

# Power, Land, and AI:

## THE NEW BATTLEGROUND OF THE DATA CENTER ECONOMY

Navigating Capacity, Sustainability, and Security in  
the Age of Exponential Compute Demand



ESCHER CAPITAL

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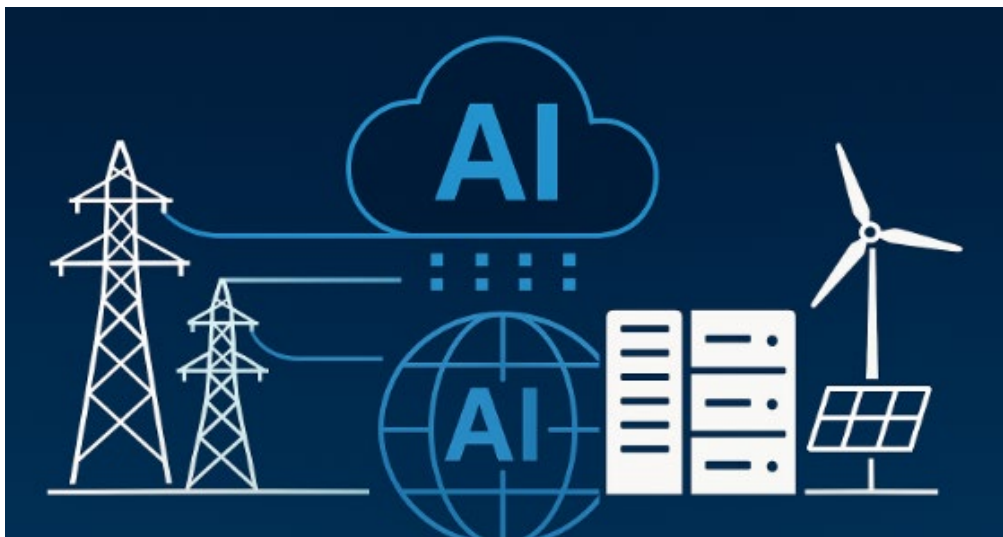
# Power, Land, and AI: The New Battlegrounds of the Data Center Economy

## Navigating Capacity, Sustainability, and Security in the Age of Exponential Compute Demand

The digital world runs on data centers, and demand for their compute power is exploding at an unprecedented rate, fueled by the insatiable appetite of Artificial Intelligence and cloud adoption. This exponential growth has ignited intense competition on new battlegrounds: securing adequate **Power**, acquiring suitable **Land**, and deploying infrastructure capable of handling advanced **AI** workloads. While the investment potential is immense, the sector faces a critical bottleneck that threatens to throttle this expansion: **reliable, scalable, and sustainable power**. Demand for data center capacity is consistently outstripping supply, with projected power consumption set to surge dramatically – potentially doubling or more by the end of the decade. Existing grids are strained, permitting processes are complex, and the push for sustainability adds another layer of urgency. This creates a fundamental tension: how can the industry possibly meet the exponential compute demand when the power infrastructure struggles to keep pace?

This white paper dissects these critical challenges and illuminates the path forward. We provide a comprehensive analysis of the market dynamics, quantifying the staggering growth and the widening power gap. We delve into the strategic imperatives of land acquisition, the evolving planning and design considerations for high-density facilities, and the non-negotiable elements of security. Crucially, we highlight how the urgent need for innovative energy solutions – from generation to storage and management – represents not just a challenge, but arguably the **single greatest investment opportunity** within the data center ecosystem today.

For investors seeking to capitalize on the foundational infrastructure of the digital age, understanding these battlegrounds is paramount. This report provides the essential intelligence to navigate the complexities of capacity, sustainability, and security, revealing where the most critical needs – and therefore, the most compelling investment theses, particularly in transformative energy technologies – lie.



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## 1. Executive Summary

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The data center market has become a critical battleground, defined by an exponential surge in compute demand fueled primarily by the proliferation of artificial intelligence (AI) and ubiquitous cloud computing. This unprecedented expansion is reshaping industries but straining the limits of existing infrastructure, creating intense competition for the essential resources of Power and Land required to support next-generation AI workloads. The sheer scale of growth underscores the pivotal role data centers play yet simultaneously exposes fundamental challenges.

This report provides a crucial analysis of these new battlegrounds, dissecting the current market state and offering insights for navigating the core challenges of **Capacity, Sustainability, and Security** in this age of exponential compute demand. We examine the market forces, critical considerations for land acquisition (where power availability is paramount), evolving planning and design imperatives driven by higher densities, essential security protocols, and the non-negotiable requirement for sustainable power solutions.

Our findings reveal a market defined by immense investment potential, precisely *because* it faces critical constraints, particularly around **power availability** and the imperative for **sustainable** solutions. Regulatory landscapes and **security** add further complexity. Understanding these dynamics – the forces driving demand and the constraints limiting supply – is essential for investors and operators seeking to capitalize on the opportunities inherent in powering the future digital economy.

