

2023

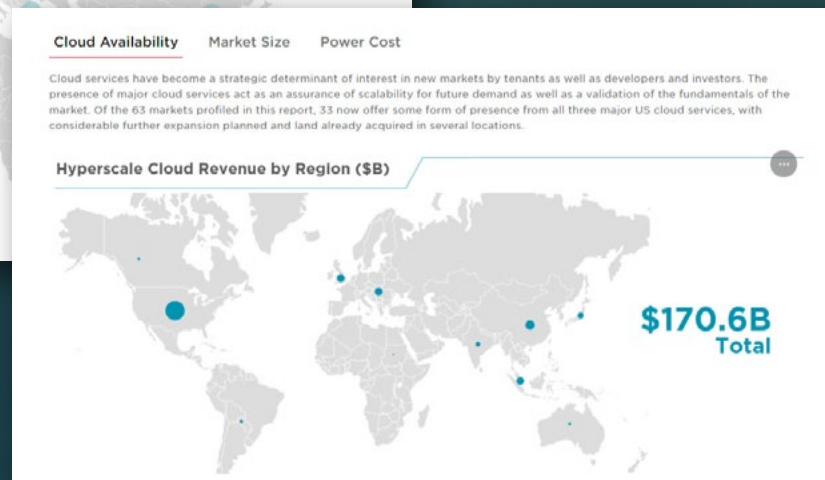
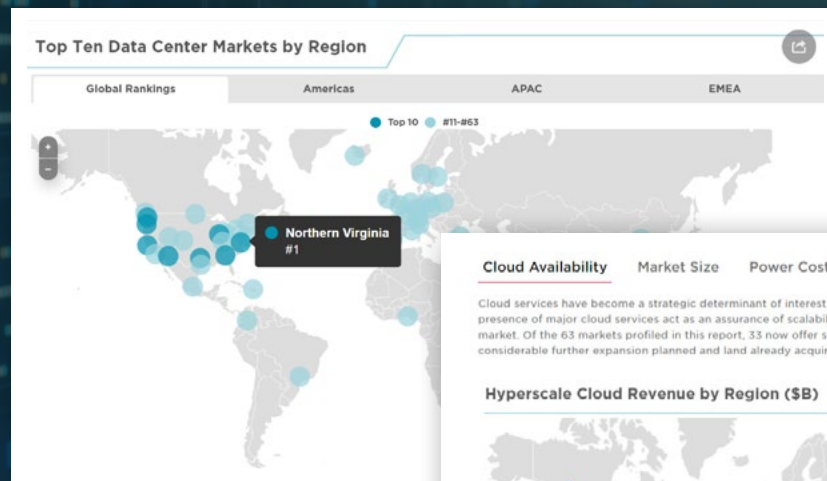
GLOBAL DATA CENTER MARKET COMPARISON

*A Publication of Cushman & Wakefield's
Data Center Advisory Group*



Interact with our top markets map, view key ranking criteria and glean global region highlights from the Americas, APAC and EMEA on our report landing page on the Cushman & Wakefield website. To receive regular updates on Cushman & Wakefield's data center insights, [subscribe here](#).

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INTRODUCTION

The rush of post-pandemic activity in the data center space seen throughout 2021 continued in 2022, despite headwinds in the overall economy and resource challenges in some of the largest markets worldwide. Hyperscale tenants continued their relentless expansion across regions, with specific interest toward secondary and emerging markets. Colocation providers and developers have followed suit, driven by higher availability and lower prices for both power and land.

The economic tumult of inflation, combined with rising interest rates and contraction in the tech sector has affected the entire data center industry. During the first half of the year, the spike in energy prices had a noticeable impact on the balance sheets of operational data centers, while the availability of power and components had a slowing affect on some pipeline projects. In some markets, utility companies increased electricity prices in response to energy availability, and as a result of supply chain issues and the instability brought about by the Russia-Ukraine war. Since then, energy prices have leveled due to a combination of supply chain improvements and government action. Currently, in our set of global markets, electricity prices are a median of 16% higher than they were in Q4 2021, though with significant variation across markets.

As forecasted in the previous 2022 Global Data Center Market Comparison, large builds from hyperscale companies have continued rapidly throughout established global markets. Hyperscalers are also some of the first movers into emerging markets, taking advantage of their ability to execute vertically integrated self-builds as well as key partnerships with local governments and telecom companies.

This year, hyperscalers made major announcements across Southeast Asia, Australia, South Asia, Sub-Saharan Africa and Latin America. While there have been a few cases of projects being paused or cancelled, fears of a complete halt of expansion plans in the wake of worldwide economic stress have been largely unfounded. Secondary markets are anticipated to continue their growth in importance as certain primary markets have run into to run into constrictions, with power usage and sustainability scrutinized more carefully.

Established markets have faced growing headwinds due to government intervention and constraints on available power and land. Northern Virginia, the largest data center market in the world, encountered an unprecedented multi-year pause for future development in key submarkets, as utility companies attempt to address a massive development pipeline. In this case, the popularity of an established market eventually exceeded its current infrastructure capabilities. Combined with high competition for available parcels and record-low vacancies, operators have increasingly looked in peripheral submarkets across Virginia and Maryland and refocused efforts on other markets across the United States. Elsewhere, there was significant progress for markets that have recently faced challenges. In Singapore, the government

Hyperscale tenants continued their relentless expansion across regions, with specific interest toward secondary and emerging markets.

lifted a moratorium on data center development, announcing new protocols to ensure sustainable development that the market's energy grid can accommodate. Operators continue to work with the local governments of these markets and others like Frankfurt, Dublin and Amsterdam, where there has been increasing tension about the energy demands and sustainability concerns from local governments. In addition, several new cooling technologies and novel data center designs—such as floating or aquatic facilities—are currently being tested around the world.

The 2023 Global Data Center Market Comparison reviews all factors outlined in the previous edition of this report, with further commentary on a region-by-region basis. As with previous editions, we assess data center markets across the globe, within 13 different categories, to determine the top overall markets along with the top performers in each category. With this fourth edition of the report, we hope to provide members of the data center community with a better understanding of how the industry is rapidly changing and expanding across the globe.

32 Research Sources / **1,600+** Data Centers / **63** Global Markets

METHODOLOGY

The 2023 Global Data Center Market Comparison reviews the same factors outlined in the previous two editions. We scored each data center across 13 weighted categories enabling us to assign each metropolitan area with an overall market score.

| HIGH-WEIGHT | MID-WEIGHT | LOW-WEIGHT |
|--------------------|----------------------|--------------------|
| Fiber Connectivity | Incentives | Power Cost |
| Market Size | Taxes | Land Price |
| Cloud Availability | Political Stability | Environmental Risk |
| | Vacancy | |
| | Development Pipeline | |
| | Sustainability | |
| | Smart Cities | |

This year's edition includes some changes and updates. The goal of this system is to mirror how data center markets truly function and to identify what factors data center investors, owners, operators and occupants value. Eight new markets have been included in this edition of our report with locations in South Asia, Southeast Asia, South America, North America and the Mediterranean.

OVERALL RANKINGS: THE TOP TEN

01 / Northern Virginia*
Portland*

08 / Dallas

03 / Singapore

09 / Phoenix

04 / Hong Kong

10 / Seattle

05 / Atlanta*
Chicago*
Silicon Valley*

* Ranking Tie

For the first time, we received a tie for first place.

For the first time, we received a tie for first place. Northern Virginia, which had received the top spot in the three previous versions of our report, now shares the highest rank with the Portland market. While remaining the largest market at over 2.5 gigawatts (GW) of capacity and vacancy at below 1%, Northern Virginia still saw several challenges this year. As previously mentioned, data center development in Loudoun County has been paused through 2025 or 2026 due to limitations on the ability of the local utility provider to distribute sufficient power. This, combined with rocketing prices for prime land, has driven operators to seek opportunities in surrounding markets, including Gainesville, Bristol, Culpeper, Manassas and even as far as Richmond.

Portland rocketed from 10th place to sharing the top of the overall standing this year. This is due to the rapid expansion of hyperscale activity in the Hillsboro submarket, as well as relatively favorable pricing, sustainability options, low environmental risk and more available land. Press reports indicate a major new build by QTS is being planned on behalf of Meta, with the prospective campus reported as requiring 250 megawatts (MW) of power at full buildout. The campus would be powered entirely by renewable energy via Portland General Electric, emphasizing the hydroelectric power available for large deployments throughout Portland and rural Oregon. Further large-scale construction remains very much in demand, with rumors of further cloud service interest along with potential relocations. Portland's rise is indicative of a number of smaller markets growing to be of key interest for the data center industry. Going forward, expect other secondary markets to see substantial jumps in rankings.

