Research

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Data Centers 2024 Global Outlook

AI and the green energy transition will bring new challenges and opportunities

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Contents

Executive summary

The democratization of Artificial Intelligence (AI) stands to be the biggest transformation in the data center industry since the sector burst onto the scene. The data center industry has experienced explosive growth over the past decade, driven by ever-increasing demand for cloud services and the expanding use of web-enabled devices globally. Now in 2024, AI and machine learning is prompting a fundamental shift in data center design, site selection and investment approach.

With power requirements for data centers growing exponentially, we are seeing a scarcity of data center colocation supply driven by regional power limitations. Data center growth is experiencing significant competition with other high-power users including electric vehicle infrastructure and advanced manufacturing. The European Commission estimates that electricity consumption will increase by 60% by 2030 while power generation capacity needs huge investment in order to meet renewable energy targets.

The impact on the data center industry is immense. Power presents both an opportunity and a threat to the sector and as a result we have dedicated our outlook to this evolving dynamic. Our report explores in detail, what this means for developers and operators in 2024 and beyond, including case studies of ingenuity and innovation as the sector evolves.

Demand drivers

The ever-growing digital economy and democratization of AI will drive demand for more and larger data centers. With many real estate asset classes seeing a pullback for developers and investors, data centers stands out as a promising asset class in 2024.

Data center design

The highly specialized equipment needed to support AI densities, particularly liquid cooling, will transform traditional facility design. Data center providers are rapidly changing designs to support these new requirements.

Data center operations

In the quest to lower power usage effectiveness (PUE), data center operators will seek new software solutions and algorithms to propel efficiency gains. For enterprise data center operators, achieving better efficiency requires specialized expertise.

Power sourcing

The urgent need for more power will lead data center operators and even governments to scramble to secure required utility, especially sustainable sources of energy while spurring innovation. AI is driving extreme scale for new developments with requirements now ranging from 300 megawatts (MW) to over 500MW. Site selection criteria have changed dramatically with a more prominent focus on power availability and delivery timelines.

01

Demand drivers

The continued transition to the cloud, growth in the Internet of Things (IoT), growing data sovereignty and residency regulations, and the expanding amount of data that consumers and businesses generate are fueling the rapid development of data centers globally.

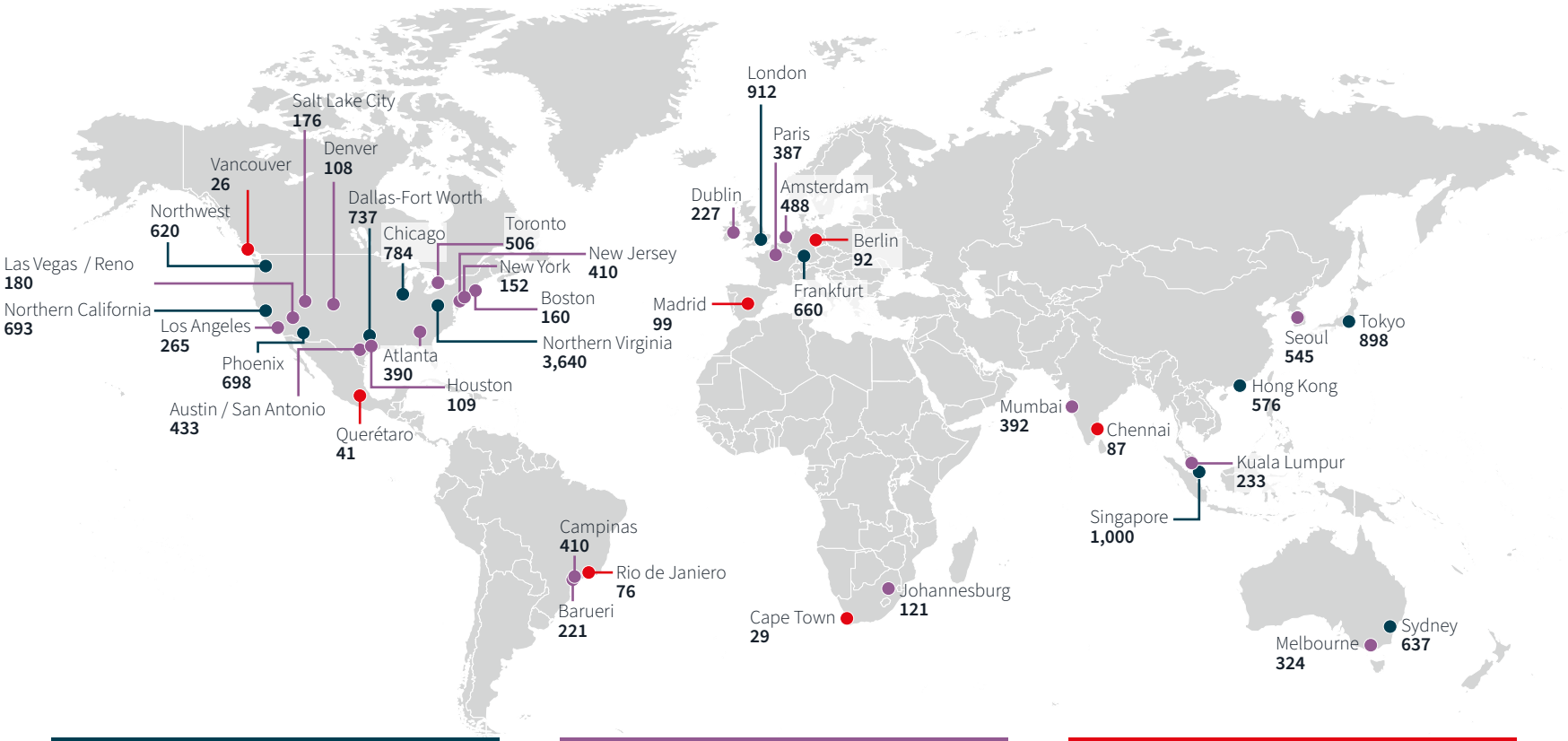
In the next five years, consumers and businesses will generate twice as much data as all the data created over the past 10 years. In response, total storage capacity in data centers and endpoint devices will grow from 10.1 zettabytes (ZB) in 2023 to 21.0 ZB in 2027, for a five-year compound annual growth rate (CAGR) of 18.5%.[1]