## 2. Current State of the Data Center Market

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### Market Size, Growth Trends, and Key Drivers

The exponential growth trajectory of the data center market shows no signs of slowing, driven relentlessly by the escalating compute demands of artificial intelligence (AI) and cloud computing across all industries. This surge is already straining capacity; demand demonstrably exceeded available supply in 2024, a trend projected to accelerate.<sup>1</sup> Looking ahead through 2025 and beyond, the proliferation of generative AI is injecting new, intense demand for facilities capable of handling unprecedented power densities.<sup>1</sup> This is spurring semiconductor advancements but fundamentally challenges existing infrastructure models: current GPU racks demand 40kW to 140kW, with future chips expected to require a staggering 250kW per rack –

amplifying the critical **battleground for power**.<sup>1</sup> Cloud computing remains a dominant force shaping the data center landscape. The top three cloud service providers experienced a compound annual revenue growth of approximately 28% between 2015 and 2022, highlighting the sustained momentum of cloud adoption.<sup>3</sup> The global cloud data center market is projected to reach a substantial value of \$75.40 billion by 2034, demonstrating a robust Compound Annual Growth Rate (CAGR) of 9.90% from 2025.<sup>4</sup> This growth underscores the fundamental shift towards cloud-based solutions across various sectors.

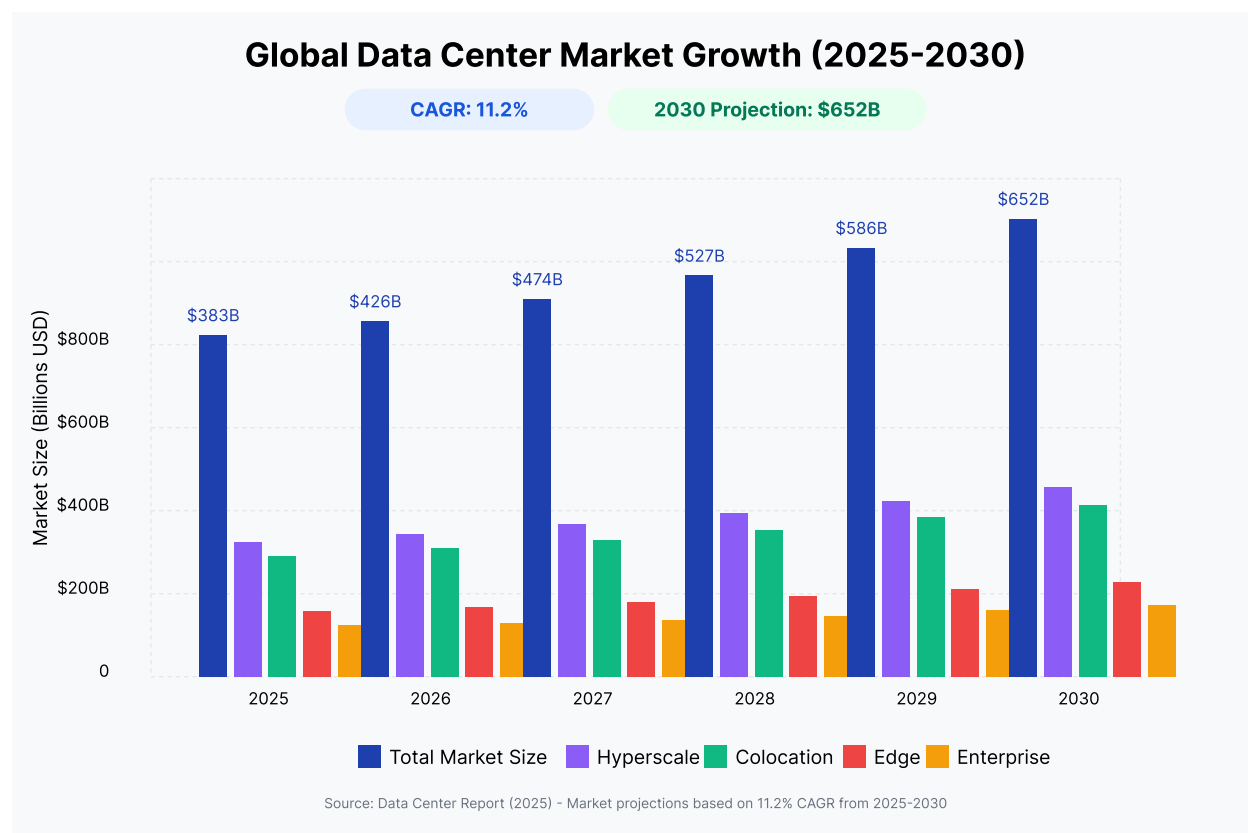
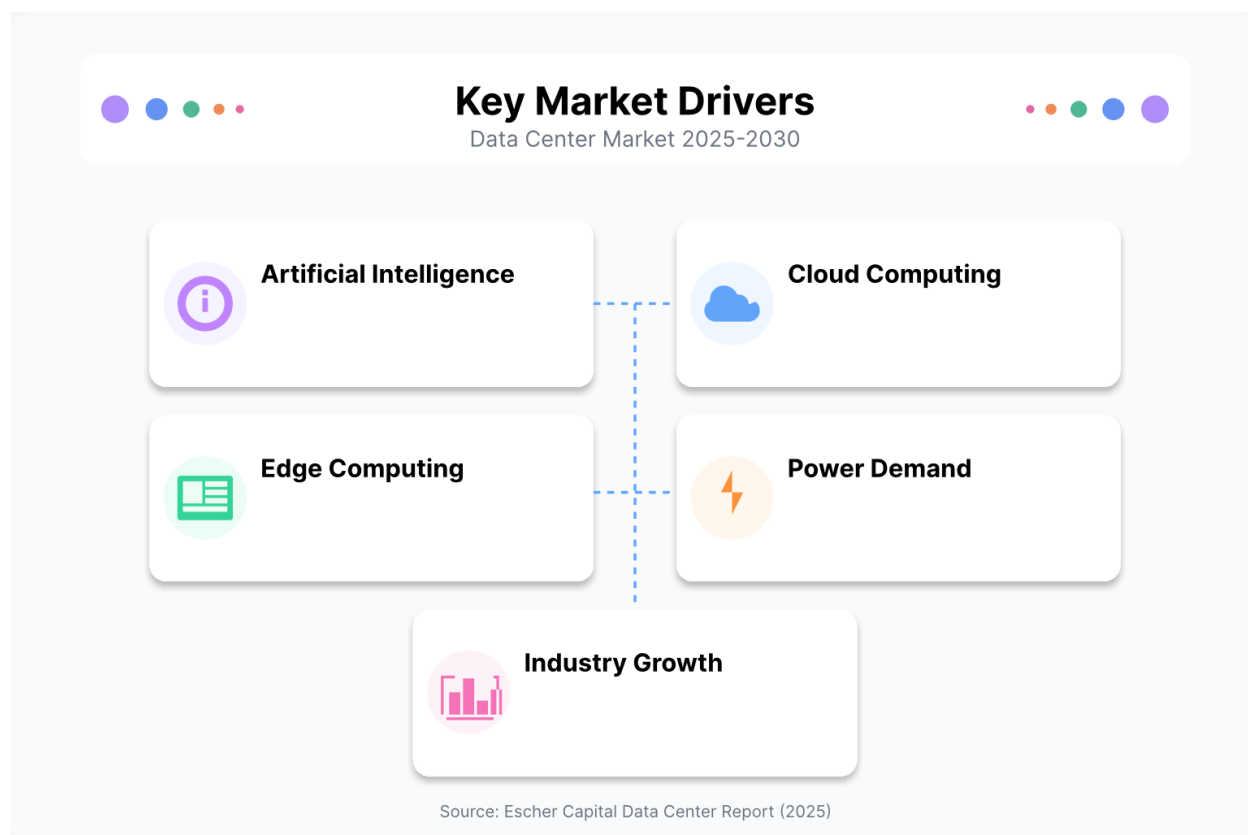


