DATA CENTERS

The quest for **99.999%**

Redundant designs for high availability and fault tolerance in data center operations
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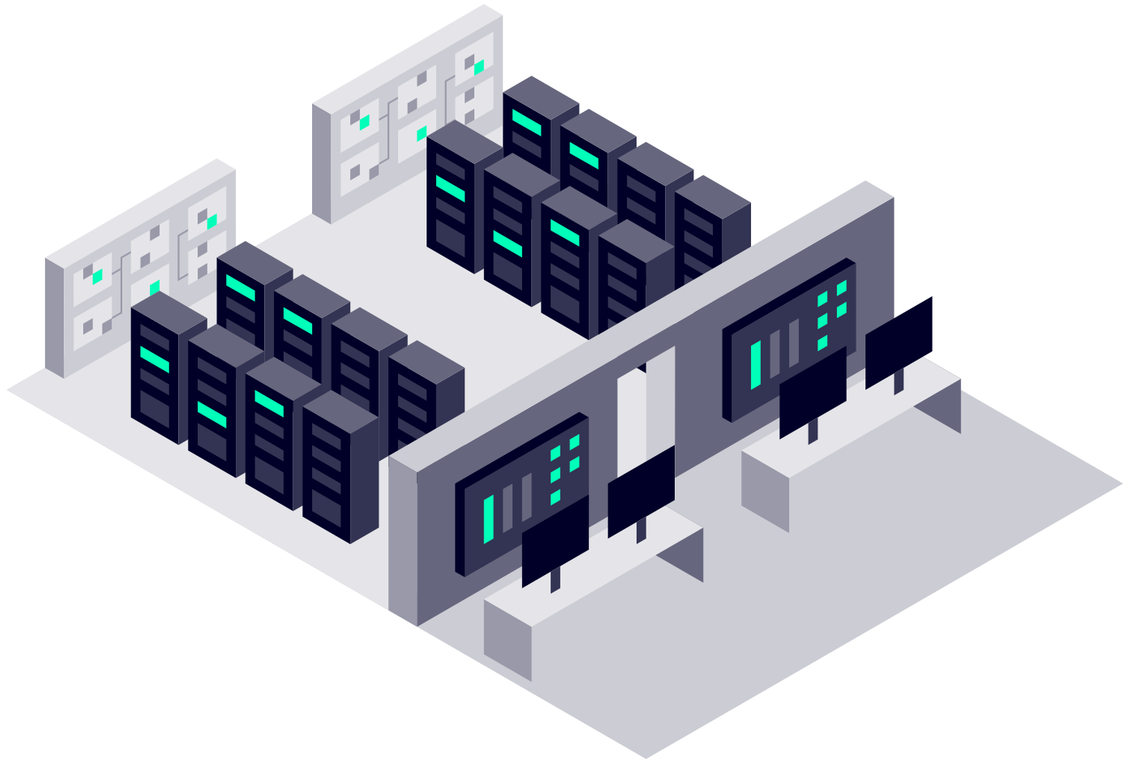
The quest for **99.999%**

Data centers are the backbone of our digital society and considered mission-critical infrastructure. Uptime is paramount because any disruption can have significant consequences. A well-designed Building Management System (BMS) and Electrical Power Monitoring System (EPMS) lay the groundwork for resilient and reliable data center infrastructure.

Data centers need to be up and running all the time. Availability is usually expressed as a percentage of uptime in a year, mostly as 99.999 percent – the so-called five nines – which translates into roughly five minutes of downtime a year.

The key to achieving this is having redundant hardware and software components. Not only do high levels of redundancy contribute to minimizing downtime and the associated costs – they also aid data center operators in complying with regulations, protecting sensitive data, enabling converged infrastructure, supporting multi-site architectures, and maintaining brand reputation.

Moreover, **redundancy is seen as a building block for achieving high availability and fault tolerance in data center operations.** Without redundancy, a single point of failure – such as a hardware component in a server, a software bug, or even a network device – can bring an entire system down.



Increasing levels of **resilience**

For these reasons, data center operators implement redundancy in their designs, often in compliance with international standards, such as ISO 22237 (in Europe, EN 50600) and the Tier Classification System from Uptime Institute.

