OXFORD JOURNAL
OF STUDENT
SCHOLARSHIP

Built to capacity: Power Constraints and the U.S. Data Center Supply Response, 2021-2025

Oliver Golub
Olivergolub@gmail.com

ABSTRACT

This study focuses on the study period 2021-2025, when developers significantly expanded data center capacity across primary U.S. markets. However, the market became more, not less, scarce. Using ten consecutive editions of CBRE's *North America Data Center Trends* series against JLL and Cushman & Wakefield market series, this study follows the U.S. data center market through a period of persisting shortages and expanding development, finding patterns between data center capacity and demand using academic research on the responsiveness of real estate supply and delays in commercial property development.

Between FY2021 and FY2025, a huge amount of new data center capacity was built, but prices kept rising, suggesting that new supply wasn't sufficient to relieve the shortage. Furthermore, almost all available data center space was occupied by large tenants even before projects were completed, limiting newly constructed capacity. Thus, supply couldn't increase extremely quickly even when prices and demand rose.

When comparing different CBRE reports, this study finds five cases where the numbers don't perfectly match, identifying that when CBRE has revised an older number, the revised number was higher than the original one. It is important to take into account that some growth rates may have changed not only because the market actually changed, but also because CBRE later altered the starting number in the growth rate calculation. Instead of calculating a causal supply elasticity, this study aims to describe patterns and compare data across time and sources, identifying that growing inventory, rising rents, low vacancy rates, and strong pre-leasing consistently move together. Ultimately, this study aims to model how the U.S. data center shortage from 2021-2025 wasn't a story of developers refusing to build; rather, it was about developers building rapidly while the infrastructure required to make those buildings "usable" lagged.

INTRODUCTION

Between 2021 and 2025, the U.S. data center industry seemed to find a solution to the shortage. Developers built immense amounts of new capacity. Across the primary U.S. markets studied by CBRE between FY2021 and FY2025, data center capacity increased from about 3,358MW to 9,432 MW, approximately three times as much capacity, a rise of 181 percent [1], [2]. However, despite this enormous increase in supply, vacancy fell to a record low of 1.4 percent at year-end 2025 [1], [2],

meaning almost all of such supply was either in use or occupied. At the same time, the rent for a typical 250-500Kw customer increased by approximately 63% from $120.00 to $196.25 per kW per month. This creates the central mystery of the paper: how could an industry nearly triple its built capacity while also becoming more expensive and less available? In a normal real estate market, the increase in supply should have lowered vacancy rates, lowering pressure on rents. But that story didn't play out in the data center market. Even as developers added large amounts of new capacity, companies reserved a significant portion as quickly as it was available, which kept space scarce and increased rents.

The data center market shows that the product being supplied is not only physical space. A warehouse without a tenant can still function as a warehouse. An office building that isn't at full occupancy is still usable office space. A data center, however, cannot provide its intended use because the space exists, as servers require electricity. Thus, the primary hypothesis is that even when demand massively increases, and customers are willing to pay more, producers can't efficiently create more supply because a data center is only truly usable if it has enough electricity, utility infrastructure, and equipment needed to deliver that electricity. In addition, since data center rent is based on kilowatts, electricity is the main factor that limits how many servers and computers a tenant can run, meaning that just having a big building doesn't mean the tenant can actually use all of it for computing.

This paper expands on previous research highlighting that real estate supply doesn't always respond quickly to rising demand or prices. Saiz argues that how much real estate is built depends both on physical and regulatory constraints [3]. Glaeser and Gyuorko similarly indicate that constraining land-use rules can make it difficult to build more property, even when high prices give developers a strong incentive to build [4]. Millar, Oliner, and Sichel document that commercial real estate projects can take a long period of time before construction even begins because of planning, postponements, and approval delays [5]. These studies reveal that a strong incentive to build doesn't always mean new supply. Data centers are even more complicated because even before a facility is fully usable, developers require utility interconnection and specialized electrical equipment. However, none of these studies directly measure how quickly data center supply itself can respond to demand.