[1] Aug 2023, IDC #US49346223, Revelations in the Global StorageSphere 2023, John Rydning

The growing need for storage translates to growing demand for data center space, fueling rapid development. In the past decade, developers have steadily increased the capacity of new colocation and hyperscale data centers. Structure Research estimates that global colocation MW will grow at 15.2% CAGR over the next five years.

Most new data centers built 10 years ago had a critical IT load capacity of less than 10MW. Today, it is not uncommon to hear developers announce new builds of 100MW or more.

Global data center colocation market size by country in primary, secondary and emerging markets (in MW of built-out critical IT load capacity)



Primary markets have at least 600MW of supply and many of these markets are now pushing beyond the 1,000MW mark. They will continue to see strong growth as colocation and hyperscalers consolidate their positions in safe metros that have become sub-regional hubs.

Secondary markets typically have 100–600MW of supply and have recently become the focus of attention as investors, lenders and developers seek new opportunities in less crowded markets.

Emerging markets will continue to grow as Edge deployments bring data centers closer to the user and national data sovereignty laws mandate in-country storage.

Source: JLL, Structure Research
Data as of June 2023

Generative AI poised to transform the data center market

Generative AI will significantly disrupt the industry, impacting not just the number of new data centers needed but also their design and location.

Bloomberg Intelligence projects the generative AI market will grow to $1.3 trillion over the next 10 years from a market size of just $40 billion in 2022.[2] Data center operators and developers that want to capitalize on this market opportunity must recognize that AI-specialized data centers look different than conventional facilities.

Generative AI requires more densely clustered and performance-intensive IT infrastructure than the framework found in standard data centers, producing much more heat. The power consumed by generative AI workloads fluctuates more than traditional IT workloads, creating challenges in optimizing a facility's overall efficiency.

For example, the workload of an AI image generator application requires much more power than a text generation application. Additionally, power requirements for the three stages of generative AI — model creation, tuning and inference — vary significantly. Data center operators need to plan and allocate power resources based on the type of data being processed and the stage of generative AI model development.[3]

Training and tuning application workloads for AI are not typically latency-sensitive. Therefore, developers building AI-specialized data centers can be more flexible in site selection and strategically choose geographies with significant available transmission power, low energy costs, abundant sustainable energy sources and climates that support free cooling.[4]

Given high demand and growing data requirements, data center development is positioned to continue at a rapid pace in 2024. However, as hyperscalers and other large requirements sign commitments to space far in advance of delivery, those with smaller requirements will need to plan ahead to find the capacity they need.

Key considerations

For investors, how will generative AI change the data center landscape, particularly the needs of each stage of model development?

For enterprises and operators, are generative AI workloads best served in on-premise, colocation, or public cloud environments?

