TIA-942-C DATA CENTER INFRASTRUCTURE STANDARD

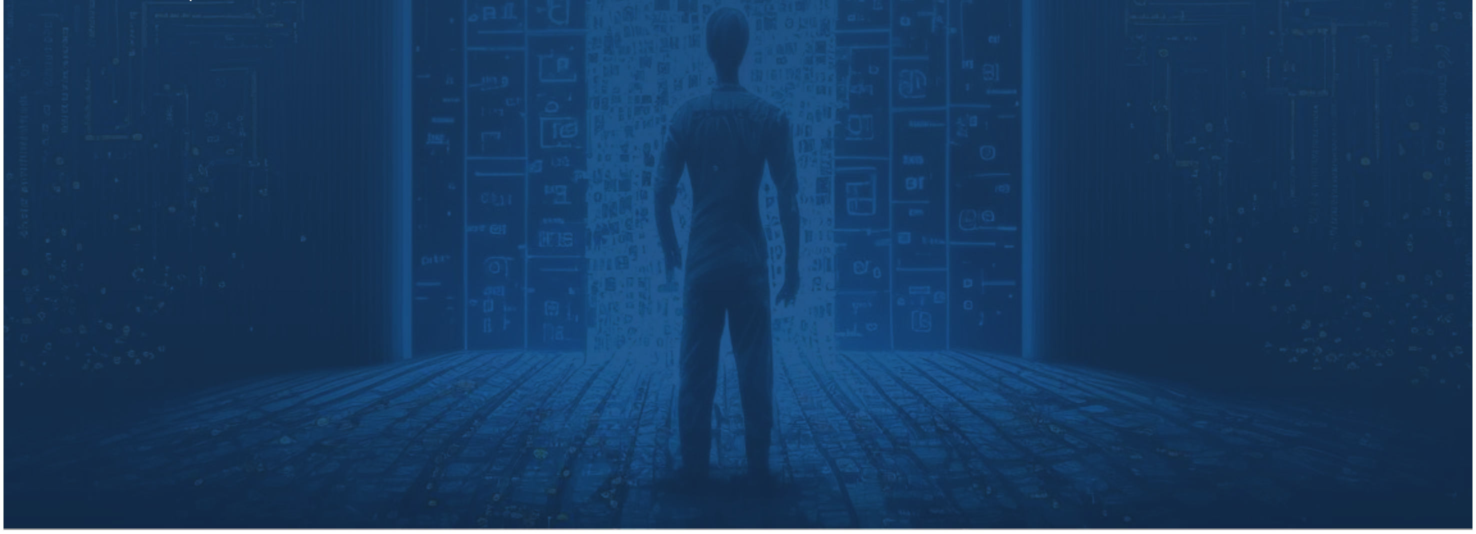
Keeping Pace with the Evolving Digital World

INTRODUCTION

The ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers is a globally adopted standard developed and maintained by members of the Telecommunications Industry Association (TIA) TR-42 Engineering Committee, which comprises industry representatives with expertise across all aspects of a data center. It specifies minimum requirements and guidelines for data center design, including power systems, mechanical systems, architecture, security, telecommunications systems, fire protection, and safety. It also serves as the foundation of the TIA-942 Certification Program that enables data center facilities to be independently reviewed and certified for conformity to the standard, providing greater assurance to customers and stakeholders.

As a publicly available standard developed via consensus-based, objective, and industry-driven specifications, TIA-942 offers an extensive global scope with transparency and standard nomenclature applicable to any data center size or type. Since its inception in 2005, it has become the go-to resource for data center designers, owners, consultants, suppliers, operators, and users worldwide.