Research on energy use highlights that data centers were already approaching electricity-related limits before the recent AI boom. Lawrence Berkeley National Laboratory estimated that U.S. data centers already used a large amount of electricity, about 70 billion kilowatt-hours, or 1.8% of all electricity used in the country [6]. A later study found that from 2010 to 2018, data center electricity use remained near 70 billion kilowatt-hours. Interestingly, even though centers were doing much more computing, total electricity use stayed the same due to efficiency and lower power usage effectiveness[7]. By the time AI demand exploded, data centers had already made many of the easiest efficiency improvements. However, by the time AI demand accelerated, much of that efficiency decreased. The challenge was therefore shifting: instead of simply increasing efficiency in facilities, developers had to create new, fully powered capacity to match demand.

Once the shortage is viewed as more than just a construction problem, the study's relevance becomes clear. Investors need to know whether data center rents are caused by a temporary period of high demand

or by a long-term shortage. Developers encounter something different: can they secure enough electricity from utilities to make a usable project? Local Governments weigh the economic benefits of data center construction against the possible downsides for the community, like noise and land use. On the other hand, grid operators aim to connect larger and larger data centers without making the power system less reliable. These groups all view data center supply shortage from a different angle. Identifying which issue is slowing development will help connect the problems in the real estate market to those on the electric grid and in local policy.

II. Data and Methods

CBRE Research's North America Data Center Trends series from H2 2021 through H2 2025 [1], [2], [8]-[14] represents the primary data for this study. CBRE is chosen as the main source because the consistent reports of data, year by year, allow comparison between multiple categories like vacancy, built inventory, and net absorption. The study then cross-checks CBRE's data with Cushman & Wakefield's, determining whether the general trends match between both sources, despite the fact that each source measures the market differently. For example, in 2021, JLL looked at 14 U.S. markets and used inventory broader than CBRE, including future capacity, while CBRE instead focused on seven major markets and only counted data centers that were already completed [16]. This study tests whether both sources point in the same direction. If rapid construction was actually alleviating the shortage, the market should've responded with a large amount of completed space, rent growth should have slowed, and less future capacity should've been occupied in advance. Vacancy reveals how much completed data center is still available, while pre-leasing highlights how much of the capacity still being built has already been occupied by future tenants.

Table 1 summarizes the study's main sources, the periods and markets covered, and the role each source plays in the analysis. Since different firms define markets and report different variables, the table helps to clarify how each study uses each source and where cross-checking is useful.

Table 1. Source inventory and analytical role

Source	Reports used	Period covered	Markets tracked	Primary use
CBRE Research	*North America Data Center Trends* H2 2021–H2 2025; *Global Data Center Trends 2026*	2021–2026	Seven primary markets in H1 2022; eight by H2 2025	Inventory, vacancy, construction, absorption, rent, pre-leasing, stated constraints
JLL	2021 year-end outlook; 2023 and 2024 releases; 2025 year-end; 2026 global and midyear outlooks	2021–2026	Varies by publication; 14 domestic markets in 2021 absorption series	Absorption, vacancy, construction commitments, power and equipment timing, pricing cross-checks
Cushman & Wakefield	2025 press release; 2026 *Global Data Center Market Comparison*	2025–2026	Global and North American market comparisons	Powered land, competition for sites, community opposition, bubble discussion
Shehabi et al.	2016 LBNL report; 2018 *Environmental Research Letters* article	2014–2018	United States	Electricity use, efficiency, PUE and workload context

Real estate research firms also tracked how the main problems slowing development changed year to year. By the end of 2021, JLL was already warning that access to electricity was starting to limit data center growth [15]. In the first half of 2022, CBRE said developers were not adding new data center capacity fast enough to match demand, and in Santa Clara, there was almost no additional electricity left for new projects [8]. By the second half of 2022, CBRE reported that new data centers in Northern Virginia could have trouble getting enough power until 2026, while some California projects might have to wait until 2028 or 2029 for substations to become operational [9]. By the first half of 2023, CBRE reported that shortages of electricity and long waits for generators could delay data center projects by two to four years [10]. JLL later reported that some transformers were taking more than three years to obtain [16].

