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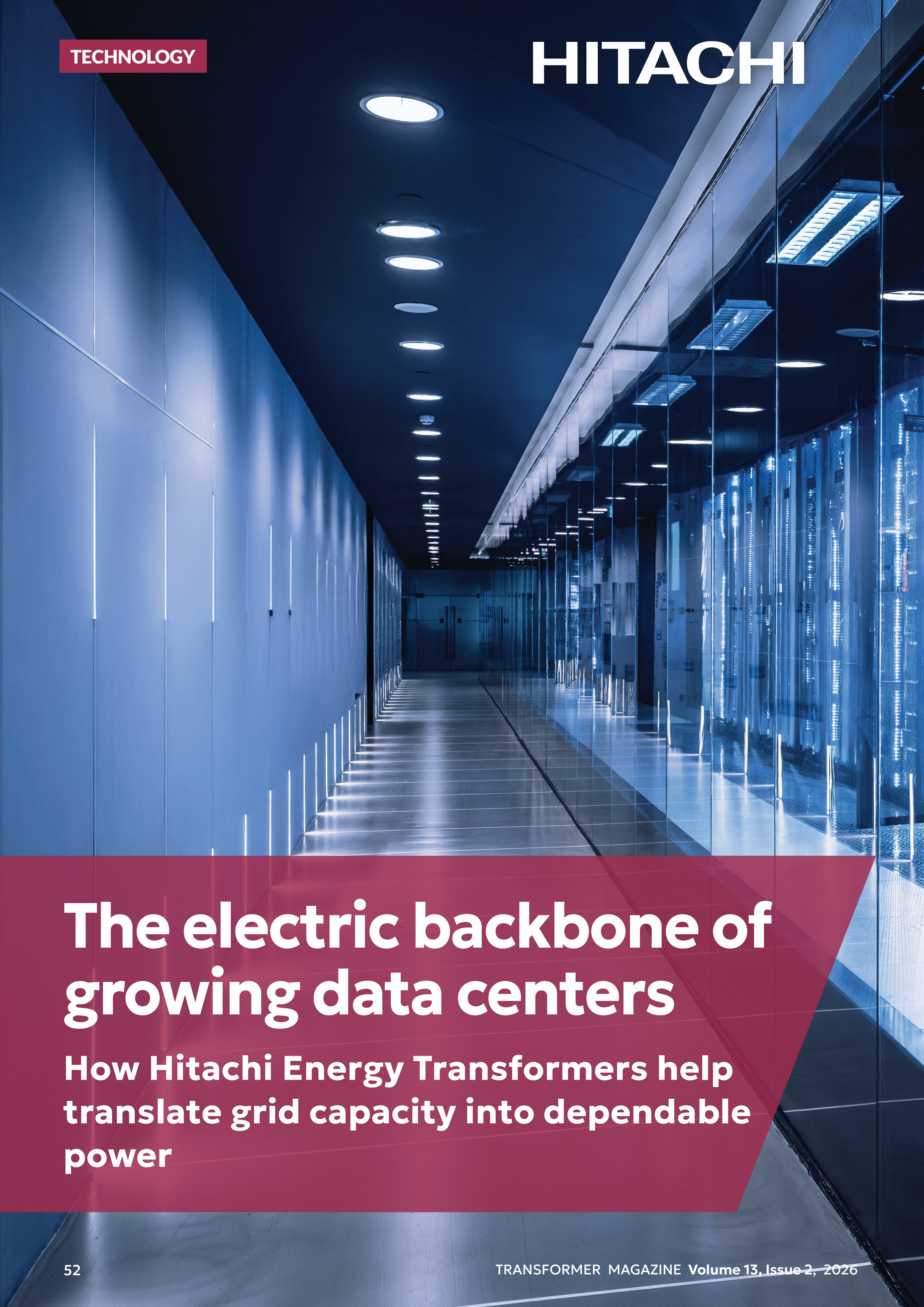

The electric backbone of growing data centers

How Hitachi Energy Transformers help translate grid capacity into dependable power

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This article examines how power constraints are influencing data center site strategies, explores the central role of transformers in the power path, and discusses infrastructure fundamentals that enable predictable scaling.