As an industry standards-making body, TIA continually updates standards to keep pace with the latest market trends, technologies, and the global economy. Since the last complete revision of ANSI/TIA-942-B in 2017, significant technological advancements and unprecedented trends have necessitated upgrades to data center cabling, power and cooling infrastructure and the need to rethink several design, installation, and operations aspects. In early 2022, TIA released the ANSI/TIA-942-B-1 Addendum for Edge Data Center Infrastructure to address new edge data centers deployed closer to end users to provide low-latency transmission and instantaneous data processing for emerging applications. At the same time, the TR-42 Engineering Committee officially opened the full TIA-942-B standard for updates and revisions. Following two years of industry collaboration, TIA has now released the latest TIA-942-C version of the standard with several modifications that address the latest technologies and trends in the evolving digital world.



EMERGING TRENDS AND TECHNOLOGIES IMPACTING THE DATA CENTER

Data centers of all types and sizes face pressure to reduce environmental impact by lowering their energy consumption, water usage, and carbon footprint. At the same time, global data generation is predicted to reach 181 trillion gigabytes by 2025, with a significant portion created and processed at the edge.[1] This surge coincides with emerging artificial intelligence (AI), machine learning (ML), 5G, and IoT/IIoT technologies that demand higher power and cabling densities.

THE DRIVE FOR SUSTAINABILITY

In the face of climate change, data centers worldwide have come under the scrutiny for their energy consumption and carbon footprint. According to the International Energy Agency (IEA), data center energy consumption could double from 2022 to more than 1,000 Terawatt hours (TWh) by 2026 without significant efficiency improvements. That total is roughly equivalent to Japan's entire annual electricity consumption. Much of the expected higher energy consumption is due to high-performance computing technologies like AI and cryptocurrencies, which could double by 2026.[2]

As a result of increasing consumption, organizations have pledged net-zero operations by 2050 or sooner, and regulatory pressure is growing. The European Union (EU) Energy Efficiency Directive (EED), is expected to be signed into law by the end of 2024, and will require data centers with a demand of 100 kilowatts (kW) or more to report their energy performance, including energy reuse factor, renewable energy use, cooling effectiveness ratio, and power and carbon usage effectiveness (PUE and CUE). Ireland, which has become a hotbed for data centers due to low tax rates, saw a 400 percent increase in data center power consumption from 2015 to 2022, representing 20 percent of all power generated in the country.[3] As a result, Ireland's Commission for Regulation of Utilities (CRU) published a decision

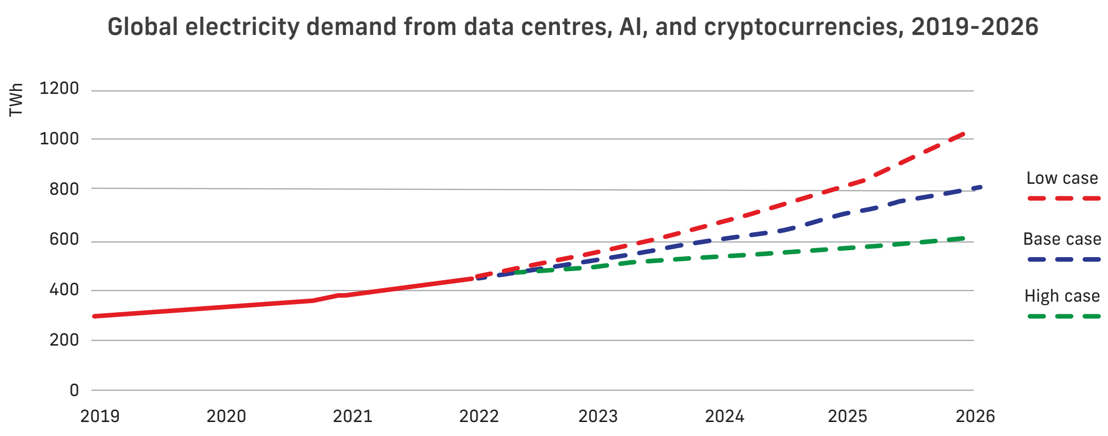


Figure 1: Global electricity demand from traditional data centers, dedicated AI data centers, and cryptocurrency consumption (excludes demand from data transmission networks). Source: IEA

on assessment criteria for data centers applying for grid connection, including impact on the surrounding region and the ability to generate and store electricity on site.[4] Denmark also has an expanding data center sector. It has become the hub of the new pan-European initiative Net Zero Innovation Hub for Data Centers, a collaboration between a number of data center operators.[5]