The paper also tracks when CBRE changed or corrected numbers in later reports, because those changes serve as an issue for determining changes in the market. Comparing editions reveals five internal inconsistencies in the CBRE Research Series. The 2023 report gives a growth rate that only works if CBRE was using a 2022 inventory number higher than the number it originally published for 2022. The

growth percentages reported in the first half of 2023 don't lead to exactly the same inventory total depending on which growth rate you use. CBRE first said that 3,077.8 MW was under construction, but a later report changed that number to 3,245.2 MW. CBRE's 2023 construction number and its claim that construction grew 46% don't mathematically match the 2022 construction number CBRE originally published. The 2025 report gives two different rent numbers for what appears to be the exact same measure. One part says $195.84 kW per month, while another says $196.25. The paper chooses $196.25 because that number appears in the section specifically focused on national pricing, but it still notes that the report also gives the other number. These revisions are significant because part of the apparent change from year to year may not only be a result of the market, but also from CBRE changing the historical number, or in other words, the starting point.

Reconciling these revisions is an integral part of the study because the priority is not to treat every number as exact, but to identify consistent patterns. Even when individual figures change, the overall story can be followed when variables move together in the same direction. For that reason, the study shows that variables move together in a direction, but doesn't use advanced statistical methods or claim that one variable definitely causes the other.

III. RESULTS

Built inventory rose approximately 181 percent from FY2021 to FY2025, while asking rent also increased by approximately 63 percent over the same period [1], [2]. Likewise, every time the reports gave a rent number, the next reported rent was higher than the previous one, leaving no period where rents fell. Vacancy rates tell a more complicated story. rom H1 2022 to FY2022, national vacancy fell from 3.8 percent to 3.2 percent. Then during 2023, vacancy rose from 3.2 percent in H1 2023 to 4.7 percent in FY2023 [8]-[11]. This period of a less tight market shows that new supply could catch up to demand, but vacancy then fell to 2.8 percent in H1 2024, 1.9 percent in FY2024, 1.6 percent in H1 2025, and 1.4 percent in FY2025 [12]-[15], proving that the gain was only temporary. Thus, despite temporary relief, developers couldn't bring new supply online quickly enough to keep pace with demand, as evidenced by the overall decline in vacancy rates.

Table 2 presents the CBRE market indicators that are used to determine whether new construction kept pace with demand. The table includes inventory, inventory growth, vacancy, asking rent, and capacity under construction from 2021 through 2025, allowing changes in supply and constraints in the market to be compared over time.

Table 2. Primary U.S. Data Center Inventory, Vacancy, Asking Rent, and Construction, 2021–2025

Period	Built inventory (MW)	Inventory growth	Vacancy	Asking rent ($/kW/month)	Under construction (MW)
FY2021	3,358.1	+17% YoY	not stated	$120.00	727.6
H1 2022	3,711.0	+20% YoY	3.8%	$127.50	1,601.5
FY2022	3,928.7	+17% YoY	3.2%	$137.90	1,839.9
H1 2023	~4,420–4,449, derived	+19.2% YoY / +12% HoH	3.3%	$147.81	2,287.6
FY2023	5,174.1	+26% YoY	3.7%	$163.44	3,077.8; later restated to 3,245.2
H1 2024	~5,687, derived	+24% YoY	2.8%	$174.06	3,871.8
FY2024	6,922.6	+34% YoY	1.9%	$184.06	6,350
H1 2025	8,155	+43.4% YoY; +17.6% HoH	1.6%	Level not stated; +2.5% since H2 2024	5,242.5
FY2025	9,432	+36% YoY	1.4%	$196.25*	5,994.4

Note: CBRE Research's H2 2021 report does not state a national primary-market vacancy rate in its text.