Figure 1 Global Market Growth by Category

Beyond AI and cloud, the broader digital transformation initiatives across all sectors are fueling an unprecedented demand for data center capacity.<sup>5</sup> The number of data centers is expected to increase significantly in response to this demand, with some operators anticipating a remarkable sixfold increase in construction over the next three years.<sup>5</sup> The estimated mean size of a new data center facility is around 32 Megawatts, indicating the scale of these developments.<sup>5</sup>

Investor confidence in the data center market remains strong and is expected to persist in 2025 and beyond. This positive outlook is driven by the continuous rise in

demand for data storage, a persistent low supply in certain markets, and the nascent but rapidly expanding popularity of AI. <sup>1</sup> JLL predicts that investment financing in the data center sector will reach new records in 2025, with a particular focus on demand geared towards single-tenant ground-up construction. <sup>1</sup> Globally, data center capacity is projected to grow at a rate of 15% per year; however, this growth may still fall short of meeting the ever-increasing demand. <sup>8</sup>



The escalating demand for data center capacity is also reflected in the projected increase in power consumption. Goldman Sachs Research forecasts a substantial 50% increase in global data center power demand by 2027, with this figure potentially reaching as high as 165% by the end of the decade compared to 2023 levels.<sup>9</sup> By 2027, AI is expected to represent a significant 27% of the overall data center power market.<sup>9</sup> The sheer volume of data being generated globally is also a key factor, with the world expected to produce 1.5 times the amount of digital data in 2024 compared to just two years prior, further amplifying the demand for data center capacity. <sup>3</sup> In the United States alone, data center power demand surged to 46,000 MW in the third quarter of 2024 and is projected to reach 59,000 MW by 2029. <sup>11</sup> Globally, the demand for data center power is expected to grow at an approximate CAGR of 16% from 2023 to 2028, reaching an estimated 130 GW by 2028. <sup>12</sup> The United States is anticipated to

