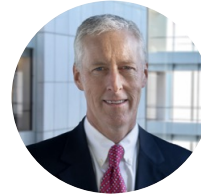


# Data centre growth abounds in the digital age



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Data proliferation continues apace, with advancements in artificial intelligence intensifying demand in one of the technology sector's most pressing areas of need. Storage capacity, while expanding, lags amid supply constraints, fostering conditions conducive to long-term growth in digital infrastructure. PGIM Real Estate's Morgan Laughlin and Jim Footh share insights on the supply-and-demand dynamics that they believe create a generational opportunity for data centres and why they are essential to facilitating projected growth in critical industries across the global economy.

## AI PUSHES DATA CENTRES MAINSTREAM

### Q: What are data centres and what is their role in a digital economy?

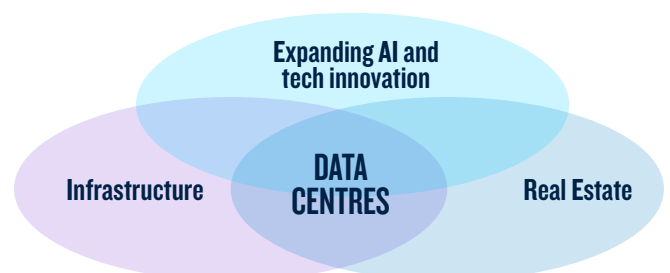
**ML:** Data centres are the physical backbone of the internet, ultimately facilitating our digital lives. They are large industrial buildings constructed to house racks of computer servers that store data and connect internet traffic. The buildings are connected to high-voltage power, as they consume large amounts of energy and contain extensive and redundant mechanical and electrical equipment to power servers and exhaust heat from the building, even amid power outages. They are connected to end-users via telecommunication networks.

Data centre tenants fall into three main segments: retail, enterprise, and hyperscale. Retail caters to customers looking for smaller power commitments, typically less than 1 megawatt (MW), that share space with other customers in a co-location data hall. Enterprises, from small and medium local companies to large multinational corporations, lease and operate their data servers in data centres. Enterprise wholesale tenants typically contract for up to roughly 1-5MWs, with the operator providing a dedicated space, power, and cooling environment that

is typically not shared with other tenants. Hyperscale tenants consume large amounts of data centre space, typically 5-50MW. These include cloud service providers, such as AWS, Microsoft, Google, Oracle, and Alibaba, and large occupiers, including Meta Platforms, Salesforce, SAP, Apple, and Nvidia.

Once seen as a niche segment within the real estate sector, data centres are evolving into a mainstream growth industry for the overall real estate industry. This is because they sit at a critical intersection of real estate, infrastructure, and technological advancements like artificial intelligence.

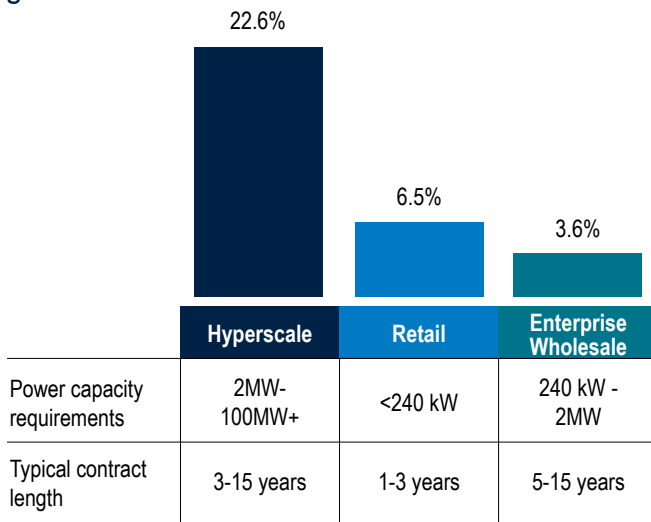
### Data centres key to unlocking growth in structural areas



## MANAGER PERSPECTIVES

This is driving strong growth in the space. The global co-location data centre market is set to grow at a compound annual growth rate of 11.3% through to 2026. Hyperscale is the fastest-growing segment by far, expanding at 22.6%, or multiple times faster than both the retail and enterprise wholesale markets.