[2] Bloomberg, Generative AI to Become a $1.3 Trillion Market by 2032, Research Finds, June 2023

[3] Jul 2023, IDC #US51013223, Generative AI: Implications for the Datacenter, Sean Graham and Peter Rutten

[4] IDC #US51013223, 2023

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Data center design

Increasing rack density

The rapid adoption of generative AI will continue to drive the upward trajectory of rack power density. Average rack density has been slowly climbing over the past few years and will see significant jumps in the coming years.

Rack density refers to the amount of computing equipment installed and operated within a single server rack. It is calculated by the rack's power requirements (in watts) divided by the available space (measured in rack units).

Hyperscalers, which have been at the forefront of adopting AI and high-performance computing (HPC), have the greatest need for high-density infrastructure. Currently, their large facilities have an estimated average density of 36kW per rack, which IDC estimates will grow at a 7.8% CAGR in the coming years to approach 50kW by 2027. Many AI cluster requirements are projected to hit 80-100kW/rack.[5]

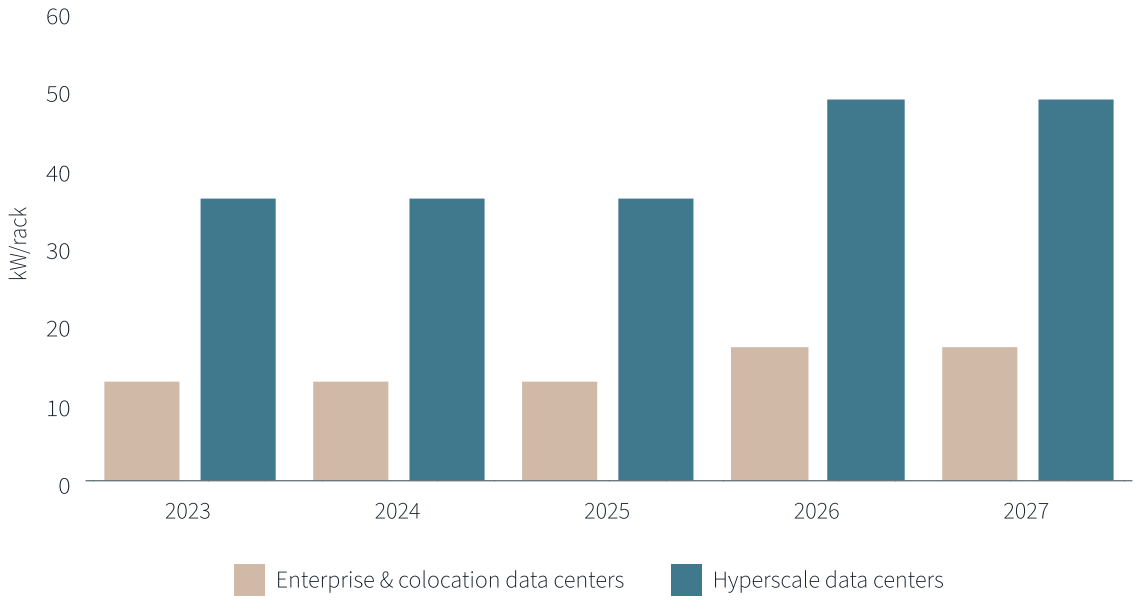
Despite its exponential growth throughout 2023, generative AI is still in its early stages of democratization for most organizations and end-users. As this transformative technology reaches more mainstream users, enterprise and colocation data centers will need to adapt to accommodate the higher power densities required to support these advanced IT loads.

In addition to increasing computational needs, rising demand for hyperconverged infrastructure (HCI) is driving the upward trajectory of power density.