Following Portland are Singapore and Hong Kong. Both rank high despite a lack of available developable land, with Singapore's new development parameters and Hong Kong's generally high land prices. However, both have strong ecosystems, excellent connectivity, consistent demand, and all major cloud services available and expanding where possible. Hong Kong has continued its rise from the sixth spot in last year's listing, as operators remain undaunted by land limitations and pricing. Singapore remains a premiere market in the APAC region.

Portland rocketed from 10th place to sharing the top of the overall standing this year.

Atlanta, Chicago and Silicon Valley are tied for fifth in our 2023 ranking. Atlanta and Chicago offer sizable incentives, lower costs of land relative to market size, plenty of development in the pipeline and lower power costs than most large data center markets. Meanwhile, Silicon Valley has been a longstanding market with higher land costs, but proximity to the high concentration of tech sector players continues to maintain demand around the Bay Area.

Rounding out the top 10 markets are dependable stalwarts Dallas, Phoenix and Seattle—all with solid performance metrics that are tried and true, yet that still retain a number of options for expansion and new entrants.



ALL MARKETS

* New market in 2023 report

Amsterdam

Atlanta

Austin*

Bangkok*

Silicon Valley

Beijing

Bengaluru

Berlin

Bogota*

Boston

Chennai

Chicago

Columbus

Dallas

Northern
Virginia

Delhi

Denver

Dublin

Frankfurt

Ho Chi Minh*

Hong Kong

Hyderabad*

Istanbul*

Jakarta

Johannesburg

Johor*

Kuala Lumpur

Lagos

Las Vegas

London

Los Angeles

Madrid

Manila*

Marseille

Melbourne

Milan

Montreal

Mumbai

Munich

Nairobi

Nashville

NYC-Northern
NJ

Osaka

Oslo

Paris

Phoenix

Portland

Queretaro

Reykjavik

Salt Lake City

Santiago

Sao Paulo

Seattle

Seoul

Shanghai

Singapore

Stockholm

Sydney

Tokyo

Toronto

Vancouver

Warsaw

Zurich

TEN MARKETS TO WATCH

01 Abu Dhabi

We're following several markets closely for future inclusion in the Market Comparison.

02 Copenhagen

03 Vienna

04 Helsinki

05 Prague

06 Tel Aviv

07 Patagonia

08 Cape Town

09 Auckland

10 Casablanca

Data centers in Middle Eastern markets are of growing interest, as they are near major technology and government hubs, such as Tel Aviv and Abu Dhabi. There are still markets of interest in the Nordics, with Copenhagen and Helsinki sitting at key points along the Baltic Sea. Vienna and Prague remain key and stable points of access to Central and Eastern Europe. A number of smaller coastal cities, such as Cape Town, Patagonia or Auckland, which remain of interest as connectivity plays.



HIGH-WEIGHT CRITERIA



Market Size

Fiber
Connectivity

Cloud
Availability



MARKET SIZE

An existing major market has a multitude of advantages that appeal to clients and operators alike; the most well-established markets have access to all major cloud services, allowing for high performance and peering opportunities. There are known operators in these markets, with corresponding experienced talent for hire and knowledgeable sales representatives to assist with filling buildings. Local governments understand the planning approval process, and utilities are not surprised when operators inquire about large power requirements. The largest markets are thus able to grow through this momentum, at least until all potential sites for development disappear, the power grid eventually cannot maintain growth, or political imperatives change.

For hyperscale cloud services, large markets appeal first as an opportunity to create new business and then to expand thereafter once usage has become commonplace. Several services will lease or build a major data center after signing an initial anchor tenant, in the expectation that surrounding enterprises or government organizations that conduct business with the initial tenant will later join on the platform. After a first hyperscaler enters, others follow to compete for market share, swelling the size of the capacity in-market and leading to further construction, with mid-scale cloud services moving in thereafter.

AMERICAS: As many primary markets grow and secondary markets move toward primary level, Northern Virginia remains the largest market globally by far, with just under 2.5 GW currently operational. The remainder of the top Americas markets are familiar to data center veterans: Silicon Valley, Dallas and Chicago.

APAC: With more accurate data on the size and scope of data center deployments in mainland China, Beijing and Shanghai have both risen notably in the rankings. Singapore, Tokyo and Sydney continue to be the other largest data center clusters in the region. In 2022, Singapore lifted its development moratorium that halted development and put new guidelines for development in place that promote responsible development, energy usage and sustainable practices.

EMEA: London and Frankfurt continue their roles as the largest data center markets in Europe. Last year, we noted concerns on the availability of power for future developments in Frankfurt. There has been apparent progress on this front, as Frankfurt's local government designated a series of specific zones for data center development. This solution is more ideal than a complete halt to new projects that other markets have established and should hopefully ensure sufficient power going forward.

Largest Markets

Northern Virginia

Beijing

London

Singapore

Tokyo

Frankfurt

Shanghai

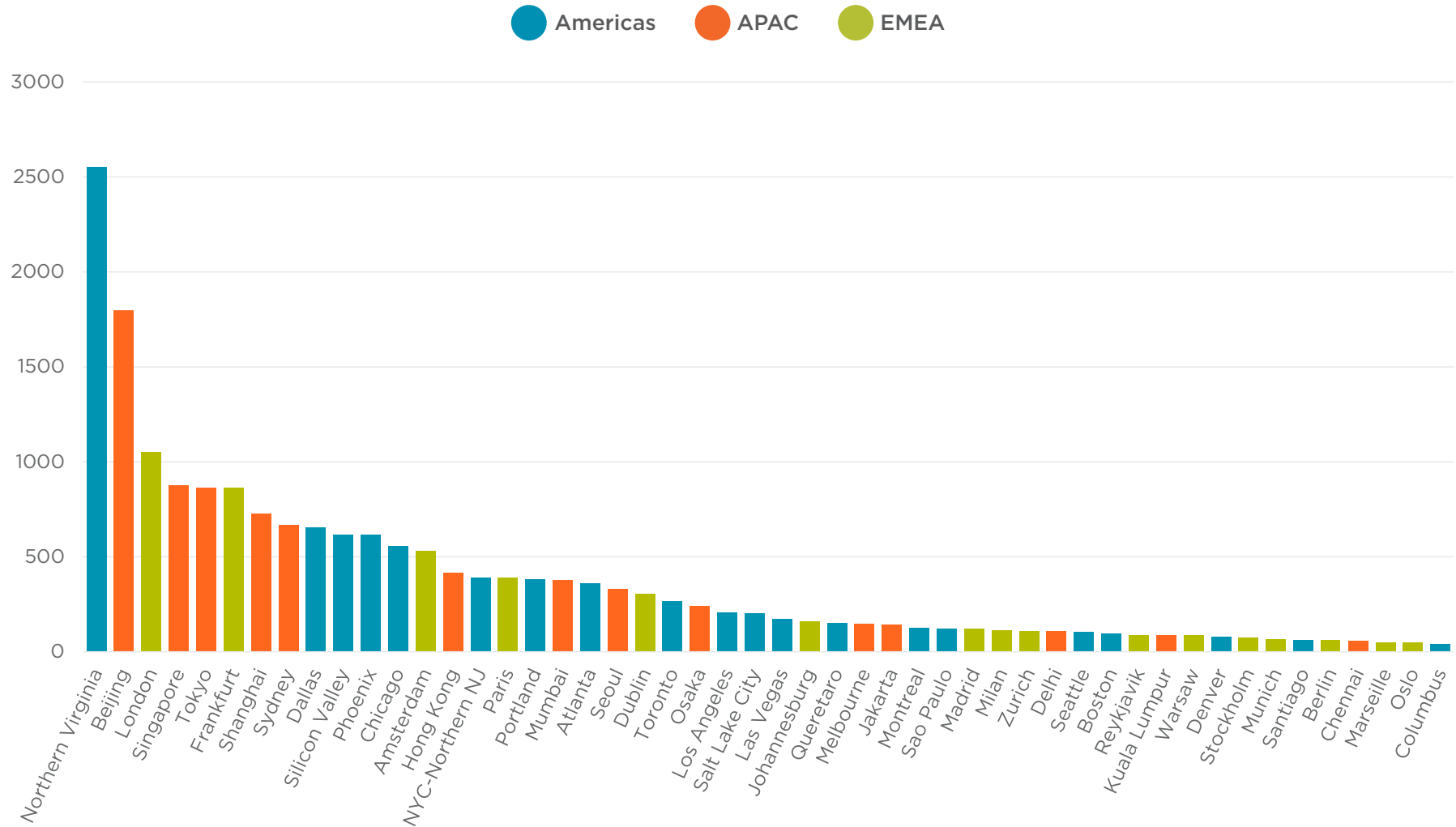
Sydney

Dallas

Silicon Valley



Total Power (MW)



Source: Cushman & Wakefield Research

FIBER CONNECTIVITY



HIGH-WEIGHT

Fiber density and quality are primary drivers for locating a data center, with fiber serving to connect the facility to others and to the end user. More networks are always better, with the diversity of fiber leading to lower latency and higher performance, even if certain networks connected to a particular data center may have bandwidth issues. Bandwidth is an increasing discussion point to the edge, considering the move over the past two years to a work-from-home environment and the correspondingly constant usage of videoconferencing platforms for meetings that were once in person. Fiber networks are constructed in an array of formats, with short-haul fiber linking a metropolitan area or long-haul fiber connecting multiple regions and countries. Undersea cables add to the mix,

directly connecting landing points in countries across seas or oceans to transmit information. Like last year, we utilize the Ookla Speedtest Global Index for broadband speeds as an indicator for fiber connectivity and speed.

