring
- SCALANCE industrial switches and BACnet/Profinet gateways for seamless integration
- Modular ET 200SP HA I/O for high-availability field connectivity

The architecture ensures real-time responsiveness, network-wide visibility, and scalable control as the data center expands. The Siemens design also enabled energy optimization and durability in an environment where transport data, safety, and uptime are mission critical.

By integrating advanced PLC-based automation into the facility's foundation, the Spain-based data center is equipped to support 24/7 operations today—and adapt as transit technologies evolve in the decades to come.



Photo Credit: Siemens

Lack of redundancy and real-time responsiveness

Advanced PLCs can support redundancy at all levels (CPUs, network, I/O, and power supplies), automatically mirroring each other for a bump-less failover in real time with no operator intervention. Within an engineering environment, it is simple to configure redundancy at all levels, often with a simple check box with the intent of eliminating any single point of failure that could threaten the operation of a data center.

Real-time adaptive control with digital twin integration

Today's sophisticated PLCs combine high-speed processing with intelligent control logic—and increasingly integrate with digital simulation platforms. This allows teams to use digital twins for virtual commissioning, system design validation, and operational optimization before deploying changes to the live environment.

Rather than dynamically adjusting parameters in real time, most data centers today use digital twins as an offline tool for simulating thermal dynamics, power distribution, and environmental scenarios. Engineers can model potential issues, test configurations, and validate system updates before implementation—enhancing performance while minimizing risk.

This proactive, simulation-based approach supports faster commissioning, improved system tuning, and better long-term decision-making. It also offers valuable opportunities for operator training, system documentation, and continuous improvement.

As digital twin technologies mature, future architectures may eventually support more integrated real-time adaptation. But, for now, their primary value lies in accelerating design, validation, and deployment.

Industrial-grade cybersecurity

As cyber threats grow in frequency and sophistication, now amplified by AI, data centers must operate under rigorous cybersecurity protocols. Siemens Defense-in-Depth cybersecurity architecture implements multiple layers of industrial-grade protection aligned with IEC 62443 standards for mission-critical infrastructure. The framework integrates plant security, network security, and system integrity through hardware-enforced boundaries and secure-by-design controllers. Core components include SIMATIC PLC and WinCC SCADA systems featuring encrypted communications, role-based access control (RBAC), and security logging with tamper-proof audit trails.

The architecture supports air-gapped operations while enabling secure remote diagnostics through Industrial Cybersecurity Services when permitted. Security features like SIMATIC Security Controller, Trust Platform Module (TPM), and digitally signed firmware updates protect against unauthorized access and malicious code execution.



Additionally, Siemens Industrial Anomaly Detection system continuously monitors network traffic patterns to identify potential security breaches, while Industrial Cybersecurity Services provide ongoing vulnerability assessments, security patches, and incident response support. This comprehensive approach ensures data centers maintain operational integrity while meeting stringent regulatory requirements for enterprise and government facilities.

This security architecture model offers peace of mind and regulatory compliance—especially for enterprise-class and government data centers.

System integration and scalability in modern data centers

Data center control architectures must deliver potential scalability beyond initial deployment requirements, providing a foundation for seamless evolution and expansion. The system must accommodate dynamic growth—whether adding server capacity, reconfiguring cooling infrastructure, or expanding the physical footprint of the site—without disrupting ongoing operations.

Siemens integrated PLC and SCADA-based solution addresses this challenge through its Changes in Run (CiR) capability, enabling real-time system modifications, including program updates, equipment additions, and firmware upgrades while maintaining operational continuity.

The combination of WinCC SCADA and SIMATIC PLCs creates a unified, extensible platform that consolidates diverse building and power systems under centralized management. This architecture excels at integrating legacy infrastructure and new installations across multiple sites, providing operators with comprehensive visibility and control over all facility systems—from cooling towers to power distribution networks.

The platform's inherent scalability ensures that as data centers expand and evolve, the control system grows proportionally, maintaining operational efficiency without requiring costly system overhauls or introducing operational risks. Increasingly, these systems must also support modular designs and offsite-fabricated components. From cooling distribution units (CDUs) to central utility plants, many data centers now rely on skidded subsystems that can be fabricated, tested, and delivered as standardized modules. This modular approach accelerates deployment and simplifies site integration—provided the control architecture is flexible enough to accommodate repeatable designs across geographies, vendors, and project scopes.