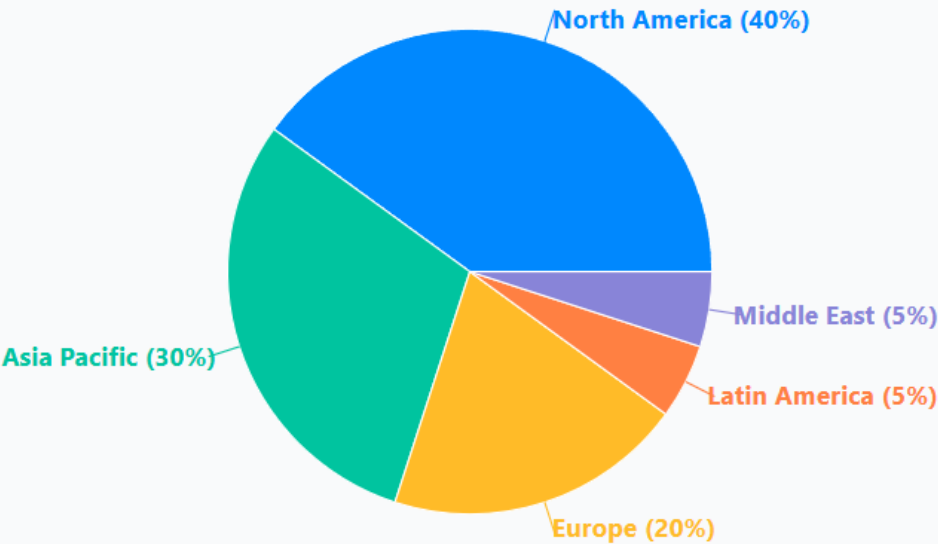
be the fastest -growing market for data centers, with demand increasing from 25 GW in 2024 to over 80 GW by 2030.<sup>13</sup>

The convergence of AI and cloud computing is establishing a sustained and potentially accelerating demand for data center infrastructure. The projected increase in power consumption clearly illustrates the magnitude of this growth. Furthermore, the robust investor appetite, coupled with forecasts of record financing, indicates strong confidence in the long -term viability and profitability of data center investments. This influx of capital is likely to fuel further development activity, although existing supply constraints may persist in the near term.



## Regional Data Center Market Share (2025)

Based on Data Center Market Analysis Report



### Key Data Center Markets

Region	Key Markets	Growth Projection
North America	Northern Virginia, Dallas, Phoenix	Stable
Asia Pacific	Beijing, Shanghai, Singapore, Tokyo, Sydney	High
Europe	London, Frankfurt	Moderate
Latin America	Various markets	High
Middle East	Various markets	High

### Key Insights

- **North America dominance:** Currently the largest revenue-generating market for data centers
- **Asia Pacific growth:** Anticipated to be one of the fastest-growing markets
- **Emerging markets:** Brazil, India, Southeast Asia, and the Middle East demonstrate strong growth potential
- **Market projection:** Global data center market expected to reach \$652.01 billion by 2030 (CAGR of 11.2% from 2025)



The balance between demand and supply in the data center market has been notably tight, with demand for computing capacity exceeding supply in 2024. This imbalance has resulted in low vacancy rates in leading North American markets, with an average of just 2.88% in the first quarter of 2023.<sup>1</sup> Power limitations in specific markets are a significant contributing factor to these supply constraints.<sup>1</sup> To address the increasing demand and navigate these limitations, developers are increasingly focusing on modular and prefabricated data center assets. These solutions enable faster deployment and reduced construction timelines, proving particularly beneficial for edge data center developments.<sup>1</sup>

Power supply challenges are expected to continue to impact new data center construction. This is leading to a trend of more distributed buildouts, with developers seeking locations closer to high-density end-user areas and regions where power is readily available.<sup>2</sup> The global data center market is witnessing a significant increase in capacity requirements driven by AI workloads, with a substantial 80% of respondents anticipating considerable increases in their capacity needs.<sup>5</sup> New data center developments, including facilities specifically designed for AI workloads, are scaling up to hundreds of megawatts, pushing the electricity demand for these new projects into the gigawatt range.<sup>15</sup>

The level of financial investment in AI-related data center development is unprecedented, with an estimated \$31.5 billion in annualized spending on new construction.<sup>6</sup> This investment has propelled the development pipeline to nearly 50 million square feet by the end of 2024.<sup>6</sup> However, projected power demands from all existing and planned data centers in the US are exceeding what utilities are currently set to supply by approximately 50%. This significant gap is compelling data center users and developers to explore alternative power solutions and to consider new geographic markets.<sup>6</sup> Emerging markets, including economically underserved regions like West Texas, are experiencing a surge in new data center projects as the industry seeks out available power resources.<sup>6</sup>