Results of the Speedtest Global Index analysis show that Santiago, Chile has surpassed Singapore for the top spot globally. Additionally, Beijing and Shanghai substantially rose in rankings, as China has continued fiber infrastructure improvements. Singapore continues to be a strong performer, with the business-friendly city-state long known as a connectivity point across Southeast Asia. New entrant Bangkok follows, proving, like Santiago did last year, that low latency and high connectivity can be present.

Santiago, Chile has surpassed Singapore for the top spot globally. Additionally, Beijing and Shanghai substantially rose in rankings.

Top Markets

| | |
|----------------|-------------------------------------|
| Santiago | Northern Virginia |
| Beijing | Denver |
| Shanghai | Las Vegas |
| Singapore | Los Angeles |
| Bangkok* | Nashville |
| Hong Kong | New York/ Northern New Jersey |
| Atlanta | Portland |
| Austin* | Seattle |
| Silicon Valley | Nashville |
| Boston | Salt Lake City |
| Chicago | Phoenix |
| Columbus | |
| Dallas | |

* New market in 2023 report

CLOUD AVAILABILITY



HIGH-WEIGHT

Trends that began pre-pandemic and launched fully during the pandemic have continued moving forward; in nearly any market around the world hyperscale cloud services represent 70-80% of all leasing in any given quarter as the all-out battle for market share continues. The three largest by market size (Amazon Web Services, Microsoft Azure, Google Cloud) continue to innovate apace, adding an array of services at the edge to join with core hosting, storage and database options, entrenching usage inside the largest enterprises and government organizations. As further entities choose to move more of their workloads to the public cloud for scalability and ease of access, a variety of markets will benefit as the hyperscalers work to bring clients online.

Of continued increase in importance are markets that offer multiple cloud services, as early adopters are now diversifying their workloads to create true hybrid IT. This will often include multiple public cloud instances for varying uses, along with some use of private cloud in a colocation environment for others. Markets that offer services such as peering opportunities and plenty of on-ramps will gain business from these more sophisticated organizations, especially those that look to access a wide array of options and seek to utilize further specialized applications in the future. One adjustment we've made to

our methodology is to include the presence of cloud providers' edge locations in a market. These edge locations provide direct access to a secure backbone connected to larger availability zones and cache sites that the cloud provider maintains in the region, reducing latency and opening access to high performance for more users.

Of the 63 markets profiled in this report, 34 now offer all three major cloud services, all of which have considerable future expansion planned and land acquired in expectation of further growth. New entrant Hyderabad already has two cloud services present, providing an alternative to Mumbai as a top Indian market with cloud access. Berlin, Dublin, Kuala Lumpur, Santiago and Johannesburg all rose to have some form of presence from all three cloud providers.

Of the 63 markets profiled in this report, 34 are now either home to availability zones or edge locations for all three major cloud services

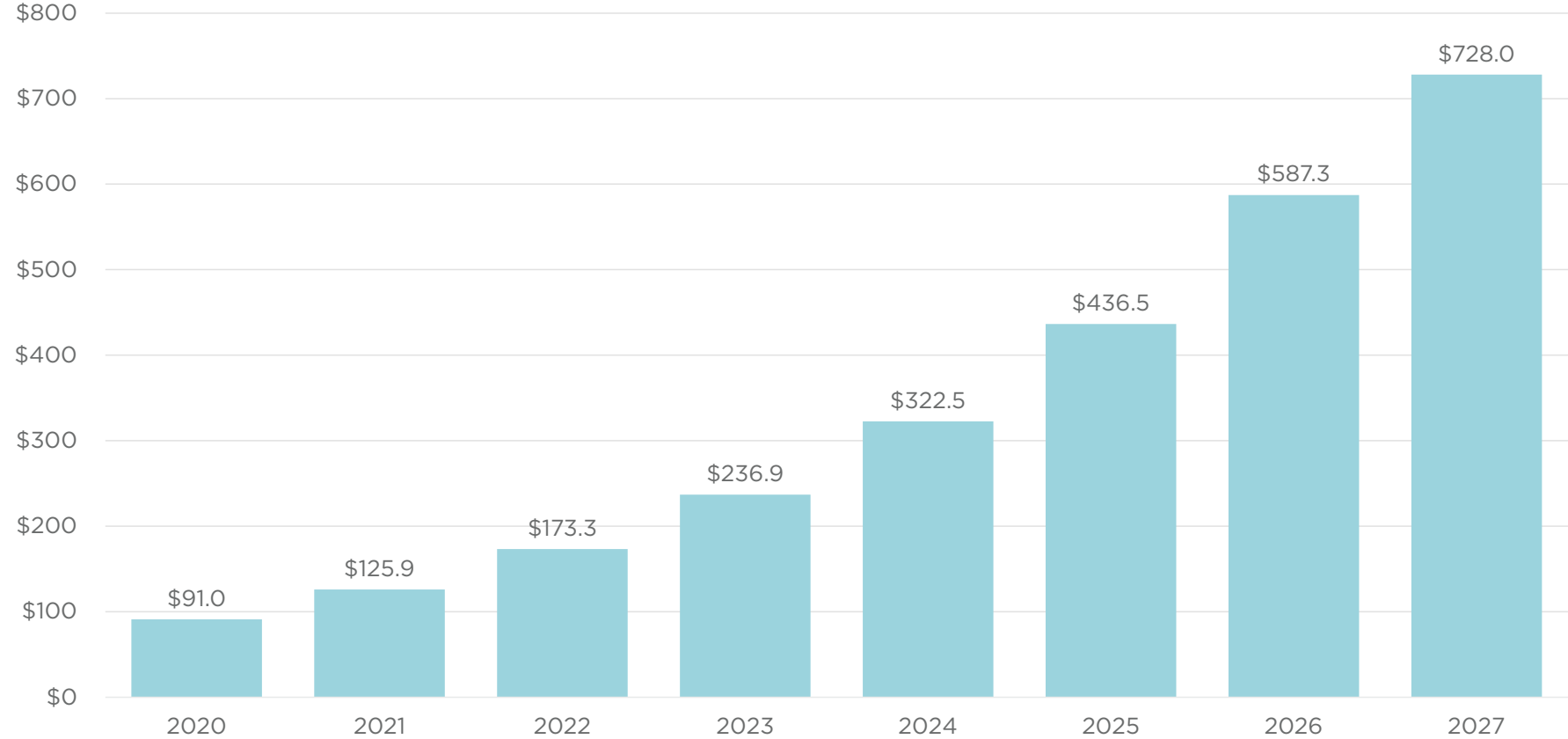
Top Markets (All three services)

| | |
|-------------------|--------------|
| Toronto | Portland |
| Montreal | Seattle |
| Northern Virginia | Zurich |
| Chicago | Madrid |
| Dallas | Milan |
| Los Angeles | Melbourne |
| Silicon Valley | Warsaw |
| Sao Paulo | Seoul |
| London | Osaka |
| Amsterdam | Atlanta |
| Frankfurt | Jakarta |
| Paris | Berlin |
| Singapore | Dublin |
| Tokyo | Kuala Lumpur |
| Hong Kong | Santiago |
| Sydney | Johannesburg |
| Mumbai | Austin* |

* New market in 2023 report

CLOUD AVAILABILITY

Hyperscale Cloud Revenue (\$B Forecast)