Similar initiatives are underway in the rest of the world. In China, where electricity demand in the data center sector is expected to double from 2020 to 2030, regulations are being updated to promote sustainable practices.[6] In the U.S., The White House Office of Science and Technology Policy (OSTP) has published a report with recommendations for annual electricity usage, greenhouse gas emissions, and electronic waste recycling performance reporting. Proposed legislation in Virginia, a U.S. hotbed for data center activity, requires site assessment before approval to evaluate a data center's impact on agricultural resources, carbon emissions, and water usage. In Oregon, a proposed bill would require data centers to reduce carbon emissions by 60 percent by 2027, with annual reporting to demonstrate compliance.[7]

Some of the ways that data centers can reduce their energy consumption include best practices and technologies that improve PUE, such as deploying more energy-efficient equipment (e.g., switches, servers, etc.), consolidating and removing unused equipment, and raising air inlet temperatures closer to the mid-range of the ASHRAE 18° to 27°C (64 to 81°F) recommendation.[8] Improving airflow and maintaining proper separation of hot and cold air via a hot aisle/cold aisle configuration, aisle containment systems, in-row or in-rack cooling, and advanced liquid cooling systems can also improve efficiency, as well as deploying air-side economizers that use outside free air to cool the data center. To lower costs and carbon footprints, data centers are also turning to renewable energy sources like solar, wind, and hydro with battery energy storage systems (BESS). Forward-thinking data centers are even reusing generated heat to heat other facilities or homes in surrounding communities to reduce their carbon footprint.

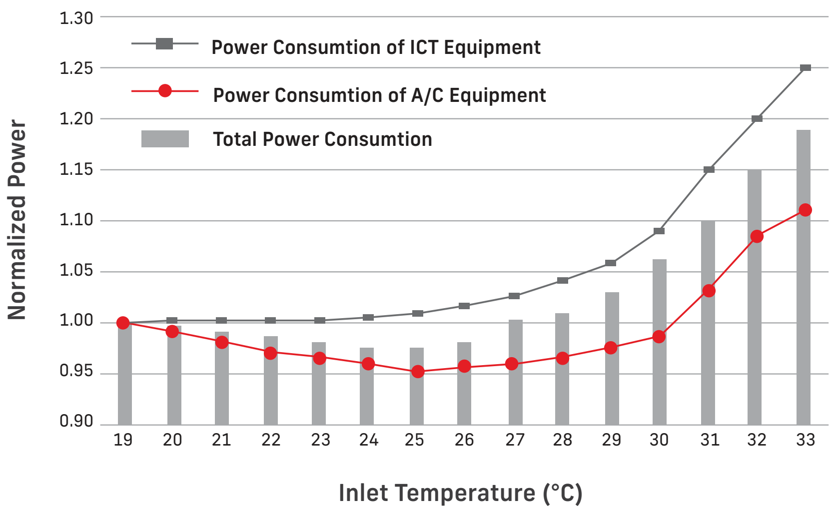


Figure 2: Increasing air inlet temperature range to 23 to 26°C (73 to 79°F) can lower total power consumption.