Traditional technology hubs are facing capacity constraints, prompting customers with less stringent latency requirements to explore alternative options in emerging technology centers or even international locations.<sup>16</sup> While the United States currently accounts for around 40% of the global data center market, substantial growth has been observed in Latin America, Europe, and the Asia-Pacific region.<sup>16</sup> Regional dynamics are also evolving due to factors such as data security and sovereignty regulations, increasing availability of low-cost power in certain regions, and the

expansion of AI applications that do not necessitate ultralow latency. These factors are influencing the geographic location strategies of data center developers.<sup>12</sup> While the US is expected to remain a leading market, significant growth is anticipated in other regions as well.<sup>12</sup>

The supply-demand imbalance in the data center market, particularly in key hubs, presents both challenges and opportunities. While limited capacity may translate to higher costs and extended lead times for clients, it also underscores the value proposition of providers capable of efficiently securing and delivering capacity. The emergence of new markets indicates a potential for geographic diversification and access to previously untapped resources. Furthermore, the increasing trend towards modular and prefabricated data centers reflects an industry-wide effort to achieve faster deployment and greater scalability, which are essential for keeping pace with the rapid advancements in AI and cloud technologies. Providers offering these flexible solutions may find a distinct advantage in this evolving landscape.

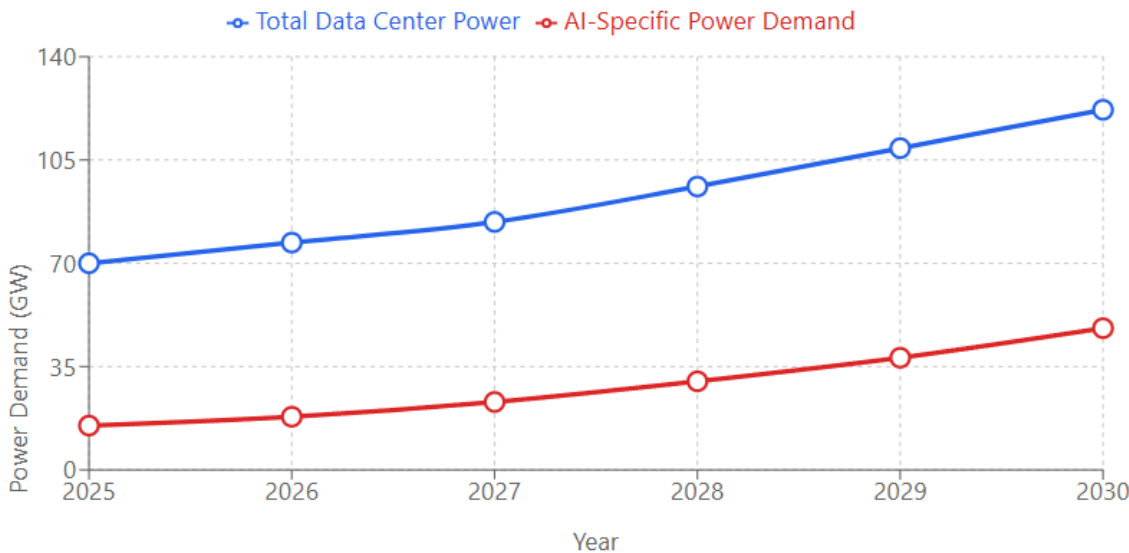
### **Investment Trends and Market Outlook for the Near Future (e.g., 2025 and beyond)**

Investor confidence in data center assets is projected to remain strong in 2025 and the years to come.<sup>1</sup> JLL forecasts a record year for data center investment financing in 2025.<sup>1</sup> Private equity firms are expected to continue playing a significant role in providing capital for data center growth, with major partnerships being established to fund investments in both data center facilities and power generation infrastructure.<sup>17</sup> While the pace of mergers and acquisitions (M&A) is likely to remain high in emerging markets, it may moderate somewhat in more established markets.<sup>17</sup>

The commercial real estate landscape in 2025 is witnessing digital infrastructure as a standout segment experiencing a boom, largely driven by investment in AI-related data center development. The level of spending on facilities supporting digital-age innovation over the past two years has been unprecedented, redirecting commercial real estate capital, physical structures, and powered land towards the data center sector, with an all-time high of \$31.5 billion in annualized spending.<sup>6</sup> An estimated \$170 billion in asset value will require development or permanent financing in 2025.<sup>8</sup> While investment transaction volumes are expected to see only a modest increase in 2025 due to discrepancies in pricing expectations between buyers and sellers and a limited availability of product, development finance is anticipated to present a compelling opportunity for investors seeking exposure to this sector.<sup>8</sup>

Global demand for computing power is surging, with leading data center players preparing for a massive capital deployment of \$1.8 trillion between 2024 and 2030 to

**Global Data Center Power Demand Projection (2025-2030)**



**Key Insights:**

- Global data center power demand is projected to increase from 70 GW in 2025 to 122 GW by 2030, representing a 74% growth over five years.
- AI-specific power demand is expected to grow at an even faster rate, from 15 GW in 2025 to 48 GW in 2030, a 220% increase.
- By 2030, AI workloads are projected to account for approximately 39% of total data center power consumption, up from 21% in 2025.
- This significant growth is driven by the proliferation of AI applications, cloud computing expansion, and increasing data processing needs across industries.