### Data centre segment 5-year compound annual growth rates



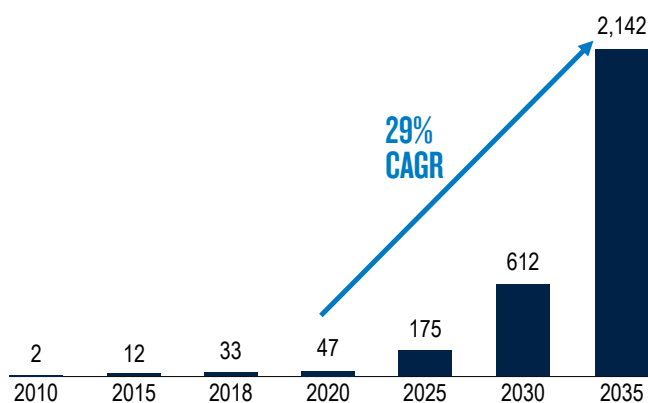
Source: Structure Research Global Colocation Report, As of February 2023. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

### Q: What is fuelling the growth in data?

**ML:** The world is becoming increasingly digital. Data is being generated at an explosive pace and is forecast to increase four-fold from 2020 levels by 2025. By 2035, more than 2,100 zettabytes of data are expected to be created worldwide. For context, 1 zettabyte equals 1 trillion gigabytes, or the equivalent of 250 billion DVDs.

### Exponential growth of data creation

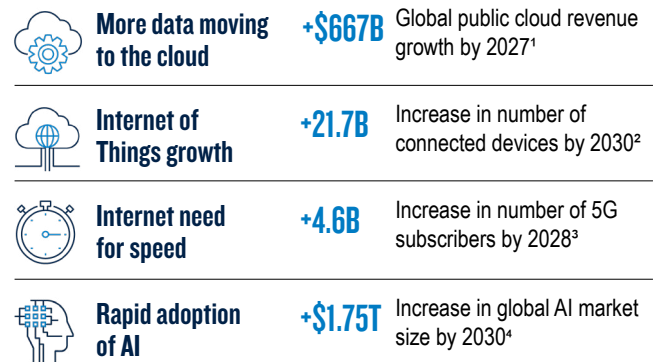
Worldwide data creation in zettabytes<sup>1</sup>



Sources: Statista, Ericson Mobility Report, Guardian, as of November 2022. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

We continue to see increased demand in social media usage, streaming, gaming, connected devices, autonomous driving, and, more recently, generative artificial intelligence (AI). All these things are fuelling a rapid migration to the cloud, which is projected to see revenue growth quadruple to \$882 billion by 2027.<sup>1</sup> Forecasts predict that there will be close to 30 billion Internet of Things (IoT) connected devices by the end of the decade.<sup>2</sup> These devices require faster communication among devices, which is propelling growth in 5G, a network system that is 100 times faster than 4G and expected to boast 4.6 billion subscribers, or more than half of the world's population, by 2028.<sup>3</sup>

### Primary drivers of digital demand



<sup>1</sup> Source: Statista as of April 2023. <sup>2</sup> Sources: Statista, Transforma Insights as of July 2023. <sup>3</sup> Sources: Statista, Ericsson as of June 2023. <sup>4</sup> Sources: Statista, Nextsc.com as of March 2023. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

As a growth catalyst, AI takes things to another level. The generative AI platform ChatGPT broke records in terms of technology reaching mainstream adoption by attracting 100 million users within two months, a feat that took Netflix more than 20 years. The rapid explosion of generative AI for general use has captured the global imagination with what the technology might enable. AI is projected to become a \$1.8 trillion industry by 2030. What's even more astounding is that AI is expected to drive exponential increases in global economic productivity approaching \$16 trillion in the same timeframe.<sup>5</sup> Much of the massively projected growth in AI and these other areas depends on increasing data storage and cannot be achieved without more data centres.

## Q: What are the implications of AI on data centre growth?

**JF:** We are very excited about how AI will impact data centre growth. In broad terms, AI is a huge demand driver. Over the next four years, more than \$100 billion is projected to go into data centre capital expenditures necessary to enable generative AI.<sup>6</sup> Generative AI has two phases, training and inference.