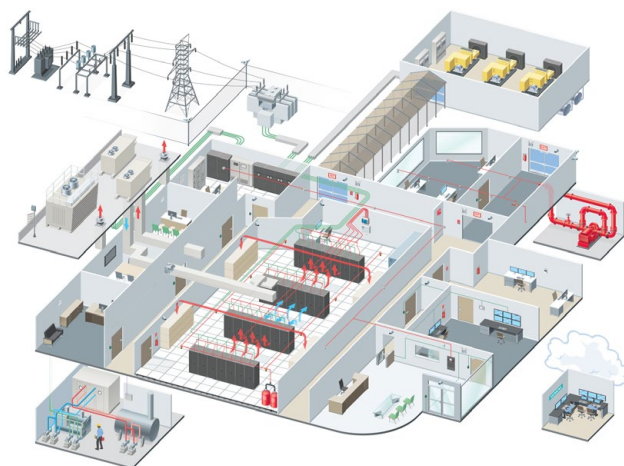


Image Credit: Siemens

Unified platform for HVAC, EPMS, EMS, and more

Traditional data centers often deploy multiple disconnected systems: one for HVAC, another for electrical power, and a third for emergency backup. Each has its own interface, logic, and vendor support. This fragmentation limits visibility, slows reaction times, and increases maintenance overhead.

A fully integrated data center management system solves this issue by bringing all building systems under the control of a single PLC-based, SCADA platform.

It's worth noting the distinction between unitary and supervisory DDC systems. Unitary DDC controllers are self-contained devices embedded in equipment like air-handling units (AHUs) or computer room air conditioners (CRACs) and are typically not intended for centralized control. Supervisory DDC systems, by contrast, connect and coordinate multiple unitary controllers across a building or site. PLC-based supervisory systems can interface with these devices via standard protocols, enabling seamless integration without requiring full system replacement.

From one interface, operators can view real-time alarms, adjust setpoints, analyze energy consumption trends, and monitor the health of power and electrical systems. One recent Siemens deployment, for example, integrated over 200 power analyzers, 413 circuit breakers, 6,000 trend points, and more than 15,000 variables—across HVAC and energy infrastructure.

A modernized and fully integrated data center management system is not just about control. It is about actionable insight—and the ability to respond fast to faults and other operational anomalies.

Flexible architecture: from edge to cloud

Modern data center management demands sophisticated control over data handling and analytics deployment, particularly as organizations balance advanced capabilities with security requirements. Contemporary PLC and SCADA architectures address this challenge through a flexible, policy-driven approach that supports multiple operational modes.

This architecture enables powerful edge computing capabilities, performing real-time analytics, AI-driven fault detection, and predictive maintenance entirely within the facility's secure perimeter. This local processing architecture proves especially crucial for hyperscalers, financial institutions, and government agencies that require strict data sovereignty. However, the system also accommodates selective cloud integration when permitted, allowing organizations to implement configurable data filtering and secure transmission protocols for enhanced analytics and remote operations.

This adaptability means operators can maintain complete air-gap isolation where required or implement hybrid configurations that selectively mirror data to cloud services based on specific security policies and compliance requirements. The result is a future-ready infrastructure that delivers advanced analytical capabilities without forcing compromises between operational innovation and security compliance, effectively preserving both technological advancement and operational autonomy.

Mission-critical by any name: lessons from batteries and semiconductors

The term “mission critical” is commonly associated with data centers, but the underlying demands—real-time response, fault tolerance, and zero downtime—apply equally to other high-stakes environments. Two sectors are driving a parallel shift from DDC to PLC-based control: semiconductor manufacturing and battery production.

In semiconductor fabs, safety systems monitor toxic gases, volatile chemicals, and ultra-sensitive process equipment. These systems must run 24/7, often without interruption for years at a time. Any interruption to the control network can result in downtime that can shut down a fab, and potentially waste tens of millions of dollars.

Battery production facilities face a different kind of risk: thermal runaway. If temperature or ventilation controls fail during critical mixing or curing steps, the result can be catastrophic, both for equipment and personnel. That is why PLC-based automation with fast scan times and high-speed redundancy is becoming the standard in these emerging plants.

While the terminology may differ, the takeaway is the same: DDC systems are not built for fail-safe environments. Whether it is a data rack, a lithium-ion cathode, or a silicon wafer line, PLC and SCADA solutions offer the control, customization, and resilience needed to protect lives, assets, and uptime.