Source: Analysis based on data from Goldman Sachs Research, JLL, and industry projections cited in Data Center Market Report (2025).

meet this growing need. <sup>12</sup> In the United States, investments in data centers are projected to exceed \$1 trillion over the next five years, with an additional \$1 trillion expected to be invested internationally. <sup>18</sup> Data center leasing activity is also poised for continued growth as the demand for AI and cloud computing services expands. <sup>18</sup>

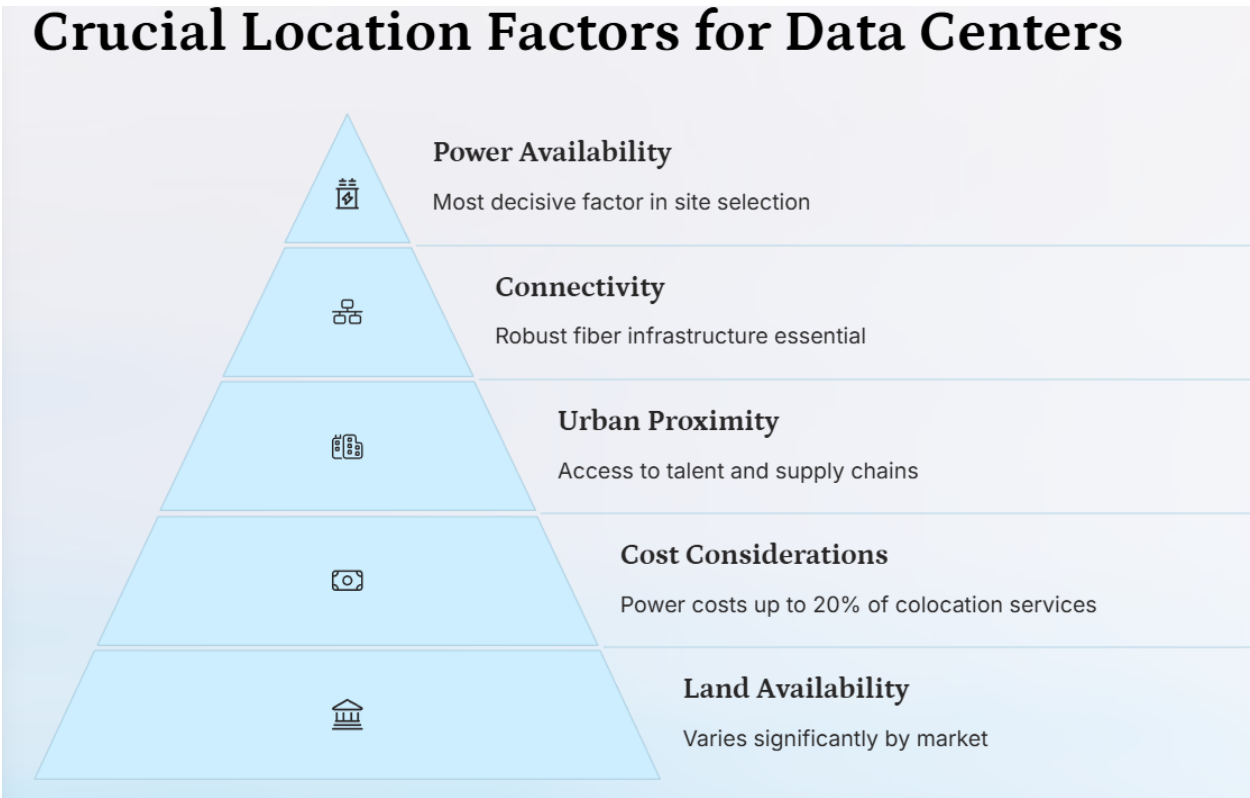
The significant influx of capital into the data center market, from both private equity and general investment sources, indicates a strong conviction in the sector's future

growth and profitability. This presents a favorable environment for providers of data center solutions. The anticipated focus on development financing as a key investment opportunity in 2025 suggests that new construction and expansion projects will be a major area of activity in the near future, aligning with the increasing demand driven by AI and cloud computing.