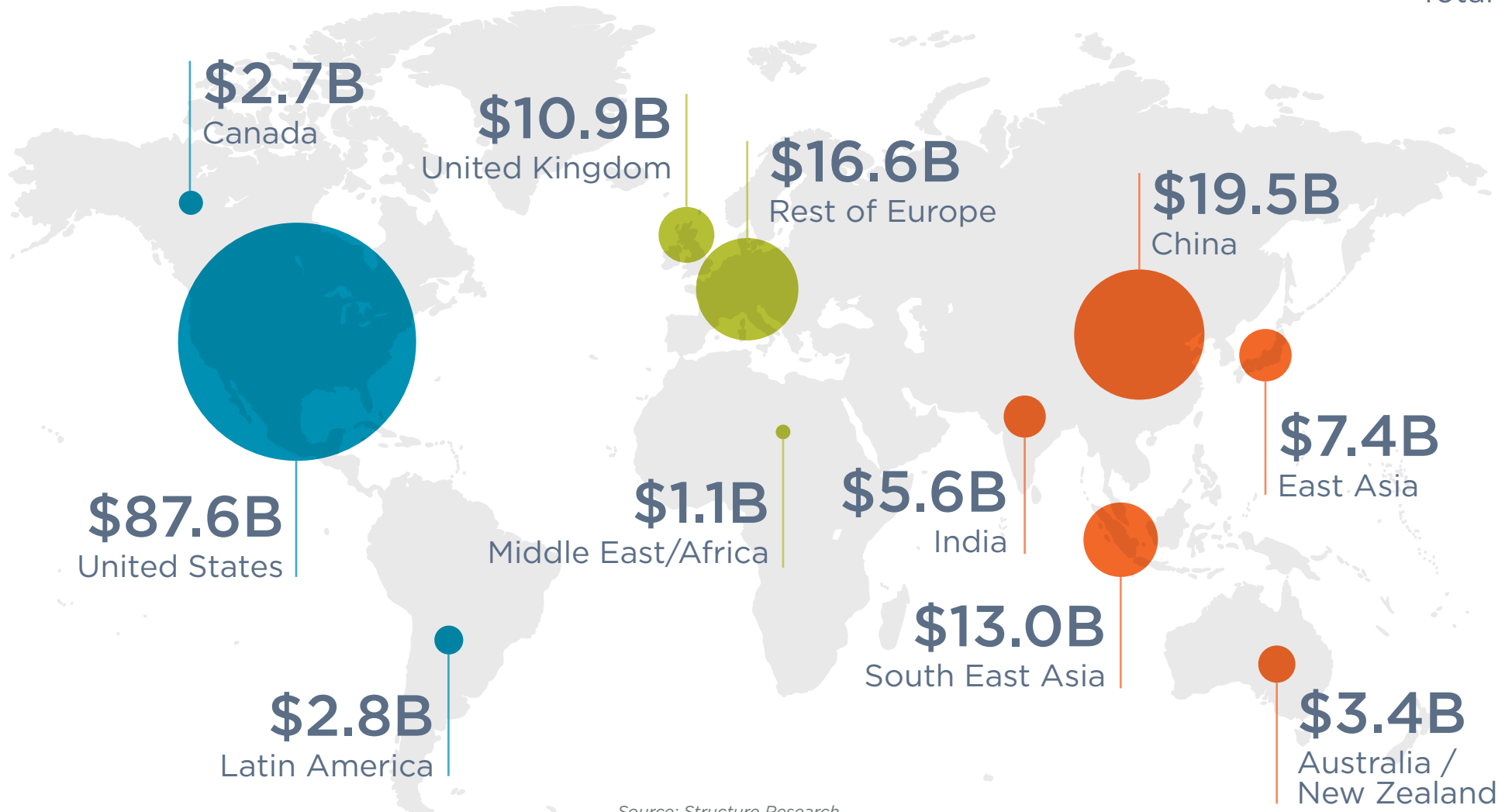


Source: Structure Research



Hyperscale Cloud Revenue by Region (\$B)

\$170.6B
Total



Source: Structure Research



MID-WEIGHT CRITERIA



/ Incentives

/ Taxes

/ Political
Stability

/ Vacancy

/ Development
Pipeline

/ Sustainability

/ Smart Cities

INCENTIVES



MID-WEIGHT

A strong package of data center incentives signals that not only is a local area amenable to supporting the data center industry, but that there are likely existing relationships with local utilities and communities to allow for such development to continue at large scale. Incentives come in many forms, though mainly involve tax relief from property taxes, value added or sales taxes, discounted power with usage of renewables, and other financial support from typical rates charged for smaller-scale purchases. As the largest data center campuses cost nine figures and beyond over time, this tax support enables areas to be considered for development more quickly with long-term expansions planned well in advance.

AMERICAS: While individual packages based on the size of a project are found in many countries, explicit state-level support is found most often in the United States, where 30 of 50 states now provide some form of benefit. Local county- or city-level areas will often provide their own incentive packages to create compelling scenarios for developers determining where to build. This year, we incorporated additional market-level incentives for data center development into our model beyond purely state-level incentive structures.

Beyond the United States,

APAC: With considerable data center growth planned across India, Tamil Nadu (Chennai) and Telangana (Hyderabad) have both established data center policies with strong incentive structures. Additionally, more emergent markets in the region have started to consider potential incentive structures, with a number using free enterprise zone policies along with additional tax relief.

EMEA: Tax incentives can also be found in certain Nordic markets, with Reykjavik, Oslo, and Stockholm all offering packages that lower taxes or provide incentives for using renewables. In France, both Paris and Marseille also offer benefits for those who acquire renewable energy for their projects.

Top Markets Offering Incentives

| | |
|----------------|-------------------|
| Reykjavik | Mumbai |
| Seattle | Austin* |
| Salt Lake City | Dallas |
| Stockholm | Northern Virginia |
| Oslo | Atlanta |
| Kuala Lumpur | Columbus |
| Paris | Chennai |
| Marseille | Las Vegas |
| Chicago | Phoenix |
| Nashville | Hyderabad* |

* New market in 2023 report

TAXES

While incentive packages to relieve overall tax burden on a project are attractors for data center development, new phases or smaller builds may not qualify for minimum thresholds to achieve this relief. These projects require the purchase of the same materials (generators, cooling systems, servers, racks and more) but may have to pay full sales or value-added taxes on the costs of all goods purchased. A sales tax is a payment to a local or national government for the total of goods sold, while a value-added tax is paid by the ultimate user at the end of the value chain. Both can rapidly add up as materials are purchased over the cost of a project.

As noted in previous editions of this report, two markets covered have neither of these taxes: Hong Kong and Portland. Hong Kong is a global financial and business capital, with a long history of pro-business policies and an accordingly robust data center sector.

Portland is a rapidly growing data center market on the west coast of the United States, with dense fiber and sites available in the local-market cluster in the suburban Hillsboro.

Other large markets have continued to enjoy lower taxation, including the world's largest in Northern Virginia, with Singapore and the data center cluster in Northern New Jersey also offering lower taxes than many primary data center locations.

Several new markets have made substantial inroads into the top 10. Johor, as a development-friendly emergent market with proximity to Singapore and Kuala Lumpur, broke into the fifth spot on this year's list. Austin, another low tax secondary market in the United States, beat out Boston for the seventh spot in this year's list. Lastly, new market entrant Bangkok emerged onto the this list at the tenth spot

Several new markets have made substantial inroads into the top 10 in this category: Johor, Austin and Bangkok.