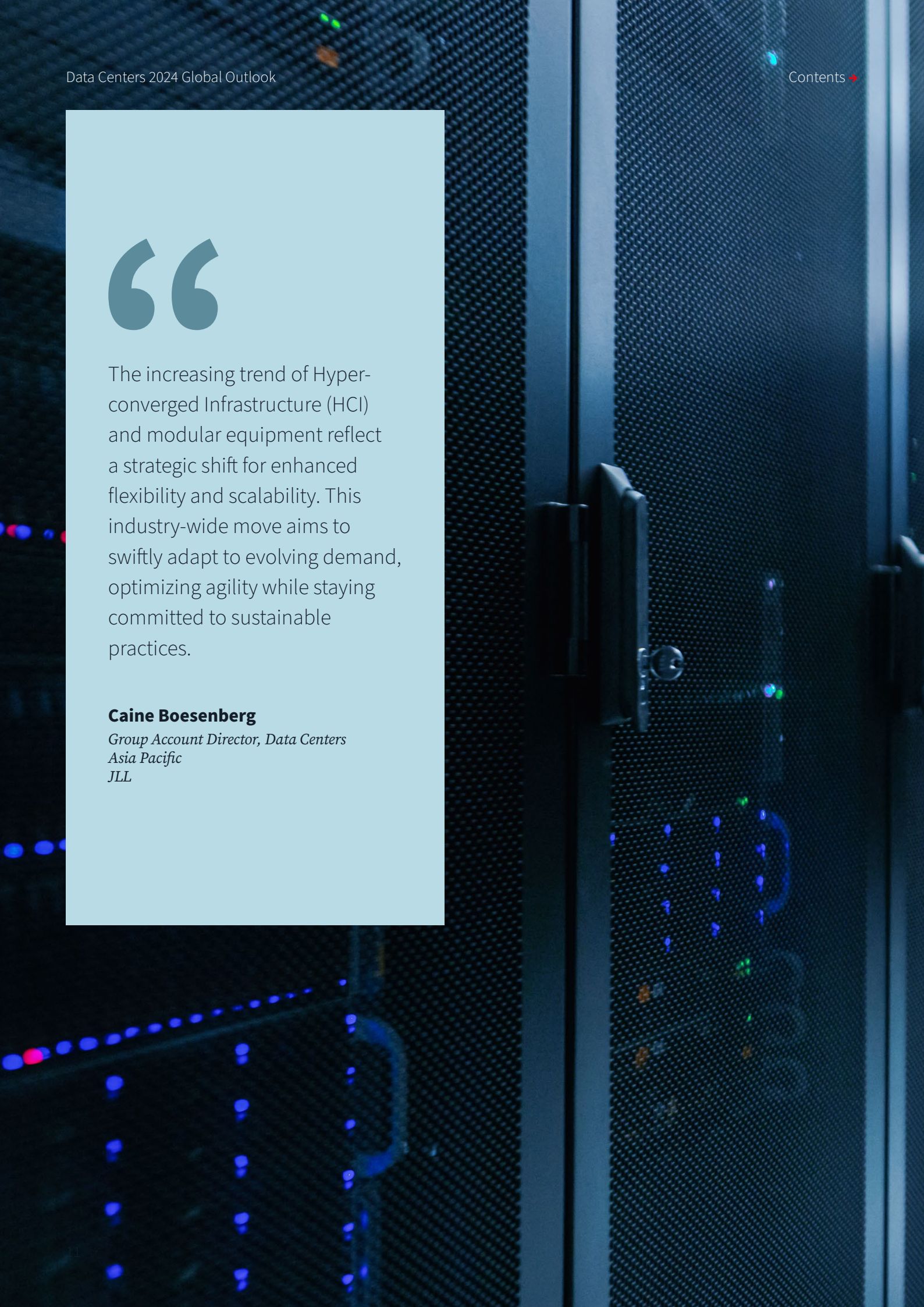
As demand for higher rack density grows, innovations on the infrastructure side are enabling the industry to keep up. Promising sustainable energy solutions and the advent of contemporary cooling solutions, especially immersion cooling, will help operators continue to increase density.

Figure 1

Average rack density is increasing, especially in hyperscale data centers (Asia Pacific excluding Japan)[6]



[5,6] July 2023, IDC #AP50326223, Asia/Pacific (Excluding Japan) DC Deployment Model and Spend Forecast, 2H22: 2022–2027, Mikhail Jaura, William Lee, Wendy Lok, Cynthia Ho



The increasing trend of Hyper-converged Infrastructure (HCI) and modular equipment reflect a strategic shift for enhanced flexibility and scalability. This industry-wide move aims to swiftly adapt to evolving demand, optimizing agility while staying committed to sustainable practices.

Caine Boesenberg
Group Account Director, Data Centers
Asia Pacific
JLL

Liquid cooling adoption ramps up

Higher rack density exacerbates the cooling demands within data centers because concentrated computing equipment generates substantial heat. Traditional methods, such as air-based cooling, may struggle to dissipate the heat generated by densely packed racks. To maintain efficiency, data centers are adopting advanced cooling technologies, such as liquid cooling or rear-door heat exchangers.

Since cooling typically accounts for roughly 40% of an average data center's electricity use, operators can offset the energy needs of higher computational power by shifting to liquid cooling. Providers have shown that liquid cooling boasts significant power reductions — as high as 90% — while improving computational capability and space requirements.

Liquid cooling is gradually becoming cost-competitive with conventional solutions, so operators should face a lower cost barrier to entry in the near future. While data centers with traditional rack densities will maintain air-cooled setups, we will begin to see wider adoption of liquid cooling in facilities with high rack densities.