### 3. Data Center Land Acquisition Considerations

#### Crucial Location Factors

Reliable access to power, including the availability of renewable energy sources, stands as a critical and often decisive factor in the selection of land for data center development.<sup>19</sup> In fact, the availability of power has emerged as potentially the most significant challenge, sometimes even surpassing the difficulty of finding suitable physical space.<sup>14</sup> Proximity to robust connectivity and a strong fiber infrastructure is equally essential, supporting the high capacity, low latency, and reliable data transfer requirements of modern data centers.<sup>19</sup> Data center providers or hyperscale operators may also opt to install their own dedicated fiber networks to meet specific performance needs.<sup>19</sup>

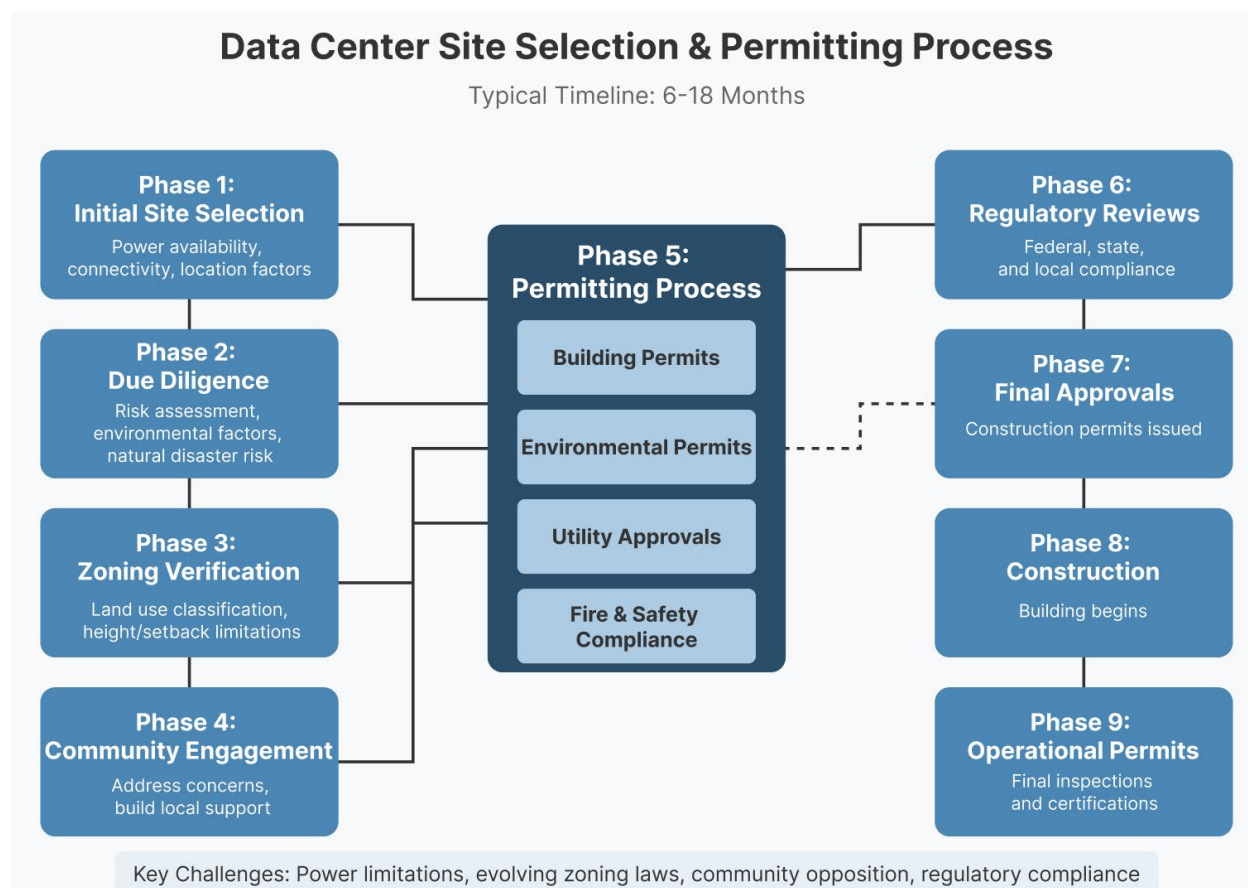


While some data center developers and hyperscalers prioritize factors like tax

incentives or power availability and bring their own workforce, proximity to urban hubs remains advantageous. Urban locations offer easier access to a skilled talent pool and reliable supply chains for necessary parts and equipment.<sup>19</sup> Furthermore, developing data centers in urban areas can reduce lag time and improve connection speeds for residents and businesses within those cities.<sup>25</sup> The cost of power is also a paramount consideration, often constituting up to 20% of the total cost of colocation services.<sup>20</sup> Some regions and power suppliers offer electricity at relatively low costs, making them particularly attractive for data center development.<sup>27</sup>

The availability and cost of land itself are also important. Markets like Dallas and Phoenix offer virtually unlimited land for development, while natural barriers such as bodies of water or heightened demand can make land acquisition more challenging in areas like Northern California or Northern Virginia.<sup>24</sup>

Power availability is a paramount consideration that is increasingly shaping decisions regarding data center site selection, sometimes even taking precedence over traditional factors such as cost and proximity to urban centers. This underscores the critical need for data center developers to secure reliable and sufficient power infrastructure early in the land acquisition process. Additionally, connectivity remains a vital factor, emphasizing the importance of proximity to fiber networks and internet hubs to ensure low latency and high-speed data transfer, which are crucial for many data center applications and tenants.