ISO 22237 covers all aspects of data center infrastructure, including power, cooling, security, and management systems. Four different availability classes have been specified – Class 1, Class 2, Class 3, and Class 4 – representing increasing levels of resilience and reliability. Similarly, The Uptime Institute's Tier Classification System is based on four tiers, from the basic Tier I to the highly resilient Tier IV, with each tier offering increasing levels of redundancy and fault tolerance.

Among others, the BMS and EPMS are pivotal to fulfilling requirements outlined in these standards, like:

- "The infrastructure controls system demonstrates autonomous response to a failure while sustaining the critical environment." [1]
- "[...] the data center critical systems must be able to autonomously detect a loss of [utility] service and respond with on-site systems to provide the service." [2]
- "[...] the ability to concurrently allow site infrastructure maintenance and IT operation requires that **each and every system** or component that supports IT operations must be able to be taken offline for scheduled maintenance without impact to the IT environment." [3]
- "The control systems for additional power supplies shall remain functional if primary or secondary power supplies are disrupted." [4]
- "The design of the system shall accommodate a situation where all [Computer Room Air-Conditioners (CRACs)] run at minimum fan speed. Where capacity allows consideration shall be given to switching a proportion of CRACs to standby mode, ready to start up upon failure of a running CRAC." [5]

Whichever standard is followed, automation and control systems in the Building Management System (BMS) and Energy and Power Management System (EPMS) play a crucial role in ensuring the optimal operation and environment for critical IT equipment.

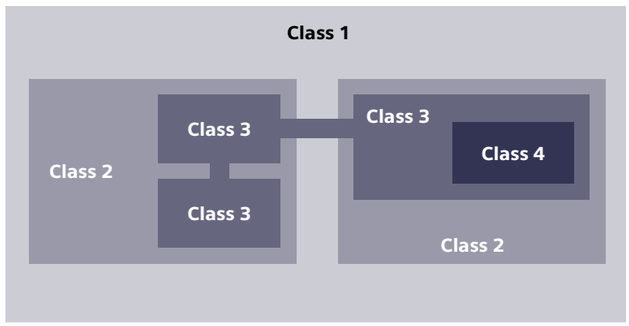
The N Concept[6]

	Tier I	Tier II	Tier III	Tier IV
Minimum Capacity Components to Support the IT Load	N	N+1	N+1	N After any Failure
Distribution Paths - Electrical Power Backbone	1	1	1 Active and 1 Alternate	2 Simultaneously Active
Critical Power Distribution	1	1	2 Simultaneously Active	2 Simultaneously Active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continious Cooling	No	No	No	Yes

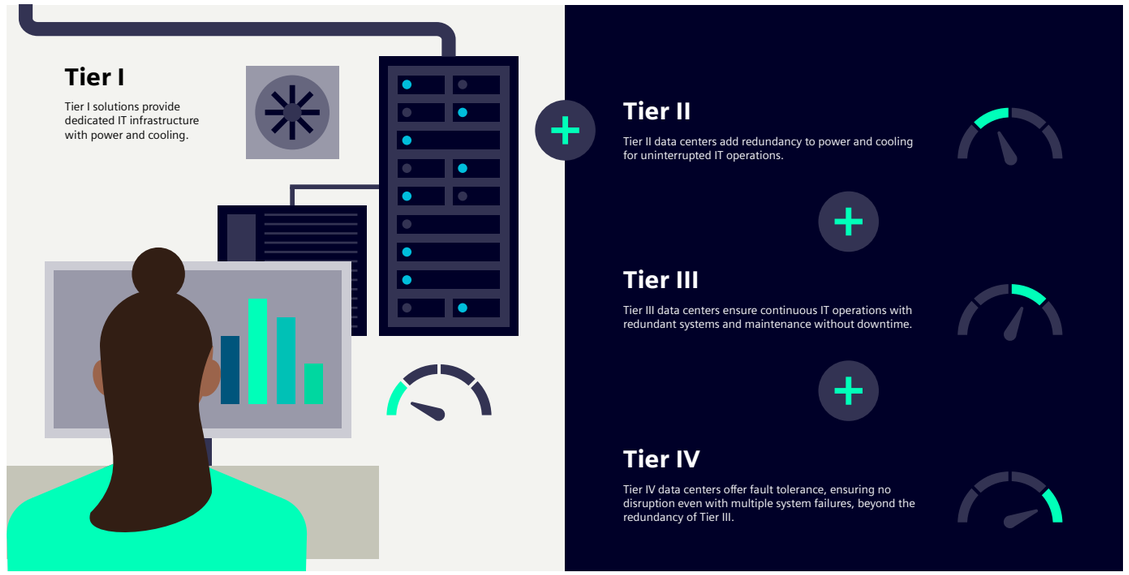
[1] Uptime Institute, Tier Standard: Topology
[2] Uptime Institute, Tier Standard: Topology
[3] Uptime Institute, Tier Standard: Topology
[4] EN 50600-2-2 Power Supply and Distribution
[5] EN 50600-2-3 Environmental Control
[6] Uptime Institute, Tier Standard: Topology