> "Liquid cooling systems demonstrates a transformative step in data center operational efficiency. Beyond processing power, the industry's focus on advanced heat management aligns with a commitment to sustainable high-performance computing, departing from conventional systems, not only for sustainability purposes but also to acclimatize to the increasing need for HPC.
>
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Data center operations

Efficiency on the rise

Leading data center operators continue to make strides in increasing efficiency. Many cloud, hyperscale and colocation data centers run much more efficiently than the traditional enterprise data centers they are replacing.

In 2022, IT and data center managers reported an average annual PUE ratio of 1.55 at their largest data center. Data center operators aim to get their PUE ratio as close to 1 as possible.

While efficiency gains have flattened in recent years, leading operators continue to explore new solutions to improve PUE ratios incrementally.

Software will fuel energy efficiency improvements

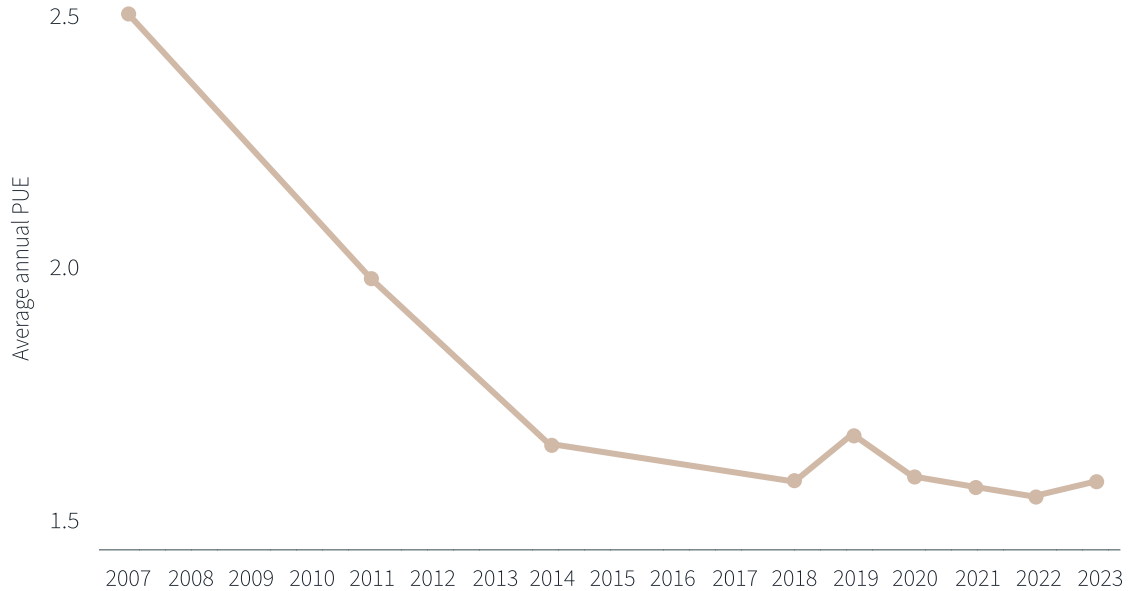
Higher power densities in new and existing centers will be necessary to do more with the same physical space. Leading data center operators will employ software for intelligent management, monitoring and rack orchestration that will fuel efficiencies, lower operational costs and require less staff.

Software-defined power, which optimizes energy use, offers one opportunity. Half of IT and data center managers believe software-defined power will likely improve the efficiency of data centers within the next five years, according to a 2022 survey.[7]

Figure 2

What is the average annual PUE for your largest data center?

Data center average PUE worldwide 2007-2023



Note: Worldwide; 2007 to 2022; 669 respondents; IT and data center managers.
Source: Uptime Institute; ID 1229367

[7] Uptime Institute Global Data Center Survey 2022, page 28

Algorithms hold potential to increase CPU cycles

While hardware improvements like renewable energy and immersion cooling tend to generate a lot of buzz, many leading data center operators are also improving efficiency behind the scenes by increasing the computational yield from CPU cycles.

With the clock speed of CPU cycles hitting a plateau in the last decade, data center operators that want to improve computational power and efficiency further will need to turn to instructions or coding improvements such as parallel and advanced algorithms.