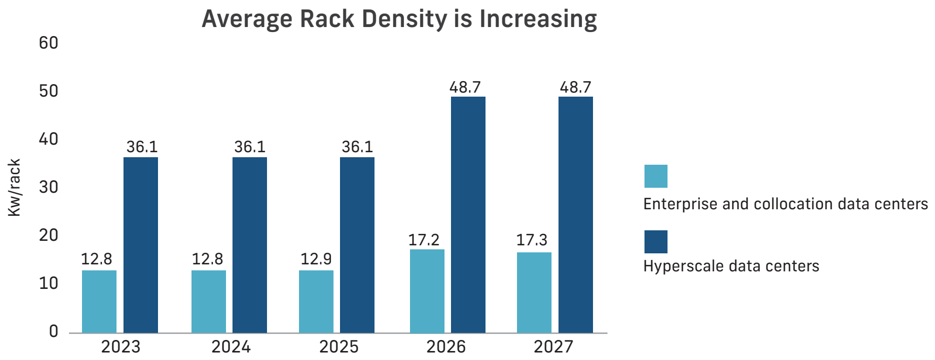


Figure 3: Average rack power densities are increasing, especially in hyperscale data centers. Source: JLL

RISING RACK POWER DENSITIES

As more data centers deploy emerging digital services and high-performance computing (HPC) technologies like AI, rack power densities are increasing in enterprise, colocation, and hyperscale data centers.[9] In 2022, 25 percent of enterprise data centers reported having rack densities greater than 20kW, and some hyperscale data centers with extreme density racks have already reached 80kW or higher.[10] Higher rack power densities lead to higher heat generation. As a result, ASHRAE's Technical Committee 9.9 published the fifth edition of its Thermal Guidelines for Data Processing Environment in 2021 with a new class H1 for high-density systems, narrowing the recommended temperature range from 18° to 27°C (64 to 81°F) to 18° to 22°C (64 to 72°F) for these environments.

At around 25kW/rack or lower, data centers can keep equipment cool via passive air-cooled solutions such as maintaining proper airflow in and around equipment and deploying hot aisle/cold aisle configurations, aisle containment systems, and highly efficient computer room air conditioning (CRAC) systems. However, rack power densities above 25kW/rack increase the demand on air-cooled systems to prevent equipment failure and costly downtime. By the same token, cooling also accounts for 30 to 50% of total data center energy consumption, so increasing the capacity of CRAC systems by adding more cooling and/or lowering temperatures comes with costs and consequences.[11] Due to increasingly stringent energy consumption regulations, sustainability initiatives, and rising energy prices, many data centers are now turning to highly efficient liquid cooling solutions, such as rear door heat exchangers, direct-to-chip cooling, and liquid immersion technologies that use chilled water or dielectric fluid to bring cooling directly to the cabinet, equipment, and heat-generating components within the equipment (e.g., computer processing and graphical processing units).

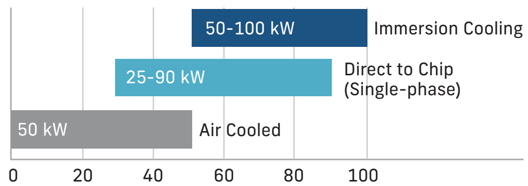


Figure 4: Data centers with rack power densities of 25kW or higher are migrating to more efficient liquid cooling technologies. Source: ASUS

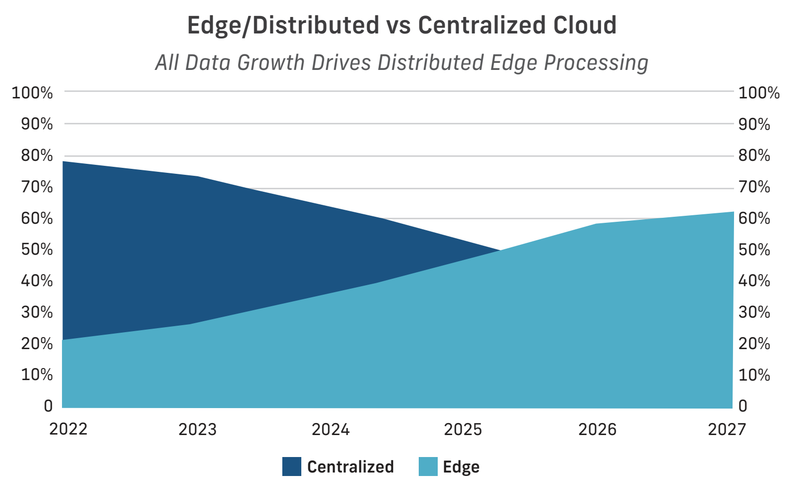


Figure 5: By 2027, 62 percent of enterprise data is expected to be processed at the edge