Deep Dive: Definitions for the power supply system under ISO 22237[1]

Availability Class 1: Low	A **single path** to primary distribution equipment and with a **single source.** This is the simplest and least resilient option, as it can be disrupted by a single fault or maintenance event. Unprotected and short break sockets will lose power in the event of a failure.
Availability Class 2: Medium	A **single path** to primary distribution equipment and with a **redundant source.** This option provides more resilience than Class 1, as it can tolerate a single fault in a source without losing power. However, it still has a single point of failure at the path between the supply transfer switchgear and the primary distribution equipment. Unprotected and short break sockets will lose power in the event of a failure of that path.
Availability Class 3: High	**Multiple paths** to primary distribution equipment and with **redundant sources.** This is the most resilient option, as it can tolerate multiple faults without losing power. It also allows for maintenance to be performed on one path without affecting the overall supply. Unprotected and short break sockets will only lose power if both sources and all paths are simultaneously unavailable.
Availability Class 4: Very High	**Multiple paths** to primary distribution equipment and with **multiple sources.** This option is even more resilient than Class 3, as it can tolerate any single event, such as a fault or maintenance, without losing power. Unprotected and short break sockets will never lose power.



[1] EN 50600-2-3 Environmental Control. For more information, visit: **iso.org/standard/78550.html**



Deep Dive: Uptime Institute's Tier Classification System[1]