- The **training phase** requires substantial amounts of data to teach algorithms. We're talking about more than 1 trillion parameters to teach the AI models how to process data and generate predictions. While this phase requires significant data, it is not imperative that the data be in prime data centre locations that enable quick communications to end users. We see this phase fuelling data centre demand in non-tier 1 locations.
- The **inference phase**, which is still evolving, requires low latency, or reduced time in relaying information from server to end user. This means tier 1 locations need to expand capacity to enable optimal communication among devices. For instance, self-driving cars need almost instantaneous communication signals from servers to devices to function efficiently, which requires the data centres to be in the vicinity of the area where the vehicles operate.

Most current cloud platforms are not equipped to handle the quantum computing requirements AI models need. Hyperscalers are rapidly rebuilding platforms to accommodate this. AI readiness is becoming a mission-critical prerequisite for data centres given that generative AI is behind an estimated 20% annual increase in data centre demand through 2026.<sup>6</sup>

## *Generative AI is creating structural tailwinds for data centre growth.*

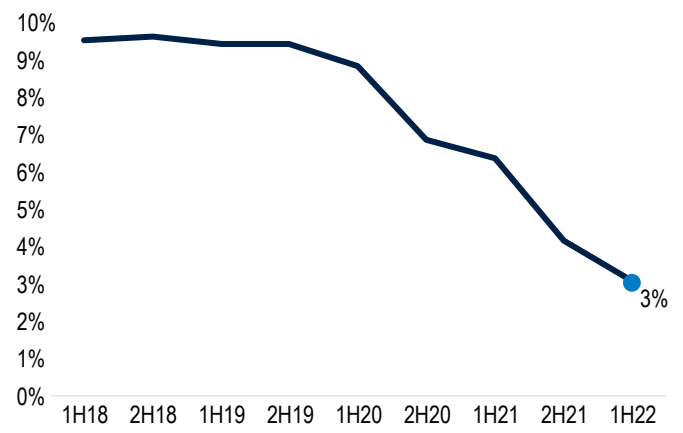
In 2023, we witnessed the beginning of a massive upgrade cycle in chip infrastructure in data centres to handle the accelerated computing power necessary to enable AI applications. Nvidia was the posterchild for this as it stunned the market with its massive data centre revenue growth. It is projected to require 1,000 megawatts of demand over the next 12 months, which equates to ~50% total demand in 2022. Additionally, the firm expects \$1 trillion will be spent over four years upgrading data centres for AI. Similar stories are unfolding with other hyperscalers, which are fuelling even stronger demand for new AI-ready data centres.

## GENERATIONAL GROWTH OPPORTUNITY

### Q: What is your outlook for data centres?

**ML:** We believe we're in the early stages of a generational structural growth opportunity for data centres. It will take years, if not decades, to build enough data centres to meet the growing dependence on data storage. Record lows for data centre vacancy rates highlight challenges on the supply side. Average vacancy rates have gone from 10% in 2018 to less than 3% today in key North American tier 1 markets. With a vacancy rate below 2%, Singapore is the world's most constrained data centre market. Rental rates are soaring in areas where it's hard to expand capacity. Take-up and net absorption rates are also at record levels in the biggest markets, as available capacity is quickly being leased out. All this amounts to a promising outlook for digital infrastructure growth and pricing power.

### Plummeting vacancy rates



Source: ULI/pwc – Emerging Trends in Real Estate 2023, September 2022.

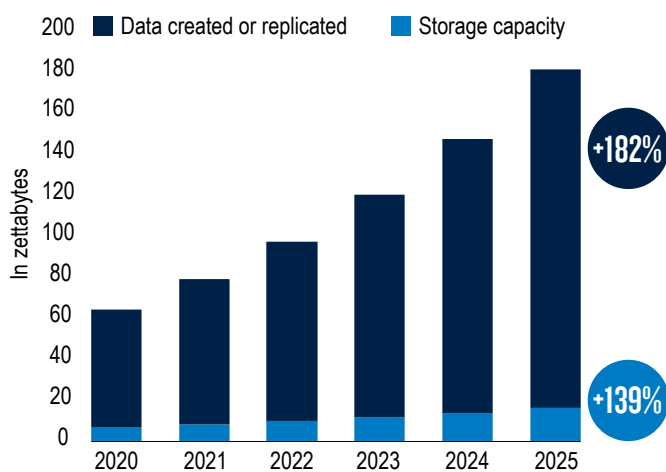
### Q: Why is data centre supply limited considering the pronounced demand trends?