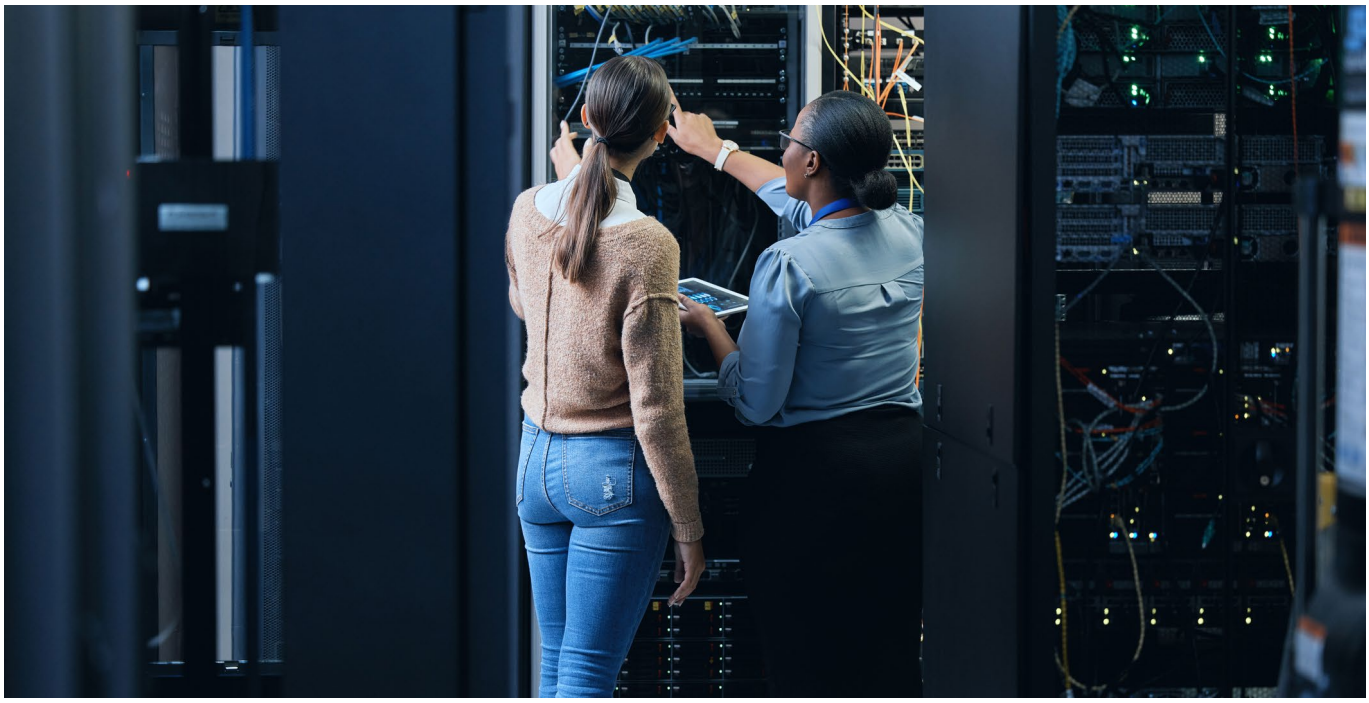
For example, parallel or distributed computing allows multiple servers to handle a heavy processing workload, thus helping to alleviate some rack density challenges. In addition, further research and development can be conducted on algorithms for quantum processing, enabling wider usage of quantum computers (QPU) for AI and machine learning.

Operators that invest in improving algorithms or software in the coming years stand to achieve greater efficiency gains than those focusing on hardware alone.

Key considerations

For investors, how can you incorporate new technologies into your data center designs to make them more efficient, particularly in relation to cooling and energy management?

For enterprises and operators, will your existing data center designs be sufficient for supporting certain stages of Generative AI model development?



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Power transmission and supply sourcing

Intensifying data center power requirements converge with the energy transition to sustainable sources

The significant power demands of HPC and AI systems put pressure on data centers' energy infrastructure, amplifying the challenges of sourcing sufficient power capacity. Global electricity use of data centers has remained flat since 2015 while data center workloads have more than doubled.[8] This has largely been due to rapid improvements to data center efficiency, infrastructure and a trend towards larger hyperscale data centers.

Despite this, smaller countries with expanding data center markets are seeing substantial increases in energy use, putting significant pressure on generation and grid infrastructure.

[8] IEA, Data Centers and Data Transmission Networks

EirGrid in Ireland estimates that electricity demand from data centers could more than double to 30% of all consumption in 2028. In Denmark, electricity usage from data centers is forecast to grow from 1% to 15% of total consumption by 2030.

The data center industry's explosive growth comes as companies are trying to navigate the challenges of the global energy transition from fossil fuels to sustainable sources and aging energy infrastructure. Antiquated grid networks were not built to handle today's power-intense data flows on top of record deployments of electric vehicle infrastructure, increases in advanced manufacturing and urban areas' growing electricity demand. Timelines for sourcing power have increased two or threefold to produce the large amounts of power required for data centers.