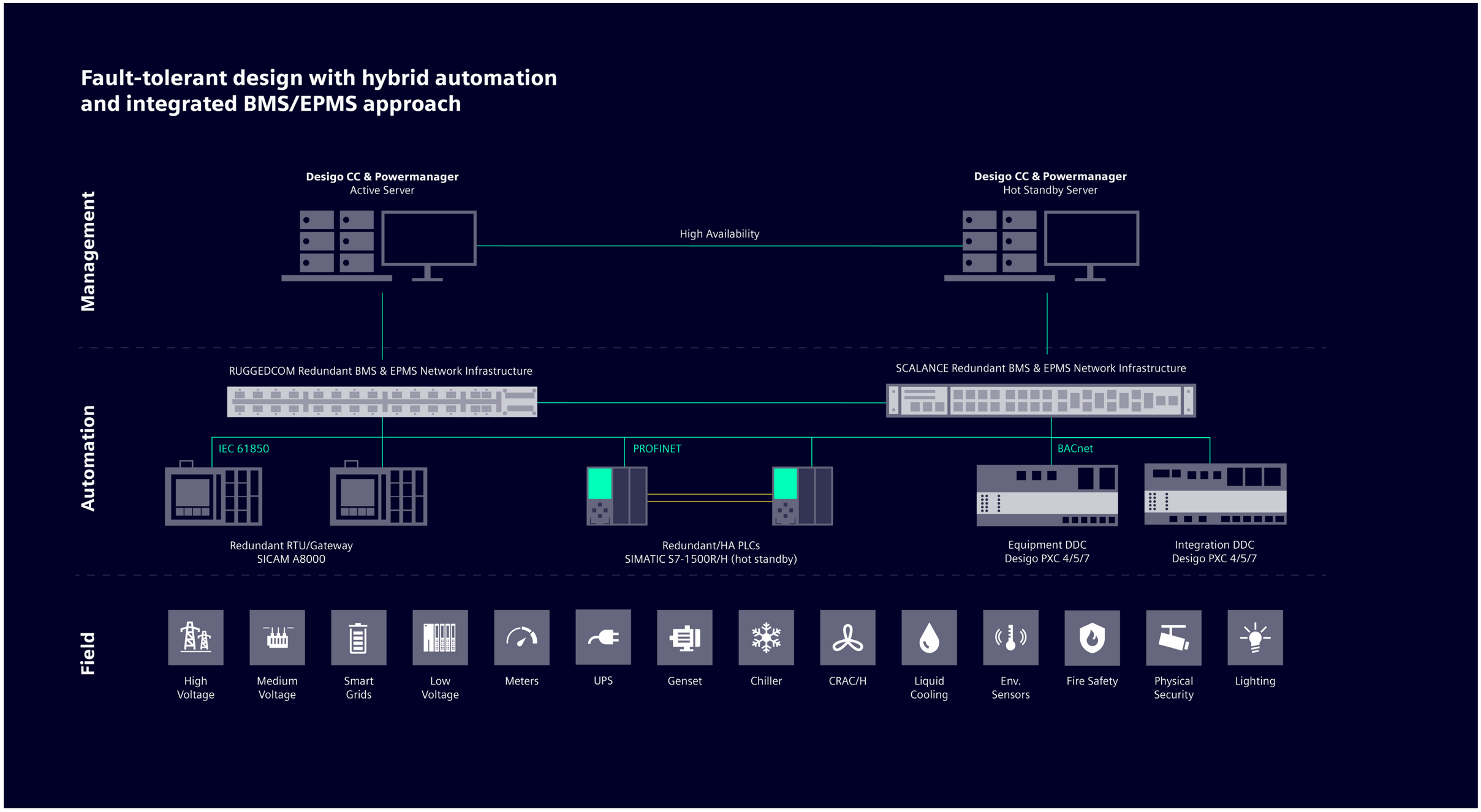
Tier	Description	Design features	Availability %	Annual allowable downtime hours
Tier I	Tier I solutions cater to owners who require dedicated infrastructure for their IT systems. This infrastructure offers a designated space, a UPS for power stability, dedicated cooling, and even on-site power generation (e. g., engine generator, fuel cell) to safeguard IT operations during extended power outages.	Single path for power and cooling distribution, no redundant components	99.67%	28.8
Tier II	Tier II data centers prioritize increased reliability by incorporatingw redundant critical power and cooling components, like extra UPS modules, chillers, and on-site power generation. This redundancy ensures that even if a component malfunctions or requires maintenance, it can be addressed without impacting IT operations.	Single path for power and cooling distribution, redundant components	99.75%	22
Tier III	Tier III data centers take redundancy a step further than Tiers I and II with Concurrent Maintenance. This means that any component supporting IT operations, from power and cooling to control systems, can be maintained without shutting down IT. Redundant delivery paths for power and cooling ensure continuous operation during maintenance, allowing for regular upkeep and peak performance. This extends to critical subsystems like generators, control systems for the mechanical plant, ATS, and power sources for the cooling infrastructure, guaranteeing reliable and predictable IT environment functionality.	Multiple power and cooling distribution paths, but only one path active, redundant components, concurrently maintainable	99.98%	1.6
Tier IV	Tier IV data centers take the redundancy of Tier III a step further with Fault Tolerance. Like Tier III's concurrent maintenance, every system supporting IT operations must be fault tolerant, meaning it can withstand the failure of any single component or path. However, unlike Tier III, a Tier IV facility must be designed to handle the domino effect of multiple failures: a single switchboard failure wouldn't disrupt the entire facility because critical systems are designed with enough redundancy to keep the computer room operational.	Multiple active power and cooling distribution paths, redundant compo-nents, fault tolerant	99.99%	0.8

[1]for more information, visit: **uptimeinstitute.com/tier-certification**

Reference architecture schematic

Specialists at Siemens have designed and installed BMS and EPMS infrastructures that fulfill these requirements in data centers around the world. A typical setup includes Siemens industrial automation and control systems, such as the PLC S7-1500R (Redundant), which allows for redundant configuration with another CPU by synching primary and backup CPUs via PROFINET network. This leads to a switchover time of around 300 milliseconds in case of a primary CPU failure.