**JF:** Simply put, there is a huge supply-and-demand imbalance stemming from data creation significantly outpacing storage capacity growth. There are currently about 9,380 data centres in the world, and they are only able to store a small fraction of the data being created.<sup>7</sup> Data creation is expected to grow 29% annually through 2035, so the demand side of the equation is poised to strengthen for the foreseeable future.

## MANAGER PERSPECTIVES

Data centres were once a niche in commercial real estate, but that has changed with cloud services and, more recently, AI inspiring major expansion. Billions are pouring into the industry to expand capacity, with about 314 new hyperscale data centres to be built out by the end of 2024.<sup>7</sup> That's still nowhere near enough to satisfy ever-increasing demand.

### Data creation continues to outpace storage capacity



Source: Statista as of June 2021. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

Moreover, persistent constraints limit supply growth such as:

- **Limited power supply.** There is limited grid capacity in key data centre markets, including Northern Virginia, Silicon Valley, Singapore, Dublin, London and Frankfurt, and it is unclear how to source added electricity to power the servers and cooling systems for new projects.
- **High construction costs.** Building a data centre requires a huge capital commitment. Depending on its size and location, a hyperscale centre can cost \$500 million to more than \$1 billion.<sup>8</sup>
- **Limited data centre zoning.** Hyperscale data centres can range from 150,000 to more than 1,000,000 square feet, which makes it difficult to procure land with the right industrial zoning, access to high-voltage power and proximity to fibre-optic telecommunication networks.
- **Significant development time.** Building a data centre is a time-intensive process that typically involves clearing various regulatory and environmental hurdles, in addition to securing to a high-voltage power allocation which can take up to five years in certain markets.

- **Skilled labor trends.** Data centre workers require strong technical skills. Research suggests that half of existing data centre engineering staff will retire by 2025, a period in which employees needed to run the world's data centres is forecast to grow from 2 million to nearly 2.3 million.<sup>9</sup>

### Q: Given the demand opportunity, is the sky the limit for a would-be operator able to overcome existing supply constraints?

**ML:** Competing in the data centre space is challenging beyond obvious barriers to entry like capital outlays, regulatory compliance, and logistical concerns. This isn't run-of-the-mill commercial real estate. An aspiring operator with the right site and all the necessary components still can't make it work without relationships with users. Providing and maintaining digital infrastructure is technically complex as the end users expect the data centre to be fully operational on a 24/7/365 basis with 99.999% reliability.

Credibility and the capacity to cater to evolving needs are essential given the long-term nature of leases in this space, so it's not a market that offers quick success to new entrants. Relationships and the reputation needed to win new business take years to establish in the data centre business. Understanding the market dynamics and developing an in-depth appreciation for the various industry participants can add considerable value from an investment perspective.

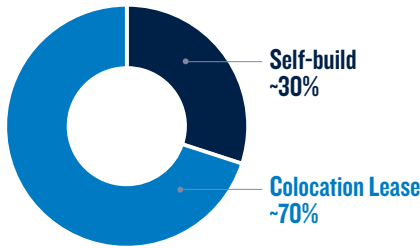
### Q: Why is this an attractive investment area if hyperscalers can just build their own data centres?

**JF:** There were only about 700 hyperscale data centres in 2021, with 30% being self-built. Most hyperscalers adopt a hybrid approach, including building their own data centres, structuring build-to-suit transactions with developers, and leasing pre-built data centre space from data centre operators. Using this hybrid approach to procuring data centre space is the only way they can keep up with demand from their own end-user customers.

Leasing in co-location centres accelerates time to market, converting a company's capital expenditure into an operating cost to offset against new revenue. Moreover, leasing offers the ability to acquire space to fulfill current needs with the capacity to expand with the operator to accommodate future growth as needed. The flexibility to scale up relatively quickly via leasing is especially well-suited to cope with unpredictable demand and to pursue expansion in multiple locations.