Grid infrastructure globally requires enormous investment. For example, one-third of Europe's grid infrastructure is over 40 years old, requiring an estimated €584 billion ($641 billion) of investment by 2030 to meet the European Union's green goals. In the United States, meeting energy transition goals will require an estimated $2 trillion in order to upgrade the grid and feed more renewable energy into the power supply. So far $13 billion has been allocated for modernizing the grid through the Bipartisan Infrastructure Law which also includes grants to expand capacity for wind and solar power as well as microgrids that can function independently in the event of a blackout.

Due to the significant investment required, challenges in sourcing power will continue to be a factor for developers and users seeking data center capacity. Advanced planning will be necessary, as delivery timelines are two to three years in the future. Users and developers will also increasingly seek sites in secondary and tertiary markets due to timelines involved in power procurement. Colocation operators will also strive to operate more efficiently, making use of the "stranded power", or power contractually guaranteed that isn't used, in order to maximize capacity.

Load shedding disrupts grid reliability

Data center operators in some markets now must contend with load shedding, a practice of intentionally shutting down power that has historically been used primarily in developing economies. In the past year, utilities in California and Texas have deployed the practice during periods of high demand. Meanwhile, Germany is contemplating using load shedding in 2024 to control the energy supply in high-demand areas.

Although a temporary reduction of electricity supply helps balance the power grid in times of high demand or a shortage of generation capacity and prevents large-scale disruption from a total grid collapse or a blackout, load shedding can be particularly inconvenient for data center operators. Data centers rely on Uninterrupted Power Supply (UPS) to ensure the continuous operation of their servers, network equipment and critical systems. Data centers have systems in place to protect against power disruptions such as redundant power sources and backup generators. However, frequent load shedding can place additional strain on these backup systems and result in higher energy consumption, leading to higher operational costs and impacting environmental sustainability efforts.

Major markets address power burden of data centers

The cost and availability of power continue to hinder development in all global data center markets. The following examples illustrate how select markets are addressing the challenge:

Ireland

The data center industry has come under immense scrutiny in Ireland over the past few years. In 2022, data centers consumed 18% of the country's electricity, up from 5% in 2015.[9]

In response, Ireland's state grid authority, EirGrid, has stopped providing connections for facilities in Dublin. The de facto moratorium means that EirGrid will not supply any new connections until at least 2028 and will only consider applications on a case-by-case basis. A handful of developers are currently seeking planning permission for new developments, with Vantage and EdgeConnex appealing their rejected decisions and CyrusOne awaiting a verdict.

[9] Central Statistics Office, Data Centers Metered Electricity Consumption 2022

Singapore

As the rapid growth of Singapore's data center industry puts pressure on the country's limited resources, the government enacted a moratorium to halt data center construction in certain regions temporarily. During the moratorium, the government carefully reviewed new data center proposals in 2022 and 2023 to ensure they align with the country's sustainability goals, examining factors such as energy efficiency, renewable energy usage and the utilization of existing infrastructure.

The government has indicated that it is actively exploring ways to meet the increasing demand for data centers through innovative solutions, such as floating data centers and underground developments.

United States

In Northern Virginia, the power capacity used by data centers doubled between 2018 and 2022 to 2,767MW, according to Dominion Energy, the state's electric utility. While it has historically matched demand, Dominion has struggled in recent years to keep up with the surge in power needs. Based on customer orders, the utility forecasts that capacity will double statewide by 2028.

To address these constraints and meet future demand, Dominion must construct major transmission infrastructure. To start, it has begun building two 500-kilovolt transmission lines in Northern Virginia to serve the data center market.

The rise of sustainable power

Sustainability has emerged as one of the most important issues for data centers today. With data centers and data transmission networks accounting for 1% of energy-related greenhouse gas emissions, operators face increased pressure to not only improve efficiency but also to source sustainable power.[10]

The intense focus on sustainability means that data center operators must tackle a dual challenge in a power-constrained environment: ensure a reliable electricity supply while minimizing a facility's environmental footprint. Several examples from leading operators offer clues to how the industry can solve this conundrum.

> "In addition to location and design considerations, data center operators are starting to explore alternative power sourcing strategies for onsite power generation including small modular reactors (SMRs), hydrogen fuel cells and natural gas. With power grids becoming effectively tapped out and transformers having lead times of over three years, operators will need to innovate.
>
> **Andy Cvengros**
> *Managing Director, U.S. Data Center Markets*
> *JLL*

[10] IEA, Data Centers and Data Transmission Networks

Case study: Energiewende

Translated in English as ‘Energy Turnaround’, Energiewende is the German name for the country’s transition to low-carbon, safe, reliable and renewable energy which involves phasing out nuclear power (the last three nuclear plants were shut down in 2023). Coal-fired power plants are aimed to be phased out by 2030 and there is increasing investment into solar and wind energy generation. The scrapping of nuclear power has been a controversial decision in Germany, as it leaves the country in a difficult place to meet its ambitious clean energy goals (65% of electricity from ‘clean sources’ by 2030). The UK for example, is expanding its nuclear energy generation with the new Sizewell C project — estimated to cost between £20 billion ($25.6 billion) and £44 billion — which will generate 3.2 gigawatts (GW) of energy and powers six million homes.