Data center developers and operators are increasingly constrained by power—interconnection timelines, available capacity, and the ability to energize quickly—making the transformer-to-load "power path" a primary design lever for schedule, resilience, efficiency, and long-term operability.

Designing the power path is no longer a downstream electrical detail. It has become an early, cross-disciplinary strategy for converting grid supply into stable, usable power at the IT load. When addressed upfront, it creates an electrical backbone that scales predictably, manages power-quality and protection complexity, and supports efficient operation over decades, while meeting rising expectations for sustainability, transparency, and compliance.

Data center growth is increasingly shaped by power realities

A data center is a purpose-built or modular facility that provides the physical environment, power and cooling, connectivity, and operational controls required to run digital infrastructure—servers, storage, networking, and the platforms that deliver cloud, enterprise, and AI-enabled services.

Because these facilities support always-on workloads and contractual availability commitments, they are engineered for high availability through redundancy, maintainability, and strong physical and cyber security. Outages can have immediate revenue, operational, and reputational consequences.

High cloud demand and the rise of AI are driving a new wave of data center expansion, but power is increasingly the gating factor. Interconnection queues are lengthening, deliverable capacity is tightening, and energization timelines are becoming less predictable. As a result, site selection has shifted toward a powerfirst logic, prioritizing access to transmission and expandable capacity over traditional real-estate drivers.

AI is also pushing compute density upward. Leading deployments increasingly reference 100 kW-class racks, with higher-density roadmaps already under discussion. This shift moves constraints closer to the IT load and raises the bar for electrical distribution, protection and shortcircuit coordination, transient behavior, harmonics, and thermal margins. In this context, transformer specifications and power-quality decisions become early, schedule-critical choices rather than latestage optimizations.

Why transformers sit at the center of the power path

Transformers are often described as the link between the grid and the facility. Today, however, they increasingly shape the entire speed-to-power strategy. As grid capacity tightens and AI-driven loads raise expectations for power quality and uptime, transformer choices influence how quickly a site can be energized, how modularly it can expand, and how efficiently—and predictably—it can operate over its full lifecycle.

For data centers, transformers are therefore more than a procurement line item. They form part of the campus design logic.

This dynamic is evident in the two archetypes that dominate current expansion.

- **Hyperscale campuses** focus on repeatable architectures, rapid energization, and coordinated growth across multiple buildings and phases.
- **Colocation facilities** emphasize standardization, flexibility, and modular expansion to support multiple tenants and increasingly AI-ready, single-tenant deployments.

Both models demand reliability, but their power-path priorities differ. Hyperscalers tend to optimize for replication and long-term expansion, driving the need for standardized transformer and substation blocks with clear interfaces between phases.

Colocation providers increasingly compete on speed-to-power, favoring repeatable electrification modules, fast commissioning paths, and predictable performance across diverse load profiles. In both cases, transformer decisions shape the interconnection approach, the substation concept, and the practical pathway for expansion.

Fundamentals for modern data center power infrastructure

Across regions, the conversation around data center power has shifted from headline capacity—how many megawatts—to deliverability: how quickly, reliably, and sustainably power can be brought online and managed over time.

This shift places emphasis on a focused set of fundamentals that increasingly

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guide infrastructure decisions for large, multi-phase data center programs.

Sustainability: Transparent, measurable, verifiable

Sustainability expectations are becoming more explicit and data-driven. Stakeholders increasingly require optimized losses, clearly documented material choices, and credible lifecycle assessments rather than high-level claims.

This places a premium on energy-efficient designs supported by transparent life-cycle assessment, alongside application-fit technologies such as natural ester fluids and dry-type solutions where appropriate. Hitachi Energy's EconiQ™ transformer portfolio reflects this approach, emphasizing lower lifecycle environmental impact supported by verifiable performance data.

Expertise and experience: Aligning with speed-to-power realities

Speed-to-power depends not only on delivery capability, but on technical alignment with grid requirements from the outset. Designs that comply with grid codes, protection philosophies, and power-quality limits help avoid late-stage rework and commissioning delays.