Top Markets

Hong Kong

Portland

Northern Virginia

Johor*

Kuala Lumpur

Austin*

Boston

Seattle

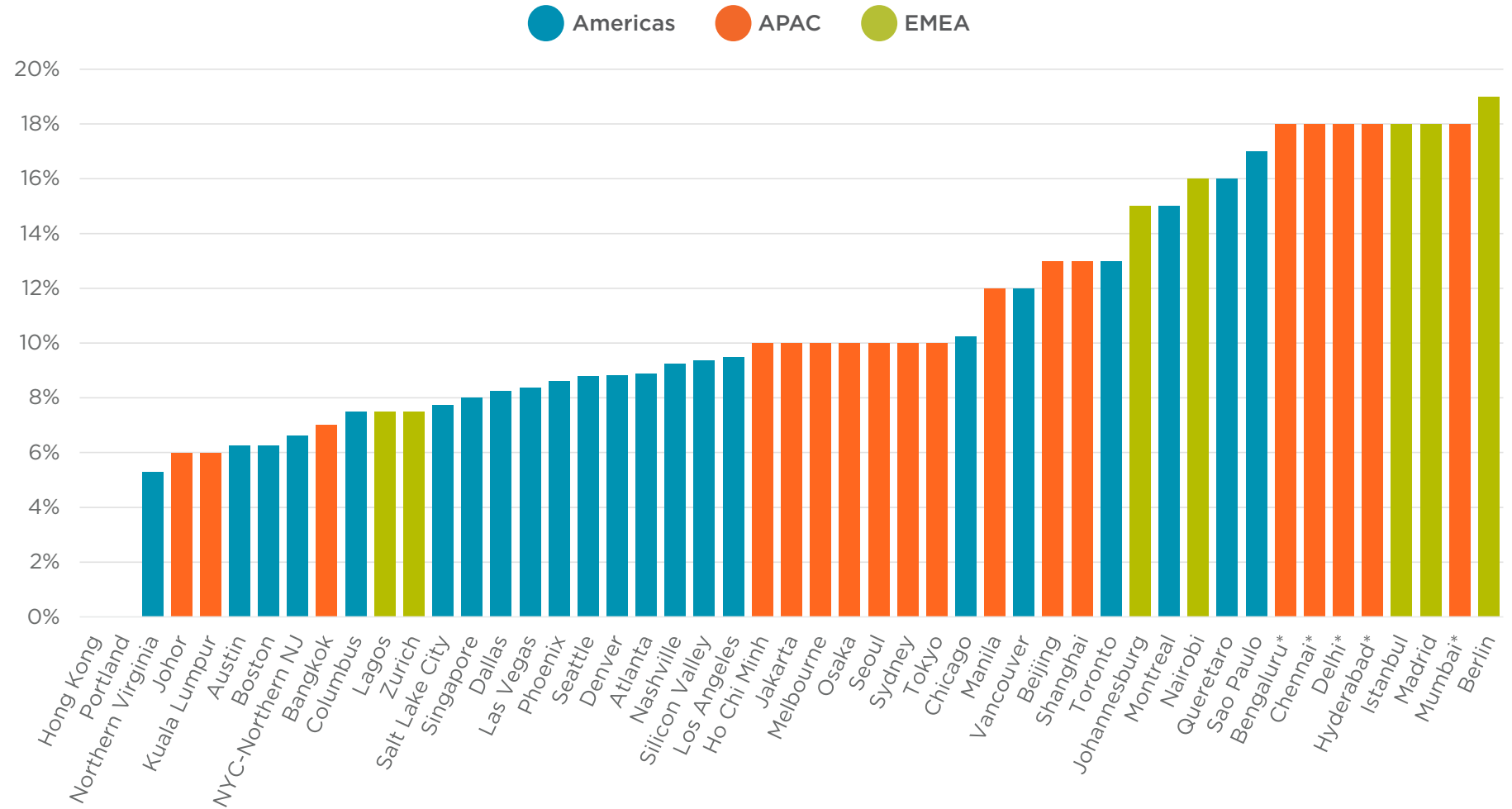
New York City /
Northern New Jersey

Bangkok*

* New market in 2023 report



Sales Tax/VAT Percentage



* While in general India has a 18% Goods & Services Tax (GST), International invoices being raised in India attract 0% GST. Also, local clients get Input Tax Credits which reduces the taxes significantly.

Source: Cushman & Wakefield Research, multiple sources

POLITICAL STABILITY

Business works best in a stable, highly functional environment and the same holds true for the data center industry. As data centers are considered mission critical to keep applications, networks, and thus entire companies operating at their highest efficiency, the greater political situation of the data center location factors into any decision making. As an established proxy for stability, the World Governance Indicators created by the World Bank have been considered for each market reviewed. The indicators include **six distinct dimensions** of stability:

- 1 Voice and Accountability** includes the ability of a country's population to select their government, along with freedom of expression, freedom of association, and free media. From a data center perspective, a government that allows its population to communicate freely means a safer data environment free from interference via censorship or outright theft.
- 2 Political Stability and the Absence of Violence or Terrorism** reviews the likelihood of political upheaval in a country and the violence that could occur during such upheaval. Political violence often leads to chaos, service disruption and property destruction, all of which are problematic for mission critical applications.
- 3 Government Effectiveness** includes the perceived quality of public services, civil service and its independence from politics, quality of policy creation and implementation, and the government's commitment to all of this. A highly effective government leads to property being registered properly and on time, electrical grids functioning as they should, and sensible zoning requirements.
- 4 Regulatory Quality** considers the ability of a government to create and implement regulations that allow private sector development. Well-structured and flexible regulations lead to a clear understanding for development and operation of data centers, as facilities can be more easily designed in accordance with local practice.
- 5 Rule of Law** indicates the confidence citizens have in laws being followed, including contract enforcement, property rights, police, courts, and likelihood of criminal activity. A strong rule of law provides confidence in the ability for business to flourish in the absence of arbitrary obstruction, leading to leases enforced, land titles remaining with their rightful owners, and less likelihood of criminal entry to a facility.
- 6 Control of Corruption** includes all forms small and large, along with the takeover and abuse of a state by private actors. Less corruption ties strongly to better contract enforcement, less hassle in operating a data center in the absence of bribes, and overall better performance of services.

Three markets across Europe and the three markets covered in this report in Canada all finished with the highest possible scores, with Zurich and Oslo retaining their positions from last year and now joined by Reykjavik. As the World Bank provides these rankings on a countrywide basis, Vancouver, Montreal, and Toronto also join at the top. These are followed next by two other well-governed locations, with Dublin and new to this report Stockholm just behind. Not coincidentally, many of these markets have sizable renewable energy on offer, thus offsetting potentially higher taxation and providing long-term benefit to data center operations.



MID-WEIGHT

Top Markets

(due to a tie for ninth- scores assigned by World Bank on a country rather than market basis):

Zurich

Oslo

Toronto

Montreal

Vancouver

Reykjavik

Dublin

Stockholm

Amsterdam

Sydney

Melbourne



VACANCY

A tight market is a general indicator of heavy demand, and the same has applied in the data center world over the past year. Appetite for new capacity from hyperscale cloud services remains unsated, with the largest moving entire markets with one or two large leases. The issue around obtaining capacity is increasingly the same in most primary locations; where the total market may have anywhere from 5-10% vacancy, finding space in large hall- or building-sized spaces is exceptionally difficult for those who require contiguous 10 MW blocks. Often a dichotomy forms between those aiming for hyperscale and those working with the retail colocation market; one side will only aim for leases of 5 MW and above, while the other works with 500-kilowatt (kWh) deployments and below.

To remedy this struggle, data center sites continue to trade not only what can be built today, but also what can be constructed in phases over a five- to 10-year period. Extra land allows for build-to-suit completions and expansions by current tenants and ensures staying power for years to come. Markets that have higher structural vacancy often witness this vanish once an initial hyperscaler moves to the area; in the continued battle for market share, one key service often leads

to many, and capacity rapidly disappears as these services compete for local enterprise, government and other organizational clients.

Surprisingly, there are 24 markets that are now under 10-percent vacancy—33% more markets than the prior version of this report.

AMERICAS: Northern Virginia hit a record low vacancy of under 1% this year. Continued demand combined with the pause on future development in the major submarket cluster of Ashburn will keep vacancies low in the market through 2023 and likely beyond. Spillover effects from Northern Virginia has led to lower vacancy rates across most North American markets, albeit with less restrictions on future supply. Columbus continued to have low vacancies as the growing secondary market seeks to deepen its pipeline of future projects. Silicon Valley and Portland continued their trend of low vacancies, while Las Vegas experienced strong take up, launching it into the top 10 for this year.

APAC: Singapore has also encountered record low vacancies of 2% in 2022. With only a few pre-moratorium developments going online this year, supply was rapidly taken up as tenants awaited to see what rules might guide future development. Vacancies continued to tighten across most markets as tenants demand for more space remained strong.

EMEA: Dublin led the world in terms of low vacancy, as local government rules have largely prevented new development in the immediate area. Paris and Frankfurt likewise tightened their already single digit vacancies to under 2%. Other notable markets include Zurich, which experienced a jump from the 24th to the 16th spot.