For professional investors only. All investments involve risk, including possible loss of capital.

Hyperscale development dynamics support leasing



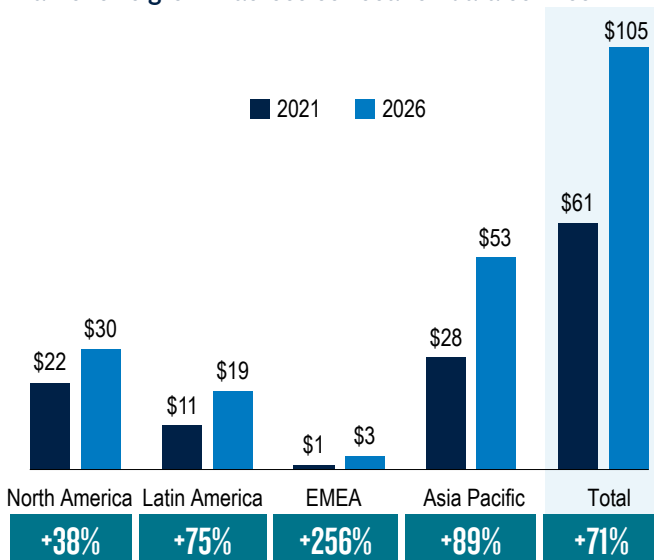
Source: Structure Research as of February 2022.

RESILIENCE AMID VOLATILITY

**Q:** How are data centres impacted by macro headwinds like rising interest rates?

**ML:** Strong growth sets data centres apart from most other commercial real estate sectors, which are struggling with high interest rates and flagging demand. Data centre owners have been less bothered by rising rates. Because of the demand versus supply imbalance, the tenants are willing to pay increased rental rates in order to procure the available space. Data centres have proven to be a highlight against the volatile macroeconomic backdrop. Demand for data has surged to record levels since the pandemic as trends related to flexible working, streaming and cloud services continue to hold firm. With growth showing little signs of stalling, the sector should remain insulated from a broader economic slowdown in the near term. Additionally, the market size for data centres is poised to grow considerably in the coming years.

Market size growth across co-location data centres



Source: Structure Research as of February 2022. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

SCALING SUSTAINABLY

**Q:** How is the industry evolving to minimise environmental impact?

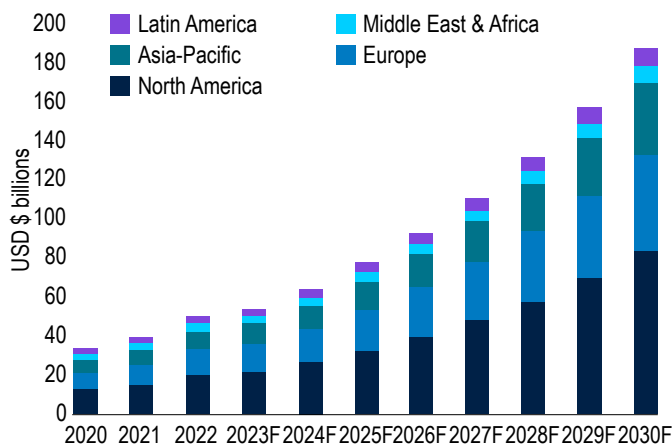
**ML:** Keeping pace with data-storage demand requires robust global expansion of facilities that consume a lot of electricity. Voracious energy consumption with a conspicuous carbon footprint is not a profile that aligns with current regulatory trends, so sustainability is rightly a priority. That’s because the benefits of climate-friendly operations go far beyond regulatory compliance. With electricity as a primary input cost, energy efficiency becomes a competitive advantage, especially at scale. Renewable energy sources also protect businesses from commodity price fluctuations.

A majority of hyperscalers have made public commitments to power operations with 100% renewable energy by 2025-30. These tenants have strong incentive to conserve power and explore ways to reduce power consumption as power cost is passed through to them. This high-level corporate commitment makes digital infrastructure development a driving force behind continued renewable capacity expansion.