Overcoming barriers to modernization

Switching from a DDC to a PLC/SCADA architecture requires training, engineering time, and testing. Even when PLC-based systems are introduced, they can interoperate with existing unitary DDC controllers, allowing teams to modernize supervisory layers without overhauling every device or subsystem.

This is where partners who are experts in industrial automation can help close that gap. By marshaling the right partners, engineering support, and solution design services, OEMs and systems integrators can accelerate their adoption of PLC/SCADA technologies for an integrated data center management solution while reducing integration risk.

Assistance can include pre-engineered templates, onboarding guidance, and collaborative agreements to offset upfront efforts with a more cost-effective, highly scalable, and future-proofed data center management model. Taken together, these advantages can reduce deployment times, costs, and risks.



Conclusion

Ready for what is next?

In the evolving world of digital infrastructure, reliability is no longer just an advantage—it is imperative. As data centers become denser with ever more powerful servers, more dynamic, and more interconnected, the systems that manage their operations must rise to meet new and increasingly rigorous requirements. Traditional DDC-based building management systems were never designed for this level of complexity or criticality.

Proven in many thousands of industrial deployments worldwide, integrated PLC and SCADA architectures offer a needed alternative: one that combines industrial-grade resilience with engineering flexibility, real-time responsiveness, and full lifecycle support. It is a system designed and engineered not just for controlling HVAC or monitoring alarms but also for orchestrating an entire data center ecosystem of energy, environment, and infrastructure with speed and certainty.

This same control architecture also lays the foundation for modular expansion. As more data centers adopt skidded subsystems and standardized components, “plug and play” control integration becomes essential. PLC-based environments are inherently suited to this shift. This enables faster deployments, seamless interfaces with prefabricated systems, and repeatable engineering across multiple sites. By predisposing facilities with PLCs today, operators position themselves to scale with speed, consistency, and confidence.

Forward-looking data centers around the world are adopting this approach today. Whether through full PLC-based control or hybrid supervisory models, the transition has begun. For organizations seeking to future-proof their data center operations, reduce risk, and unlock deeper insight into system performance, the path is clear: move beyond the limitations of legacy BMS. Choose an architecture designed for what is next.

BW Design Group

Building the future of manufacturing + technology

BW Design Group is a premier System Integrator within a fully integrated AEC firm delivering over 3GW of greenfield Data Center BMS and EPMS systems. From Strategy to Commercialization™, we bring broad expertise across all BMS/EPMS platforms to implement control systems, computer infrastructure, network design, and ensure optimal implementation with the latest technologies and integrated cybersecurity. Additionally, we specialize in the design, manufacturing, and certification of industrial control and power distribution panels for the Data Center industry. Learn more about us at bwdesigngroup.com or [Accelerating the Future of Data Centers at Scale](#).



BW Design Group
8027 Forsyth Blvd., Suite 800
St. Louis, MO 63105
United States of America

bwdesigngroup.com

Integrated data center management solutions

from Siemens and BW Design Group

Siemens and BW Design Group have partnered on the design and engineering of numerous mission-critical data centers of all kinds and sizes. Collaborating closely with each customer's facility architect, engineering, and construction (AEC) teams, our companies have successfully deployed modern, fully integrated data center automation architecture built on industrial-grade SIMATIC PLCs and WinCC SCADA. This combination provides the speed, fault tolerance, scalability, and cybersecurity requirements necessary to operate mission-critical environments with confidence. We invite you to learn more at [siemens.com data centers](http://siemens.com/data-centers) or call our representatives for a complimentary assessment of your goals and requirements.



Siemens Industry, Inc.
100 Technology Drive
Alpharetta, Georgia 30005
United States of America

Telephone: +1 (800) 241-4453
usa.siemens.com



BW Design Group

BW Design Group
8027 Forsyth Blvd., Suite 800
St. Louis, MO 63105
United States of America

Telephone: +1 (314) 778-4300
bwdesigngroup.com

© 2026 BW Design Group

This document is provided solely for informational and educational purposes and does not constitute legal, financial, investment, tax, or professional advice. Before making any decisions based on this document, consult with qualified professionals. All information is provided without warranty of any kind, express or implied, and BW Design Group does not warrant the accuracy, completeness, or timeliness of any information contained herein. All content, including text, graphics, and data, is the intellectual property of Siemens and/or BW Design Group or their licensors. By accessing this document, you acknowledge that you have read, understood, and agree to be bound by this disclaimer.