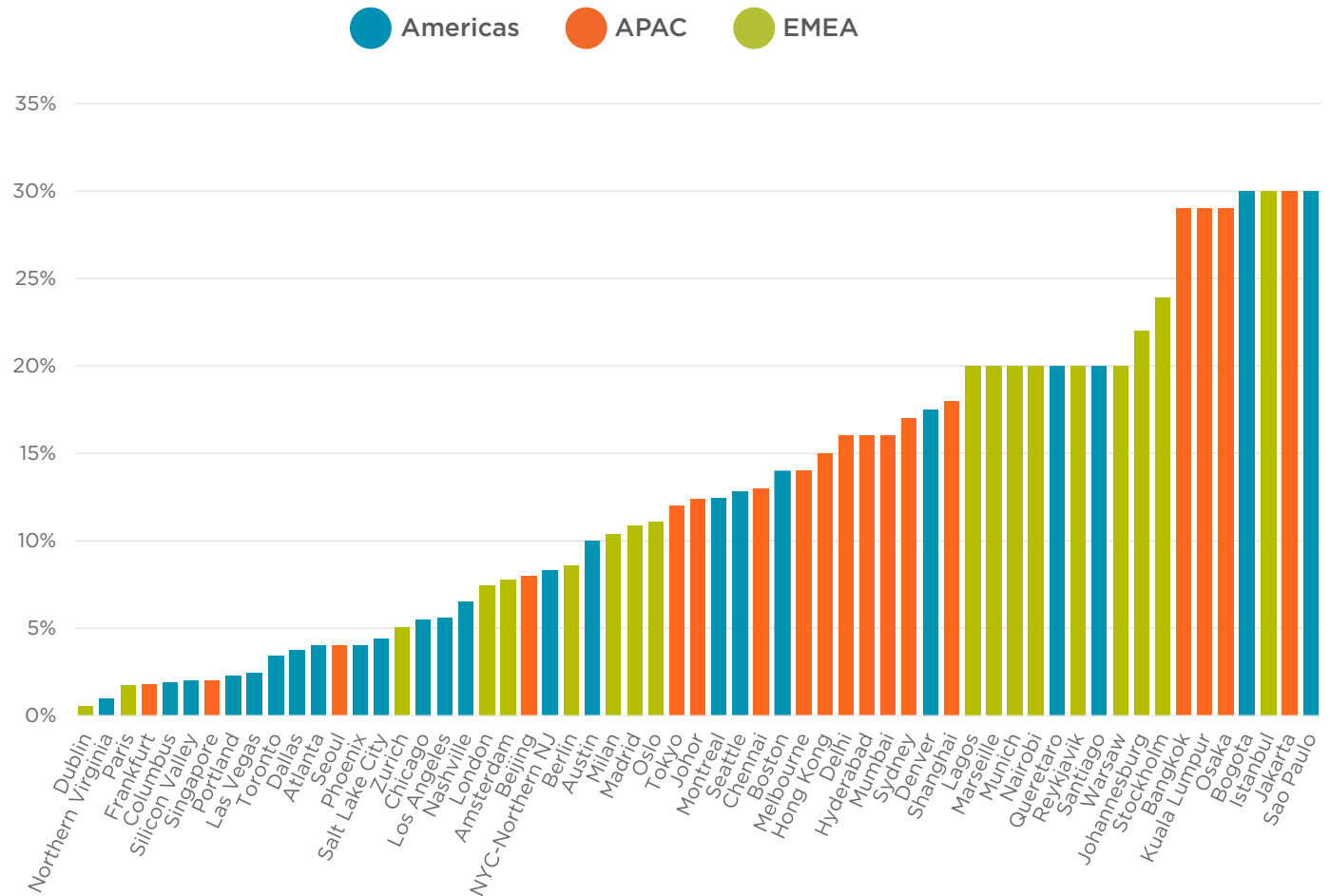
There are 24 markets that are now under 10-percent vacancy—33% more markets than the prior version of this report.



Top Markets

- Dublin
- Northern Virginia
- Paris
- Frankfurt
- Columbus
- Silicon Valley
- Singapore
- Portland
- Las Vegas
- Toronto

Vacancy



Source: Cushman & Wakefield Research, datacenterHawk

DEVELOPMENT PIPELINE

The continued growth in data center needs globally has led to an ever-growing development pipeline, as formerly secondary and tertiary markets rapidly scale. In the first edition of this report, 1.6 GW were under construction across the 38 markets profiled; this swelled to 2.9 GW in 48 markets in 2021, and now an incredible 4.1 GW are currently under construction in the 55 markets in 2022. Now, in 2023 there are 7.1 GW under development across 63 markets. As new regions grow across Southeast Asia, the Middle East, Latin America and Africa, a new array of markets will beget smaller outposts, and the cycle will continue. Several countries around the world have already observed this development, with the strength of Frankfurt leading to development in Berlin and Munich in Germany, or an initial hub of Mumbai in India, leading to growth in Delhi, Chennai, Hyderabad and Bengaluru as examples.

Supply chain concerns, which had been present during the pandemic period, grew throughout the year. Certain projects experienced pauses in development as specific component sourcing faced challenges in the current economic climate. In other instances, developers began stockpiling certain components in expectation of further challenges. Disruption will likely continue to be a nuisance over the next several years, as further supply chains are constructed, and vendors adjust manufacturing accordingly.

AMERICAS: Northern Virginia regained its top ranking in terms of MW under construction, even while facing paused construction in Loudoun County. Chicago and Phoenix both rose in rankings as hyperscale interest in both markets continued to grow at a steady pace, ballooning their sites under active development to over 300 MW, an expansion of over 100 MW from the previous year. Silicon Valley, Portland and Atlanta all saw their total MW under construction continue to grow.

APAC: Mumbai and Beijing both rose to top spots in this year's ranking, albeit this is in part due to more accurate data tracking of projects as well as organic expansion of the market. Ultimately, both markets have seen significant activity as hyperscaler tenants look to expand coverage for the massive populations of India and China. New entrants Johor and Hyderabad ranked at 15th and 28th on the overall index, respectively.

EMEA: London's pipeline, which had been the largest in last year's ranking, contracted slightly but remained squarely in the top 10 with over 300 MW under construction. Dublin also retained a ranking at eighth, despite regulatory and power availability challenges, totaling just under 300 MW under construction.

Top Markets

Northern Virginia

Mumbai

Chicago

Phoenix

Beijing

London

Silicon Valley

Dublin

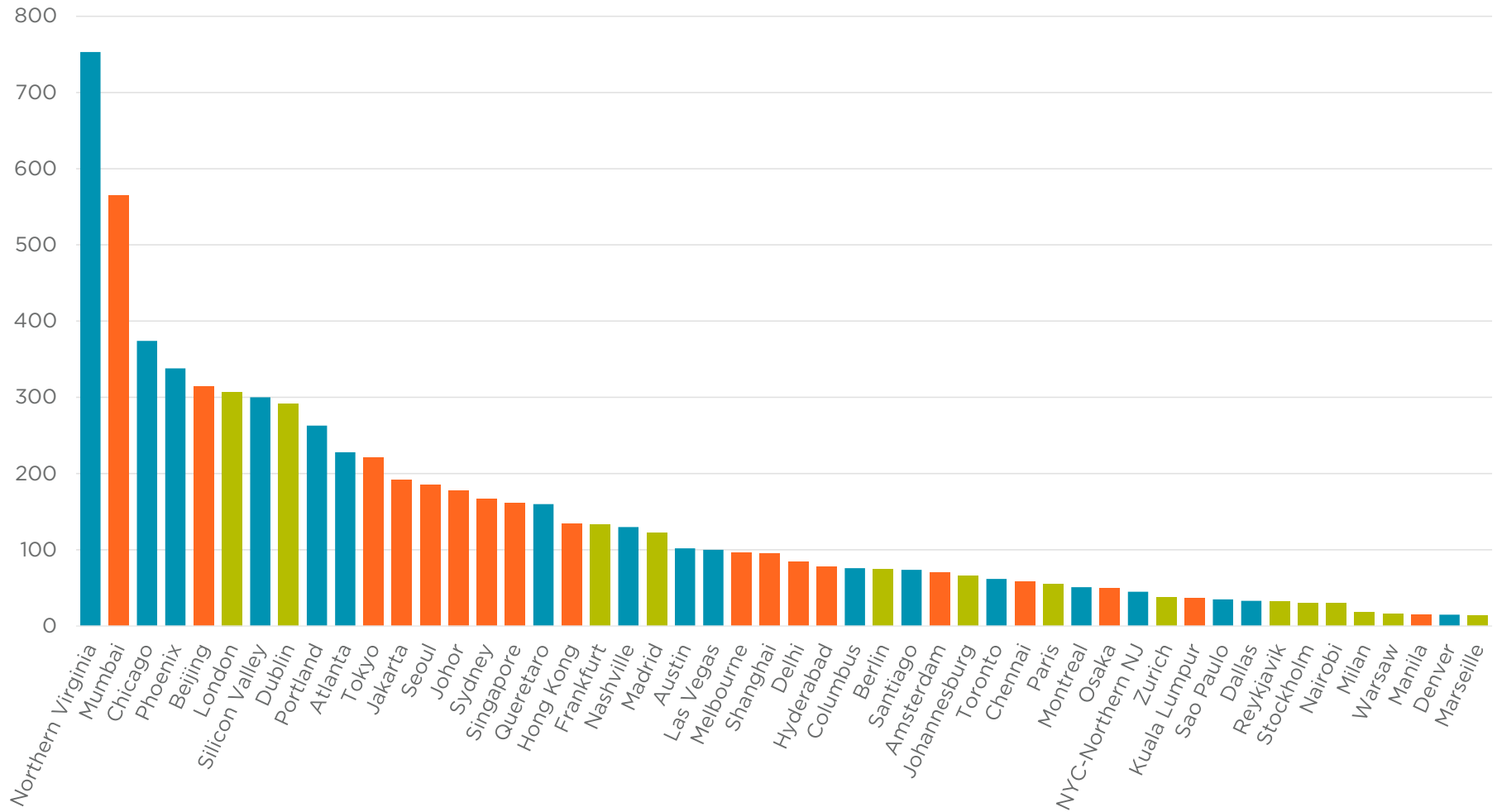
Portland

Atlanta



Under Development (MW)

Americas APAC EMEA



Source: Cushman & Wakefield Research



Recent news regarding the lack of progress on carbon emission reduction has continued to focus minds on the rapidly increasing need to derive efficiencies from all industries globally, with data centers an increasing focus. While many industries will have considerable difficulty reducing their carbon footprint, as a high-tech and multilayered asset class data centers have many opportunities to do so, including immersion cooling, artificial intelligence to better manage data center workloads, sourcing renewable materials for use in construction, and much more. Not only are all these methods excellent for the environment, they also lower operating costs over the life of the asset, which in the largest data centers can be well past nine figures. Increasingly creative methods are being discovered to better utilize all parts of a data center, expanding to the reuse of waste heat to warm nearby homes.