As such, data centre development, from retrofitting to new construction, is largely attuned to decarbonisation trends amid clear carbon-reduction efforts among major economies. A recent Uptime Institute survey of IT and data centre managers reported average annual power usage effectiveness (PUE) ratio of 1.55 at their largest data centre.<sup>10</sup> Data centre operators building new hyperscale and co-location data centre aim to reduce the ratio to 1 by gaining greater efficiencies.

Underpinned by sound business reasoning, the industry is evolving to minimise the environmental impact of data centres. The harmony between regulatory direction and competitive positioning makes the long-term data centre infrastructure opportunity uniquely attractive. This is contributing to strong projected growth in the size of the green data centre market globally.

### Growing global green data centre market



Source: Statista Extrapolate as of May 2023. Forecasts may not be achieved and are not a guarantee or reliable indicator of future results.

### Q: How are cooling technologies being used to improve efficiency?

**JF:** Data centre use a lot of power, which translates into heat, making data centre cooling systems essential to ensure a proper supply of cooling, ventilation and humidity control to keep all equipment within desired temperature and humidity ranges.

Free air cooling and evaporative cooling are two of the most popular and most energy efficient types of data centre cooling today. Refrigerant-based cooling technology is required in hotter and humid climates, though with the penalty of being less energy efficient. Liquid cooling technologies have evolved in the past three to five years and are creating additional efficiencies. Some liquid cooling technologies can be installed in existing data centres and can support greater computer equipment densities that generate above-average heat, including the newer GPU servers primarily used in the AI training and inferencing models. While liquid cooling is still relatively new, other more environmentally friendly cooling technologies are on the horizon. These include areas such as geothermal cooling, solar cooling, and smart technologies that use AI to better monitor and manage cooling. As data centre demand grows, advanced cooling solutions will play an increasingly important factor in tenant considerations and put data centre operators who are early adopters of these technologies as more desirable landlords.

## A DIFFERENTIATED APPROACH

### Q: How can investors gain exposure to the data centre market?

**ML:** There are two main ways to gain exposure to data centres. One is to invest in a public data centre REIT or a private fund, which typically are comprised of portfolios of stabilised assets. The other way is to make direct property-level investments in the buildout of new data centres. Suitable for investors with lower risk profiles, the former approach can earn decent income while offering capital appreciation potential. Given the huge supply-and-demand imbalance, we find it more compelling to capitalise on the opportunity through direct property-level investments, which often offer much higher return potential. While development opportunities are typically considered higher risk because exit values, sales timing, and other related considerations are unpredictable, we believe the supply situation and strong demand tailwinds significantly mitigate risks related to these factors. We think there are compelling development margins to be gained by capturing the spread between development yields and lower estimated exit caps to meaningfully increase return potential for investors.

### Q: What is your approach to capitalising on the opportunity?

**ML:** We primarily use a globally diversified build-fill-sell approach, where we partner with leading data centre operators to build new data centres for hyperscale customers. We seek to build state-of-the-art, high-efficiency data centres designed to minimise the environmental impact of the growth in digital infrastructure. There are high barriers to entry in this market due to the capital, experience, and relationships required for success. Our dedicated data centre team sources compelling property opportunities based on market demand and partners with appropriate data centre operators, whether regional or global, based on the nature of the opportunity and/or tenant profile. We then fill the centres with hyperscale tenants to maximise occupancy and optimise revenue potential. Once they are established as stabilised properties, we seek to sell the data centres into strong market demand from income-seeking investors like REITs and private equity firms.

## Q: How do you seek to optimise return while managing downside risks?

**JF:** We focus on the hyperscale segment, which is primarily comprised of investment grade credit-quality tenants with pristine balance sheets. These tenants tend to lease large amounts of space with growing needs for capacity in current locations while concurrently expanding into new markets. This is a low-churn market due to large upfront tenant investments, long lease terms in the five-to-15-year range, and above average probability for renewal upon lease expiration given the potential negative customer consequences associated with relocating facilities.

We take a thoughtful approach to risk management by limiting upfront capital expenditures until tenant leases are solidified. We typically spend just one-quarter of the total development cost to build out the data centre shell. The remaining cost is spent to outfit the space over time in line with leasing. To limit IT obsolescence risks, tenants are responsible for IT infrastructure costs.