The high-end CPU S7-1500H (High Availability) or the RTU A8000 offer a dedicated high-availability configuration that significantly reduces the **switchover time to around 50 and 30 milliseconds** respectively, making them ideal for applications demanding minimal downtime. While 100% uptime is an ideal, a configuration like the one described here brings a data center **remarkably close to achieving 99.999%** – the five nines of availability.



BMS and EPMS design: **Redundancy in practice**

Redundancy is a critical aspect of BMS and EPMS design, as it safeguards against potential failures that could disrupt data center operations and compromise data integrity. It typically involves having multiple components or systems that can take over in case of a primary component's failure, thus ensuring that the data center can maintain its critical functions even in the face of unexpected disruptions.

In BMS and EPMS infrastructures, redundant design supports high availability and fault tolerance. The aim of **high available (HA) systems** is to ensure an agreed level of operational performance, usually uptime, for a longer period than non-redundant systems. This is accomplished with redundant hardware and software components. When a failure occurs, HA systems automatically switch to the backups to ensure continued operation with minimal disruption. Furthermore, defective components can be replaced during operation without any downtime.

The goal with **fault tolerant (FT) systems** is to maintain continuous operation even with (several) component failures. This is achieved through techniques like redundant hardware and software modules, error correction, and automatic failover to healthy components.

For BMS and EPMS infrastructures, three areas are impacted by HA and FT systems: hardware, software, and data. Here are some details of what this could entail...

Hardware:

- Duplicated power supplies (e. g., I/O units)
- Control systems with an active/stand-by configuration mode
- Ring topology network switches that support both RSTP (Rapid Spanning Tree Protocol) and two redundancy protocols, (PRP) Parallel Redundancy Protocol and HSR (High-availability Seamless Redundancy)

Software:

- Application availability through a virtualization layer
- Distributed or active/stand-by applications

Data:

- Business-essential data across multiple storage devices or geographically dispersed data centers

Siemens offerings that **support this reference architecture:**

Desigo CC

Siemens' integrated building management system for high performing buildings has the power to increase comfort, efficiency, resiliency, and safety; acting as the technology backbone to leverage the full potential of your smart building infrastructure.

SENTRON Powermanager

This software lets you monitor energy consumption in buildings and plants, keep an eye on the condition of their low-voltage power distribution and on the power quality, and generate reports for operational power management according to ISO 50001.

SIMATIC WinCC OA

Build vendor- and platform-independent SCADA systems with software designed for large, complex applications and custom functionalities. Solutions are scalable and provide unlimited global access over the web, including native iOS and Android user interfaces or browser-based clients.

SCALANCE

These network components form the basis for communication networks in industrial automation. They meet all requirements for highly efficient industrial networks and bus systems, whether for switching, routing, security applications, remote access or industrial wireless LAN.

Siemens offerings that **support this reference architecture:**

Desigo PXC

Our Direct Digital Controller (DDC) provide optimal control for high-performing automation of all facility operations, based on four key pillars: scalable, smart, simple, secured. The cost-effective solution minimizes deployment time and operational overhead while maximizing reliability, performance, and long-term value across the data center lifecycle.

SIMATIC S7-1500 R/H PLC

These redundant industrial PLCs use redundant communication to the connected I/O units. The components offer a standard system feature of down to 50 millisecond switchover time.

SICAM A8000

These modular and scalable automation and remote terminal units range for telecontrol and automation applications in all areas of energy supply. It's suitable for rough ambient conditions thanks to mechanically stable modules and an extended temperature range from -40 to +70 °C.

RUGGECOM RSG900 series

These managed gigabit compact switches are tested and certified to withstand extreme environments, featuring High-availability Seamless Redundancy (HSR) and Parallel Redundancy Protocol (PRP). Their RedBox functionality enables simultaneous operation across HSR, PRP, or RSTP networks, ensuring continuous, secure, and reliable performance even during power failures. They are suitable for temperatures from -40°C to + 85°C and meet industry standards such as IEC 61850-3, IEEE 1613, and IEC Ex.

Let's talk!

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Discover the Siemens data center offering and use cases that align with the strategic business goals.

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Discover more information and offerings for increased uptime with redundant automation design!

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