THE GROWTH OF EDGE COMPUTING

Technologies like 5G, AI, ML, IoT/IIoT data analytics, virtual and augmented reality (AR/VR), video streaming, and gaming demand near-instantaneous network functionality performed in milliseconds. Large core centralized cloud data centers, often located hundreds of miles from the source, can't deliver the extremely low latency required for these real-time applications. Edge computing solves the latency problem by storing and processing data in smaller decentralized data centers closer to the source. As these applications grow, market research predicts that by 2027, 62 percent of data will be processed at the edge.[12]

Depending on the applications to be supported, edge data centers range in location, owner/operator, and size. An edge data center could be just a switch and a few servers in an outdoor enclosure on a city street corner to process ultra-low-latency smart traffic and autonomous vehicle data, or a single rack in a hospital closet for processing and analyzing real-time patient monitoring information. An edge data center could also be multiple racks in a container or shelter at the base of a 5G cell tower or on the outskirts of a rural community to support real-time applications for thousands of users. They can also comprise dozens of racks in a regional central office to support content delivery networks (CDNs), such as those that cache video-streaming content for thousands of local users. An edge data center can even reside within a traditional colocation data center near an urban center for aggregating and processing massive amounts of data for latency-sensitive cloud applications.

With the increasing adoption of edge-native applications, edge data centers are expected to proliferate. Reports suggest a 26% annual growth rate, reaching nearly $35 billion by 2028 (from $14 billion in 2023).[13] However, due to the mission-critical nature of many edge applications, ensuring low latency and high resiliency is paramount. Many edge data centers also differ significantly from traditional ones—especially smaller, remote unmanned facilities. Therefore, they have unique requirements for site selection, power, cooling, physical security, operations, and maintenance.

EVOLVING CABLING INFRASTRUCTURE

Data center cabling infrastructure also needs to adapt to the ever-changing digital landscape. Bandwidth demands are surging, particularly between switches and servers. This shift is driving a move away from traditional twisted-pair copper cabling towards fiber optics for switch-to-server links. Fiber offers significant advantages in terms of speed, handling 10 to 400 Gigabits and beyond while boasting a smaller and lighter design. However, as rack power densities increase, so does the amount of cabling. Data centers are packing more equipment into less space. This includes powerful generative AI systems with high-compute CPUs and GPUs that require massive amounts of data for parallel processing. A typical AI cluster can house hundreds or thousands of these processors, all interconnected with multiple high-speed connections (e.g., 100, 200, or 400 Gigabit). This results in a significant amount of cabling at the rack level, requiring proper management to prevent damage and maintain optimal airflow.

Data centers contain more than just servers and switches. They are also intricate facilities with their own cabling infrastructure for network operations, lighting, security, life safety, and other facility functions. Performance reliability and resiliency are paramount, so data centers often deploy numerous smart IoT sensors. These sensors monitor factors like occupancy, vibrations, temperature, humidity, airflow, smoke, air quality, water leaks, and other potential hazards. Sensors also monitor human activities, power consumption, cooling systems flow rate and pressure, equipment performance, and other important information about the data center performance and security. Careful planning and ensuring the right cabling infrastructure for these ancillary functions is essential for any data center, especially those demanding exceptional reliability and availability. For example, smart IoT sensors are typically low-speed, low-power devices that connect wirelessly or via new cost-effective technologies like single-pair Ethernet (SPE) that can deliver up to 52 W of power and transmission speeds of 10 Mb/s to devices over a single copper twisted pair for distances up to 1000 meters (m).