## Q: How has your experience at Amazon helped you better understand the hyperscale tenant needs?

**JF:** I have over 30 years of industry experience. Prior to joining PGIM Real Estate, I spent eight years as a senior leader within the Amazon Web Services (AWS) infrastructure team, most recently as the senior manager of AWS Strategy and Planning leading a team of infrastructure planners to develop private-cloud infrastructure solutions for AWS U.S. government and non-U.S. government clients. Wearing multiple hats and covering regions across the globe through my AWS tenure, I learned a great deal about the intricate market dynamics and nuances of each region. For instance, as a principal at AWS Strategy and Technical Leadership group, I had a global role focused on solving difficult and systemic infrastructure expansion challenges for new and existing AWS

commercial regions. My prior six years I led the data centre real estate development teams in Asia Pacific, Europe, Middle East and Africa, as well as the western half of the U.S. and all of Latin America and Canada. These experiences gave me a unique perspective on the challenges and opportunities in most every key data centre market across the globe. I believe marrying the breadth of knowledge and relationships I have gained working at one of the world's largest hyperscalers with the deep experience of our PGIM Real Estate investment professionals, gives our team an unmatched ability to meet the evolving needs of our hyperscale customers in a scalable way.

## Q: What differentiates your firm from others in the space?

**ML:** PGIM Real Estate is top-3 global investment manager<sup>11</sup> with scale and 50-plus years of experience in real estate investing. We benefit from more than a decade of experience focusing on data centre investing and enjoy well-established relationships with leading global data centre operators, including two of the biggest operators in the world. Our dedicated data centre team averages over 20 years of experience and is integrated into global infrastructure that leverages more than 300 investment resources. We believe data centres are essential infrastructure needed to support a rapidly growing global digital economy. We have \$1.5 billion invested and available to invest in data centre projects, with a robust pipeline of upcoming opportunities. We believe AI will transform the world in as-yet-unimagined ways, contributing to data storage and compute needs in similarly unforeseen fashion and contributing to a once-in-a-lifetime growth opportunity in data centres.

## WHY WE STAND OUT

### A REAL ESTATE LEADER WITH STRONG PARTNERSHIPS

PGIM Real Estate is a top-3 global investment manager with 10+ years of data centre investing experience and strong partnerships with leading data centre operators.<sup>11</sup>

### GLOBALLY DIVERSIFIED BUILD-FILL-SELL APPROACH

A dedicated global data centre strategy with direct property-level investments in new essential infrastructure expands the opportunity set to enhance return potential.

### HYPERSCALE SEGMENT FOCUSED

Hyperscale is the fastest-growing data centre segment and benefits from primarily investment grade quality tenants with strong balance sheets with low churn due to long lease terms.

- 1 Source: Statista as of April 2023.
- 2 Sources: Statista, Transforma Insights as of July 2023.
- 3 Sources: Statista, Ericsson as of June 2023.
- 4 Sources: Statista, Nextsc.com as of March 2023.
- 5 Source: PWC as of July 2023.
- 6 Source: Structure Research Global Colocation & Interconnection Report & Worksheet 2022. RBC Capital Markets Global Cloud Report July 2023. PGIM Real Estate Research, August 2023. The potential demand projection for generative AI deployments is using Structured Research's projection of forward hyperscale revenue in dollars, using that in conjunction with their market size projections to determine a base development projection for hyperscale.
- 7 Source: Statista as of September 2023.
- 8 Source: Digital Infrastructure (Dgtlinfra) as of March 2023.
- 9 Source: Uptime Institute as of March 2023.
- 10 Source: Statista, Uptime Institute as of September 2022.
- 11 PGIM Real Estate is the third-largest real estate investment manager (out of 76 firms surveyed) in terms of global real estate assets under management based on *Pensions & Investments* Top Real Estate Managers list published October 2023. This ranking represents global real estate assets under management by PGIM Real Estate as of 30/6/2023. Participation in the ranking is voluntary and no compensation is required to participate in the ranking. Rankings are subject to change.

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