Low-carbon strategies to overcome supply issues

Location

Hyperscalers are looking to diversify their geographical footprints and find readily available and scalable power by expanding into different secondary and tertiary markets like Atlanta, Salt Lake City, Reno, Denver, Columbus, and Charlotte. Globally, Sweden and other Nordic countries offer data centers a secure source of green electricity as well as a colder climate that reduces the need for cooling operations. It's no surprise that Google, Meta, and Amazon have all established data centers in the Nordics over the past several years, and experts expect the region will see more growth in the coming years.[11]

Onsite power generation

Rooftop solar may be the most prolific form of low-carbon, onsite power generation today, but comes with the downside of high variability. New solutions are emerging, like small modular reactors (SMRs) — advanced nuclear reactors with a power capacity of up to 300 MW. In the U.S., the first approval for an SMR to supply a data center was granted to NuScale in February 2023. Microsoft is also exploring SMRs as part of its energy strategy.

Hydrogen fuel cells are another emerging technology to watch. Microsoft is testing this technology in the U.S. to replace diesel-based backup generators.[12] Meanwhile, Lumcloon Energy in Ireland and South Korea-based SK Ecoplant are partnering to build the first hydrogen fuel cell-powered data center in Europe.[13]

Power purchase agreements (PPAs)

Over the last couple of years, PPAs have enabled cloud giants to make record levels of investment in renewable energy. Major cloud providers already rank among the world's largest buyers of renewable energy. Amazon in 2023 invested in more than 100 new solar and wind energy projects. The company now supports more than 400 renewable energy projects in 22 countries.[14]

What is a power purchase agreement (PPA)?

Through a PPA, a third-party developer installs, owns, and operates an energy system on a customer's property. The customer then purchases the system's electric output for a predetermined period.

[11] Infrastructure Investor, The rise and rise of the Nordic data center industry, June 26, 2023

[12] Data center Dynamics, Preparing for the hydrogen grid, September 13, 2023

[13] The Irish Times, Offaly firm signs South Korea data center deal, November 2, 2023

[14] IEA, Data Centers and Data Transmission Networks

As disclosure requirements grow for environmental and carbon footprints, sustainable energy sources for data centers will be a key requirement in selecting an operator or developer. Users will become more knowledgeable in asking questions about sustainability before signing a commitment, and developers will focus on sustainability improvements to ensure a longer lifespan for the deployment.

Key considerations

For investors, how much sustainable energy is available in new data center markets, and what are the opportunities to invest in new sustainable energy projects to serve under-supplied markets?

For enterprises and operators, what is the supply pipeline from new sustainable energy sources in current markets of operation?

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> Opportunity and threat are often two sides of the same coin. While the global energy crisis presents an ongoing challenge to the data center sector it also opens opportunities for sustainable growth. Globally, there is a sizable energy infrastructure funding gap. By partnering with renewable energy projects, companies, cloud providers and data center operators, as the largest purchasers of renewable energy, have the ability to transform and drive the energy infrastructure sector. Through long-term PPAs that are driving development of new renewable energy projects, investing in advanced grid technologies that improve stability and optimization to onsite power generation that can export power back to the grid during periods of low demand.
>
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> *Associate Director, EMEA Data Centers*
> *JLL*

04 Opportunities for sustainable growth

The growth of AI and intensifying focus on sustainability present opportunities for data center developers and operators to evolve their business models to meet the industry's changing needs.

Over time, developers will build specialized data centers for training and tuning AI models. In the meantime, there will be significant opportunities to redesign existing data centers to cope with the increased power and cooling demands as rack densities rise due to AI. Those who can meet these demands while minimizing environmental footprints will stand ready to benefit from meeting the needs of our data-intense digital economy.

Key considerations

For investors, operators and enterprises

Has your organization sufficiently factored in the transformative impact of Generative AI into its strategic decision-making around data centers?

“

Managing aging infrastructure with increased demand intensity, alongside new ESG requirements and legislation, provide data centers with a uniquely challenging environment in 2024. However, each is an opportunity to drive meaningful change using a combination of data center expertise, platform tools and truly creative innovation – we’re set for an extremely exciting year.

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