ANSI/TIA-942-C RESPONDS

Based on the evolving digital world and feedback from association members, the TR-42 Engineering Committee, and other industry experts, TIA has updated the ANSI/TIA-942 data center infrastructure standard. The recently released TIA-942-C standard provides new specifications and guidance that address sustainability, higher high rack power densities, edge data center requirements, and advanced cabling infrastructure. The updated standard also clarifies several details to better align with industry best practices, including clarifying the applicability and structure of annexes by renumbering and changing several key annexes from informative to normative. It also clarifies details surrounding security, seismic resistance, fire protection, and remote operations. It improves the TIA-942 rating system (i.e., 1 Basic, 2 Redundant, 3 Concurrently Maintainable, and 4 Fault Tolerant) for more flexible and straightforward implementation. The following are examples of how TIA-942-C keeps pace with the evolving digital world.

SUSTAINABILITY

Sustainability and climate change are now a greater focus throughout the TIA-942-C standard with several new considerations, including site selection risk analysis and mitigation for better adaptability to regional conditions, self-generated power such as onsite renewables, energy reuse, and other initiatives for efficient use of resources. The term “standby power” is now used to refer to any technology used as standby power, including battery energy storage systems (BESS), natural gas, and hydrogen fuel cells.

HIGHER RACK POWER DENSITIES

TIA-942-C addresses higher rack power densities associated with technologies like AI by updating temperature and humidity guidelines to align with the 5th addition of ASHRAE TC 9.9 Thermal Guidelines for Data Processing Environments, including the new H1 class for high-density air-cooled equipment. The standard also adds a new informative annex on liquid immersion cooling, and the term “heat removal” is now used to refer to any technology that cools equipment.

EDGE DATA CENTERS

TIA-942-C addresses edge data centers by incorporating the previously released TIA-942-B-1 addendum into the standard, with more precise guidelines and infrastructure requirements for edge data centers. This includes multiple updates to reflect the current state of technology, including adding thermal guidelines from ASHRAE TC 9.9 Technical Bulletin on Edge Computing. The standard also adds new recommendations for managing micro edge data center environments to harmonize with ASHRAE TC 9.9.

CABLING INFRASTRUCTURE

In response to increasing cabling densities, TIA-942-C now requires a minimum of 800mm-wide cabinets in functional areas that house switches (i.e., MDA, HDA, and IDA). The standard also responds to the need for higher bandwidth in switch-to-switch and switch-to-server links by recommending a minimum of two optical fibers for horizontal and backbone cabling and allowing for any TIA-568.3-compliant optical fiber connectors outside equipment outlets (EOs). The infrastructure requirements are also updated to recognize SPE for horizontal cabling and require a minimum of two category 6A or higher performing cables to support high-throughput wireless access points when using balanced twisted-pair cabling.

GET STARTED ENSURING YOUR DATA CENTER CAN KEEP PACE

As a publicly available standard developed via consensus-based, objective, and industry-driven specifications with transparency and standard nomenclature, the updated TIA-942-C standard allows it to remain a vital global resource for any data center size or type in the evolving digital world—from hyperscale, cloud, and colocation to the enterprise and the edge. Whether upgrading and expanding existing facilities or building from the ground up, the standard is ideal for anyone involved in the data center lifecycle—from design and construction to installation, commissioning, and ongoing operations—to effectively support the latest trends and technologies. It also serves as critical information for data center users to specify service provider requirements for various levels of resiliency and security.

TIA-942-C is now available for purchase at the TIA standards store. For more information about TIA or the TIA-942 Certification Program, visit www.tiaonline.org. And if you are interested in contributing to the future of data centers, please contact datacenterinfo@tiaonline.org.

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TO LEARN MORE ABOUT THE TIA-942-C DATA CENTER INFRASTRUCTURE STANDARD

CONTACT

datacenterinfo@tiaonline.org

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