As noted in the previous version of this report, the largest hyperscale tenants have all committed to reducing their carbon footprint in all facets of operations, with data centers

a primary concern as the largest source of these emissions. With 2030 net-zero goals on the very near horizon, many hyperscale self builds and larger-scale developments are being paired with new renewable energy infrastructure development. In multiple instances, wind and solar farm sites have been developed alongside 100MW+ deployments. The ability to build out energy infrastructure such as these is becoming more a point of evaluation for the largest facilities.

For cities that have committed to fully renewable power, including Montreal, Sydney, Oslo and Reykjavik, this means abundant hydropower and utilities that are able to tap this energy accordingly. With the abundant hydropower in the Pacific Northwest, Vancouver and Seattle follow closely behind. New entrant Bogota also enters the top 10, as another major city that primarily utilizes hydropower—a critical differentiator for operators seeking to expand in Latin America. Filling out the list is Austin, with a diverse array of power sources, including wind and solar.

Increasingly creative methods are being discovered to better utilize all parts of a data center, expanding to the reuse of waste heat to warm nearby homes.

Top Markets

Montreal

Sydney

Oslo

Reykjavik

Vancouver

Seattle

Bogota*

Nairobi

Stockholm

Austin*

* New market in 2023 report



Data centers rely on fiber networks, electricity grids, backup supplies, interconnections, and software in a dense ecosystem that is managed on behalf of clients. In a similar fashion, the leading cities of the world utilize technology to manage their own population dynamics, understanding employment opportunities, traffic patterns, health outcomes, crime, and much else. Successful cities in which residents can grow, feel safe and well, and find meaningful work generate positive ecosystems of their own, attracting talent from across the world and creating sustainable communities.

For this year's proxy for smart cities, the widely quoted Smart City Index 2021, created by the Institute for Management Development in Switzerland and Singapore University of Technology and Design, is cited, to incorporate the impact that a well-managed city has on a local data center market. The report reviews resident perspectives on health, safety, mobility, activities, employment, educational opportunities and governance, and it combines this information with the United Nations Human Development Index.

As expected, the top three markets considered smart cities—Singapore, Zurich, and Oslo—all have sizable data center markets. Primary data center markets, such as New York/Northern New Jersey, Amsterdam, Sydney, London, Northern Virginia, and Toronto also finished among the top 40 locations. Several mid-sized data center markets appear throughout the top rankings, suggesting that as these factors continue to play into data center ecosystems, local market strength in other categories may contribute to the growth of these areas.

Successful cities in which residents can grow, feel safe and well, and find meaningful work generate positive ecosystems of their own.

Top Markets

Singapore

Zurich

Oslo

New York/Northern
New Jersey

Seoul

Munich

Amsterdam

Sydney

Melbourne

London



LOW-WEIGHT CRITERIA



/ Power Cost

/ Land Price

/ Environmental
Risk



POWER COST

Analysis of data center costs often focus on initial capital expenditure with the costs of planning, permitting, acquiring land, building construction and potentially substations and fiber extensions resulting in an considerable barrier to entry of circa \$x-y m per mw. These initial costs end up as a small fraction of the overall operating expenditure over the life of the building, as the consistent need for increasing power over several phases of expansion can lead to spiraling power needs.

As noted in other sections of this report, new technology (or the better use of current technology) from artificial intelligence to predict workload needs and more sophisticated forms of cooling can assist with saving power costs, particularly for the increasingly dense workloads favored by the heaviest users. Those fortunate enough to operate in certain climates are also able to utilize free cooling in the evenings, with many of these cooler areas also using lower-cost hydropower. The benefit of renewable hydropower cannot be understated; not only does this assist in lowering the total carbon footprint of a data center, it also is available at far lower cost than other methods with a concurrently lower cost of total operating expenditure.

Power costs have substantially increased over the past year, with our set of global markets experiencing a median 16% growth in electricity costs for industrial or commercial purposes. These rate increases have not been even across markets, with some markets experiencing little to no change from last year to others that have seen YoY price growth exceed 40 to 50%. The current top ten are a mix of low-cost hydropower markets (Montreal, Portland, Reykjavik) and larger markets with diverse and plentiful power generation from both renewable and traditional sources.

Power costs have substantially increased over the past year, with our set of global markets experiencing a median 16% growth in electricity costs.

Top Markets

Montreal

Dallas

Austin*

Salt Lake City

Reykjavik

Chennai

Northern Virginia

Portland

Nashville

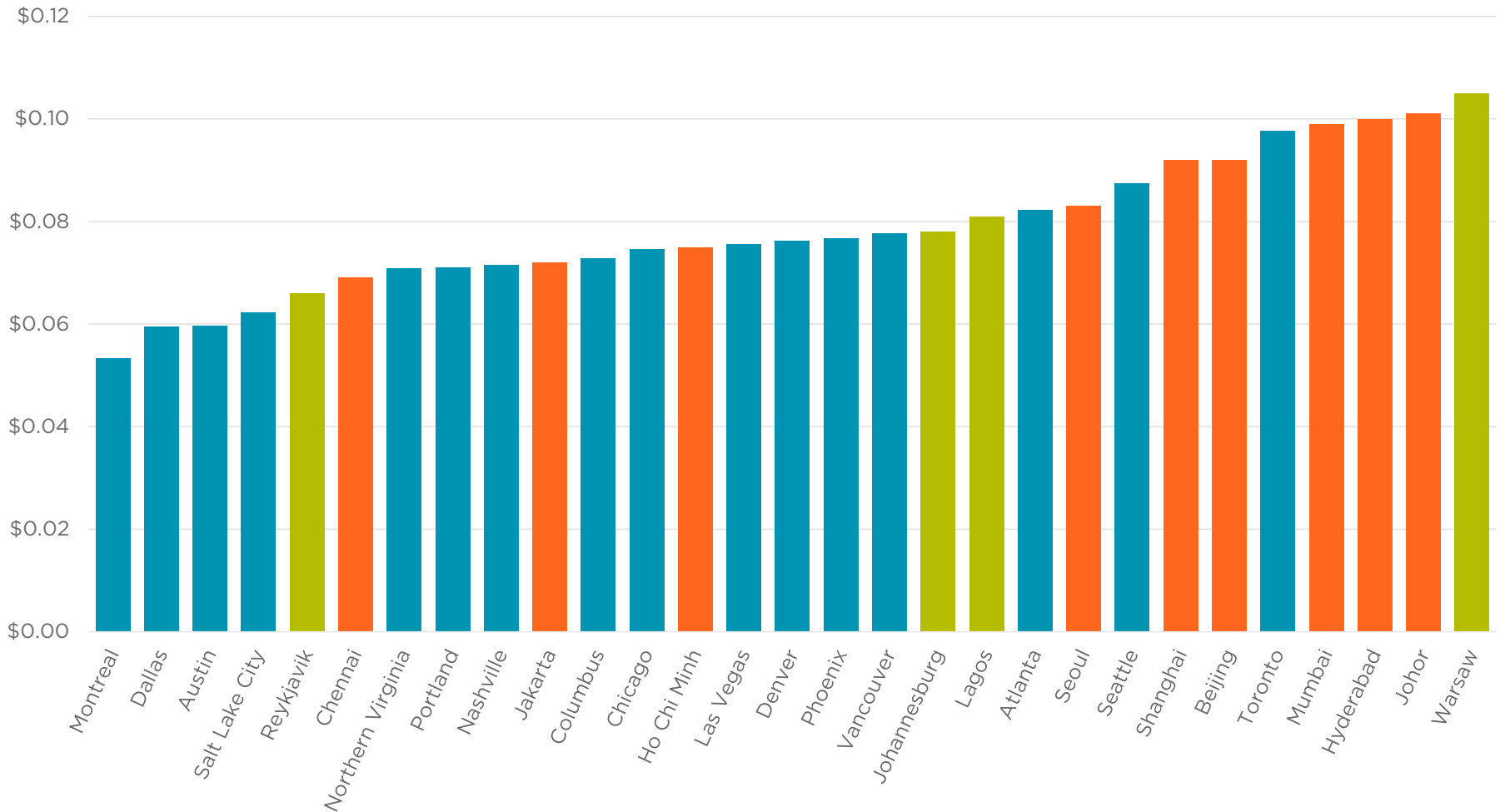
Jakarta

* New market in 2023 report



Power Cost (\$/kWh/month)

Americas APAC EMEA



Source: Cushman & Wakefield Research

LAND PRICE

While the cost of land ends up as a small fraction of the total cost of data center construction, higher initial land pricing can provide certain barriers of entry and are a concern in several key data center markets that have grown accustomed to the largest deployments. A quality data center site has several factors noted throughout this report; access to power (and a supportive utility to work with), limited exposure to natural disasters, access to networks, provision of water for cooling systems, and potentially incentive packages for locating in a particular area. The best markets have all of these and still maintain a low cost of land, a very tricky balance with sites in such demand.