Front-end engineering and system integration—including grid and system studies—play a critical role in proving compliance early. Paired with service and digital capabilities, this approach supports consistent performance as assets age and campuses expand under live operating conditions.

Global footprint: Delivering at scale

Many data center programs are now executed as portfolios, with multiple sites and phases delivered in parallel and replicated across regions. Delivery resilience in this environment depends on manufacturing flexibility, localization where required, and consistent engineering standards worldwide.

A global manufacturing and engineering network, supported by standardized design platforms such as TrafoStar and dynamic allocation strategies, enables consistent performance while balancing

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regional qualification and schedule requirements. This reduces program risk and supports predictable execution at scale.

System view and operational flexibility

End-to-end power-path design—from grid connection through campus distribution—requires a system view rather than isolated equipment choices. Integration across grid-interface transformers, distribution transformers, and substation building blocks helps minimize hidden constraints as campuses scale phase by phase. This includes hybrid switchgear, prefabricated or modular HV switchgear, and containerized GIS solutions with off-site integration.

At the same time, data center power strategies are increasingly shaped by conditions outside the fence: interconnection timelines, congestion, and local market rules. Resilience therefore extends beyond redundancy to include flexibility options such as battery energy storage, microgrids, DC architectures where efficiency gains are relevant, and targeted power-quality solutions for sensitive loads. In specific contexts, alternative backup approaches—such as hydrogen fuel cell systems—may also play a role.

Technology edge under real operating constraints

Technology leadership in data center power infrastructure is ultimately measured by outcomes under real constraints: reduced downtime risk, stable switching behavior, higher density within fixed footprints, and predictable lifecycle performance.

Practical enablers include transient voltage protection for managing fast switching phenomena, digitally enabled transformers that support condition-based maintenance through monitoring and diagnostics, and compact transformer designs where thermal performance and space efficiency are critical. These capabilities are complemented by ongoing exploration of next-generation concepts—such as integrated mini substations and solid-state transformer pathways—so future architectures can be engineered around site-specific constraints from the outset.

In practice

Some of the main ideas discussed above are shown **in practical terms** in the technical whitepaper *"Designing for scale: Transformer design strategies for a sustainable global growth of data centers" (check it out using the QR code at the end).* The paper takes an engineering perspective, examining how transformer design choices affect real operating behavior in highdemand electrical systems.

Rather than focusing on nominal ratings, it analyzes transformer performance under dynamic conditions characteristic of modern data center networks. Switching operations, transient phenomena, and protection coordination are treated as recurring features of fast-evolving power systems, particularly in environments where power density increases and expansion occurs incrementally.

The analysis also addresses how thermal design, insulation systems, and digital monitoring capabilities contribute to long-term reliability during sustained, high-load operation. By linking design assumptions with observed behavior, the whitepaper illustrates how transformer performance is shaped by actual network conditions and evolving load profiles over time.

These examples provide tangible evidence for the broader argument indicating that transformer decisions are foundational design choices rather than downstream optimizations. They explain how transformer performance affects resilience and operability, translating those insights in a data center context, where speed to power, predictable expansion, and lifecycle performance are the prevailing objectives.

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The infrastructure behind tomorrow

Often described as the backbone of the digital economy—and increasingly treated as a “fifth utility” alongside water, electricity, gas, and telecoms—data centers are entering an era in which AI-driven load growth collides with tighter power availability.

In this environment, the infrastructure that converts grid supply into stable, usable power becomes a decisive lever for time-to-market and long-term performance.

Leadership in this space is defined by practical outcomes:

- Speed-to-power: choose transformer and substation approaches that reduce design/commissioning friction and keep expansion pathways clear.
- Resilience: engineer for switching behavior, protection coordination, and power quality so sensitive IT loads remain stable under real grid conditions.
- Lifecycle performance: prioritize efficiency, serviceability, and digital visibility so asset health supports predictable operations as the campus scales.

The next step for data center programs is therefore to align early on a clear power-path concept and study plan—covering interconnection, power quality, and operating model—to reduce schedule risk and ensure long-term operability.

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Learn more about Hitachi Energy Transformers for Data Centers