Source: CBRE Research, *North America Data Center Trends*, H2 2021 through H2 2025. *CBRE Research's H2 2025 State of the Market section reports $195.94 and 6.5 percent growth for the same rent metric; National Pricing reports $196.25 and 6.6 percent.*

Additionally, much of the newly built capacity was reserved before it ever opened. CBRE Research reported 44.2 percent of capacity under construction was already pre-leased at FY2021, 73 percent in H1 2022, 73.1 percent in H1 2023, about 80 percent in H1 2024, and 74.3 percent in H1 2025 [1], [8], [10], [12], [14]. Large cloud and technology companies reserved data center space 2 to 3 years before the buildings were expected to be finished [10]. This meant that even as developers added more capacity, much of the future supply was already booked. Although the market was expanding, much of that growth was already committed, which left far less new capacity to incoming customers than it looked like.

CBRE had already mentioned power as a problem in several major data center markets by 2021. In Northern Virginia, the issue involved transmission lines and substations, whereas in Silicon Valley the

issue was delivering enough electricity to new sites [1]. These problems continued through 2022 and 2023, when utilities couldn't provide power quickly enough, new substations took time, electric generation was limited, and backup generators were difficult to get [8]-[10]. The market was already running into power constraints even before the rise of generative AI companies. The AI boom intensified the pressure, but it was already entering an industry that was struggling to expand electricity infrastructure fast enough.

By 2024 and 2025, the obstacle was more than simply finding enough electricity. Even when a developer had land and a power agreement in early 2024, a wait time of more than three years for transformers, which are necessary to actually deliver electricity at the site, was possible [17]. By 2025, Cushman & Wakefield reported that land with a confirmed way to obtain electricity was especially valuable. Data-center developers weren't only competing with each other, but they were also competing with EV and chip manufacturers for sites with secured power access [17]. By 2026, a problem of local political and community resistance became the primary concern. Communities were pushing back against new data centers, leading to stricter laws or temporary bans on new projects [18]. Likewise, JLL's 2026 outlook highlighted that developers chose sites based on how quickly they could obtain electricity. Only afterward was the question of whether the local community would support the project, followed by considerations like being close to customers or networks [19]. The pattern suggests that solving one constraint exposed the subsequent one. A developer could secure land, then wait for power; secure power, then wait for equipment; clear those hurdles, then still face community opposition.

Interestingly, by 2025, the construction boom began to lose momentum. Capacity under construction fell from 6,350.1 MW in FY2024 to 5,994.4 MW in FY2025, the first decline since 2020. At the same time, demand was moving in the opposite direction: customers absorbed a record 2,497.6 MW in FY2025, 38 percent above FY2024 [2]. CBRE's explanation described how developers weren't necessarily building less because they wanted to, and instead projects were slowed by gaining government permits, zoning approval, and securing enough electricity [2]. The contrast is important: as customers were taking space at a record pace, the construction of new capacity stopped expanding. This case fits the pattern of developers running into constraints as they attempted to keep up with demand, although one year of data alone isn't sufficient to rule out the possibility that the market was slowing more broadly.

IV. DISCUSSION

The early evidence suggests that developers did respond to rising demand by increasing supply, however, the market remained tight because generating usable data center capacity was an additional step to simply constructing the building. Developers faced problems of power availability, permitting, and infrastructure delays, which limited them from expanding capacity as quickly as demand needed. The temporary rise in vacancy in 2023 reveals that new construction did temporarily ease market tightness, but the extra capacity was still being quickly absorbed by demand. But that relief didn't last, as tenants absorbed the additional space. This suggests that the central problem was a mismatch in timing: demand could rise immediately, while capacity took years to bring online. The key question, therefore, was whether

developers could bring enough fully powered capacity in the market quickly enough to keep up with demand, even as construction persisted.