Competition for sites between both data center players and other asset classes has reached a fever pitch over the course of the past year. Fulfillment centers and large-scale single family rental developments have been evaluating similar sites to data centers. One notable advantage that data centers have in competition for these sites is the limited impact on surrounding traffic and parking availability, a key area of concern for a number of local communities. However, data centers do require a higher power draw, and we have seen greater local community concerns about potential effects on electrical grids. The growth of edge data centers has continued, optimizing workload

for latency. This will have the effect of smaller data center developments closer to major urban areas, while hyperscale deployments are likely to move to further outlying areas with less competition for land and power.

AMERICAS: Many similar markets from the last edition of the report have maintained their spots as the most cost effective for purchasing land. Secondary and emerging markets like Columbus and Santiago top the list. Larger markets from the Sun Belt, such as Atlanta, Phoenix, Denver and Austin, also find their spots here—with access to plentiful open land. One should note that competition for sites in Sun Belt markets from other asset classes is increasing, as developers of all stripes look to tap into the demand of the fastest growing markets in the United States.

APAC: With many of the largest markets in the region boasting particularly high land costs, only Ho Chi Minh ranks within the top 10 for this category. However, high land costs have not dissuaded continued interest in the region's top markets.

EMEA: Johannesburg remains a highly affordable market. Similar to APAC, a number of the top EMEA markets continue to have limited availability for land, keeping land prices high as they have been in previous editions of this report.

Top Markets

Columbus

Santiago

Johannesburg

Atlanta

Nashville

Phoenix

Austin*

Denver

Ho Chi Minh

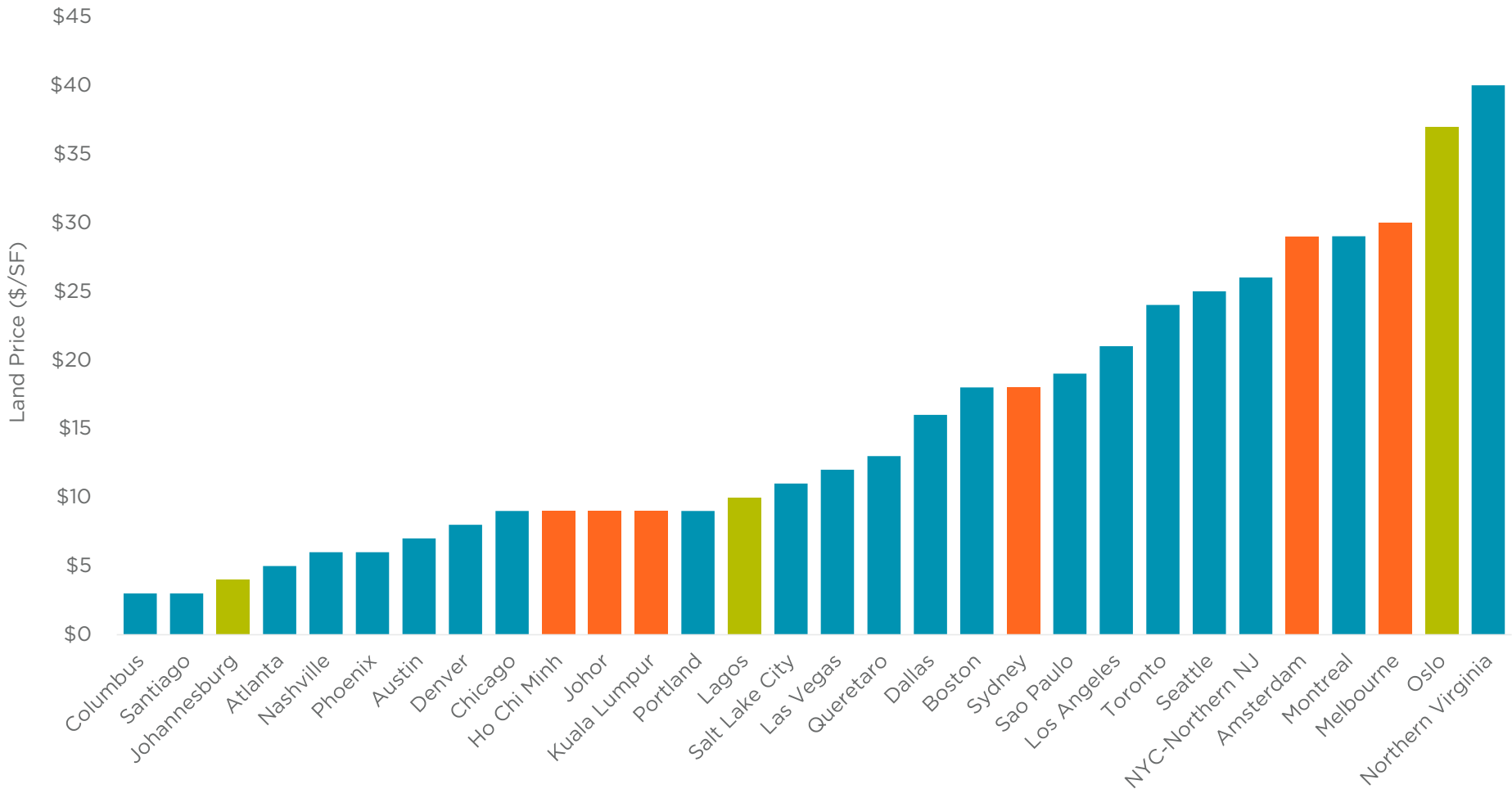
Chicago

* New market in 2023 report



Land Price Per Square Foot

Americas APAC EMEA



Source: Cushman & Wakefield Research

ENVIRONMENTAL RISK

While sustainability comes in many forms, the need to locate data centers in areas which are safe from natural and other disasters is crucial to maintain uptime, particularly if other sectors of the economy are disrupted. The location of gas mains must be scrutinized, flight paths near airports must be reviewed, and a full analysis of the possibilities of failure must be accounted for via engineering and other studies before a site can be selected and construction can begin. As most large metropolitan areas have some or all these preexisting risks, data center builds in densely populated areas come with additional layers of concern beyond those in more rural locations.

Flood maps were reviewed for each facility to determine if the building sits in a 100-year floodplain (a 1% or greater chance of severe flooding each year) or in a 500-year floodplain (a 0.2% chance of severe flooding).

With sea levels rising in coming years due to global warming, many coastal cities may experience heavier flooding. Data centers located in these areas may come under greater peril. Certain cities have succeeded in locating data centers entirely outside of floodplains, including Dublin, Singapore, Mumbai, Denver, Columbus, Vancouver, Madrid, Johannesburg, Queretaro, Oslo, Osaka, Marseille, Lagos, Bangalore, Kuala Lumpur, and Nairobi. As this list shows, data centers can be constructed in coastal cities and still be located away from floodwaters with careful planning.

Earthquake risk is a danger to all buildings, with data centers constructed in areas prone to seismic activity requiring additional support structure. Many organizations that choose to have their main data center in a seismically active area ensure that a full disaster recovery facility exists for backup purposes in a

secondary market, as major earthquakes can prove catastrophic for equipment and business operations alike. Cities studied with the lowest earthquake risk include several primary and secondary markets across Europe (Dublin, Amsterdam, Paris, Madrid, Warsaw, Oslo, Berlin, Stockholm), along with Dallas, Hong Kong, Seoul, and Lagos.

Tornadoes and hurricanes can bring equally catastrophic damage to an area, tearing through buildings and downing power lines and entire electrical grids. As with data centers located in earthquake zones, many organizations choose to have a disaster recovery location outside the area, as obtaining power after such an event can prove problematic. Most locations across Europe and the western United States are free of this risk, as are Vancouver, Singapore, and newly reviewed markets Nairobi and Santiago.

The need to locate data centers in areas that are safe from natural and other disasters is crucial to maintain uptime, particularly if other sectors of the economy are disrupted.



LOW-WEIGHT

Top Markets

Dublin

Madrid

Oslo

Stockholm

Berlin

Warsaw

Paris

Lagos

Nairobi

Singapore

Vancouver



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