Traditional real-estate economics asks how feasible it is for developers to add more buildings when demand and prices rise. Saiz's model shows that real estate supply can be limited by both physical obstacles, such as limited land or geography and regulatory obstacles, such as zoning and permitting [3]. Data centers face those same obstacles, but also a different problem: the value of the building depends on the availability of several essential inputs. Land, power access, electrical equipment, and approvals all complement, rather than substitute, each other. A surplus of one cannot make up for the absence of another. As a result, data center supply is not just determined by how much developers want to build, but by whether the needed inputs to make a facility usable can work together. The industry doesn't act like ordinary real estate and acts more like a production process where a scarce required input can limit total output.

Investors and developers therefore have to think differently about what "supply" means in the data center market. For investors, both prices and availability are scarce: CBRE reports about 63 percent rent growth from FY2021 to FY2025 [1], [2], while JLL reports a similar 60 percent increase since 2020 despite using a different market database and focus [20]. The firms don't report the same numbers for everything, which makes the similarity in their pricing trends stand out more. Both firms suggest that the market consistently placed a higher value on access to capacity even with the additional inventory developers added. The most essential aspect is how much of the construction becomes powered, operational, and still available to tenants.

Loudoun County, Virginia, displays the difficult decisions governments have to make in the expansion of new data centers in one area. In 2023, more than 175 data centers in the county were generating approximately $600 million in taxes, serving as a strong source of government revenue. However, the downside was that more than 40 resident noise complaints occurred [21]. Even so, by 2026 almost half of thecounty's property-tax revenue was expected to come from data centers, representing heavy dependence on data centers [2]. This creates a dilemma for local governments: more development can generate greater tax revenue, but greater concentration also increases the risk of conflicts in the local community such as noise and land-use. As those costs become more apparent, residents may end up pushing for stricter rules on future projects. These rules adress community concerns, but they can also extend permitting and approval timelines. Rapid data center growth can create political opposition that makes supply slower to build.

The study has several limitations. CBRE, JLL, and similar firms generate revenue in the real-estate industry, meaning they aren't completely neutral academic sources. In addition, their raw databases are exclusively private, meaning outside, independent researchers cannot fully check how every number was created. Since different firms define markets differently, their numbers may also differ. CBRE sometimes changes older numbers after they were first published. More importantly, this study cannot isolate the effect of one single constraint. Power shortages, equipment delays, land availability, regulation, and rising demand usually occur at the same time, so the analysis cannot determine how much each factor

contributes to the shortage. For the same reason, the study doesn't estimate how strongly supply responds to changes in rents or apply findings from housing research to data centers because data centers face different costs and constraints.

One primary unanswered question is why data center capacity under construction declined in 2025. Future research should determine whether the decline happened due to worsening constraints or because the market for data centers itself started slowing. A stronger way to answer that question could be to compare individual markets over time rather than national averages. Researchers could track the same variables in Northern Virginia, Dallas, Phoenix, and other important markets, including power delays, electrictiy, rents, vacancy, and continued rent increases. If construction accelerates, vacancy rises, and rent growth slows, then 2025 could have marked the beginning of a less tight market. Following and comparing these markets separately would make it easier to determine which constraints matter the most and when they begin to soften.

V. CONCLUSION

The study argues that electricity is the main limitation, but not the only one. Even though a developer can have the money and incentive to build, this outcome doesn't immediately become data center supply due to delays in power, transformers, equipment, permits, along with government and community approval. The main problem from 2021 to 2025 was not that developers were unwilling to build, but that demand grew faster than projects, due to these constraints. As a result, even rapid construction wasn't enough to consistently relieve scarcity. Determining whether that shortage will continue will depend on how fast developers can turn planned projects into fully powered, operational capacity.

ABOUT THE AUTHOR

Oliver Golub is a high school senior at Riverdale Country School in New York City. He is fascinated with economics, real estate, and the infrastructure that truly determines how these markets grow and respond to demand. His research focuses on data center development, energy constraints, and real estate supply, and he hopes to continue studying economics and related fields in college.

REFERENCES

[1] CBRE Research, North America Data Center Trends H2 2021. CBRE, Mar. 2022. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h2-2021. Accessed: Sep. 7, 2026.

[2] CBRE Research, North America Data Center Trends H2 2025. CBRE, Feb. 25, 2026. [Online]. Available: www.cbre.com/insights/books/north-america-data-center-trends-h2-2025. Accessed: Sep. 7, 2026.

[3] A. Saiz, "The Geographic Determinants of Housing Supply," The Quarterly Journal of Economics, vol. 125, no. 3, pp. 1253-1296, 2010.

[4] E. Glaeser and J. Gyourko, "The Economic Implications of Housing Supply," Journal of Economic Perspectives, vol. 32, no. 1, pp. 3-30, 2018.

[5] J. N. Millar, S. D. Oliner, and D. E. Sichel, "Time-to-Plan Lags for Commercial Construction Projects," NBER Working Paper 19408, National Bureau of Economic Research, Sep. 2013.

[6] A. Shehabi et al., United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory, LBNL-1005775, 2016.

[7] A. Shehabi et al., "Data Center Growth in the United States: Decoupling the Demand for Services from Electricity Use," Environmental Research Letters, vol. 13, no. 12, Art. no. 124030, 2018.

[8] CBRE Research, North America Data Center Trends H1 2022. CBRE, Oct. 2022. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h1-2022. Accessed: Sep. 7, 2026.

[9] CBRE Research, North America Data Center Trends H2 2022. CBRE, Feb. 2023. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h2-2022. Accessed: Sep. 7, 2026.

[10] CBRE Research, North America Data Center Trends H1 2023. CBRE, Sep. 2023. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h1-2023. Accessed: Sep. 7, 2026.

[11] CBRE Research, North America Data Center Trends H2 2023. CBRE, Mar. 2024. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h2-2023. Accessed: Sep. 7, 2026.

[12] CBRE Research, North America Data Center Trends H1 2024. CBRE, Aug. 2024. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h1-2024. Accessed: Sep. 7, 2026.

[13] CBRE Research, North America Data Center Trends H2 2024. CBRE. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h2-2024. Accessed: Sep. 7, 2026.

[14] CBRE Research, North America Data Center Trends H1 2025. CBRE, Sep. 8, 2025. [Online]. Available: www.cbre.com/insights/reports/north-america-data-center-trends-h1-2025. Accessed: Sep. 7, 2026.

[15] JLL, 2021 Year-End Data Center Outlook: Insight into the Industry's Top Trends in the Second Half of 2021. JLL Global Research, Mar. 2022.

[16] JLL, "Growth of AI Creates Unprecedented Demand for Global Data Centers," JLL Newsroom, Jan. 30, 2024. [Online]. Available: www.jll.com/en-us/newsroom/growth-of-ai-creates-unprecedented-demand-for-global-data-centers.

[17] Cushman & Wakefield, "Surging Demand for Data Infrastructure Fuels Real Estate Transformation Across Global Data Center Markets," May 7, 2025. [Online]. Available: www.cushmanwakefield.com/en/news/2025/05/. Accessed: Sep. 7, 2026.

[18] Cushman & Wakefield, Global Data Center Market Comparison, 2026 ed., May 2026. [Online]. Available: www.cushmanwakefield.com/en/insights/global-data-center-market-comparison. Accessed: Sep. 7, 2026.

[19] JLL, 2026 Global Data Center Market Outlook. JLL, Jan. 5, 2026. [Online]. Available: www.jll.com/en-us/insights/market-outlook/data-center-outlook.

[20] JLL, "Data Center Sector Enters Hyperdrive as Texas Prepares to Dethrone Virginia as Global Leader," JLL Newsroom, Feb. 17, 2026.

[21] R. Chan, "Virginia's 'Data Center Alley' Residents Say an Eerie Hum Is Keeping Them Up at Night," Business Insider, Nov. 27, 2023.