### Zoning Regulations, Permitting Processes, and Community Impact

Data centers are subject to a variety of regulations governing land use, environmental protection, and noise levels.<sup>23</sup> Navigating these regulations and ensuring compliance can be a complex process, particularly as zoning laws specific to data centers continue to evolve.<sup>23</sup> Zoning laws dictate where data centers can be constructed and impose restrictions on their operation. Local governments often regulate land use to strike a balance between economic growth, infrastructure demands, and community interests. Primary zoning challenges include land use restrictions, which can classify data centers as industrial, commercial, or special -use properties depending on the jurisdiction.<sup>28</sup> Developers must verify these zoning designations early in the planning process. Setback and height limitations imposed by local zoning codes can also impact the design and construction plans for data center facilities.<sup>28</sup>

A growing challenge for data center development is community opposition, often stemming from concerns about high energy consumption, potential environmental impacts, and increased traffic congestion.<sup>28</sup> Early engagement with the local community is crucial for addressing these concerns and streamlining the approval process.<sup>28</sup> Securing the necessary permits, including building permits for structural,

electrical, mechanical, and fire safety compliance, environmental permits related to air quality and waste management, and utility and power approvals, is another critical step in data center development. Delays in obtaining these permits can significantly impact project timelines, particularly with tightening power constraints in key markets, which may necessitate additional approvals from utility companies. <sup>28</sup>

Regulatory compliance at the federal, state, and local levels is paramount for data center development. Developers must adhere to various regulations, including energy efficiency standards, seismic and structural codes in earthquake-prone areas, and fire and safety regulations. <sup>28</sup> Understanding these compliance requirements in advance can help prevent project interruptions and unexpected costs. To navigate the complexities of zoning, permitting, and compliance, developers should proactively engage with local authorities early in the process and consider partnering with regulatory experts. <sup>28</sup>

Data centers are often not explicitly mentioned in local zoning codes and may fall under the broad category of general industrial zoning uses. <sup>30</sup> This mis-categorization can lead to planning challenges. However, some municipalities are taking a proactive approach by revising their zoning regulations to specifically accommodate or manage the increasing demand for data centers. This includes establishing dedicated data center overlay districts and specific use designations. <sup>31</sup> In regions like Northern Virginia, new zoning regulations have been introduced to address setbacks from residential areas, require noise impact studies, and consider building aesthetics to balance technological advancement with community preservation. <sup>37</sup> The typical land development review process for data centers can extend from six to eighteen months, highlighting the importance of thorough preparation and engagement. <sup>33</sup>

Navigating the complex and evolving landscape of zoning regulations and permitting processes poses a significant hurdle for data center development. Early and proactive engagement with local authorities and communities is crucial for mitigating risks and ensuring project approval. The trend towards data center-specific zoning and the increasing consideration of community impact indicates a growing awareness of the unique characteristics and needs of data centers. This could lead to more tailored regulations and potentially smoother approval processes in the future for developers who are proactive and collaborative.

### **Risk Assessment (Natural Disasters, Environmental Factors)**

Conducting a thorough risk assessment is an essential step in data center land



acquisition, helping to identify potential hazards and constraints that could impact the long-term viability and value of a site.<sup>19</sup> Risk profiles can highlight red flags that might impede a transaction or lower the land value for data center development. Key considerations include the potential for flooding, proximity to chemical plants, location within hurricane-prone regions, susceptibility to wildfires, the presence of water stress or drought conditions, the existence of wetlands, and potential biodiversity impacts.<sup>19</sup>

Weather and climate patterns can significantly influence both the data center development process and the quality of service it can provide. Harsh weather conditions during construction can lead to costly delays, while natural disasters can disrupt power and energy delivery to the data center, compromising its service quality.<sup>23</sup> Data centers located in earthquake-prone areas must adhere to stringent seismic design standards to protect their critical infrastructure.<sup>28</sup> While markets like Phoenix and Chicago are considered relatively safe from natural hazards, other regions, such as Northern California, face a high risk of seismic activity yet still attract substantial data center investment.<sup>24</sup> Considering data on flood zones and other environmental and natural hazards is therefore an important aspect of the site selection process.<sup>25</sup>

Thorough risk assessment, considering both natural and man-made hazards, is a critical part of due diligence in data center land acquisition. Identifying and mitigating potential risks early on can significantly impact the long-term viability and value of a data center site. The increasing focus on environmental factors, such as water stress and biodiversity, highlights the growing importance of sustainable site selection and development practices in the data center industry.

## 4. Planning and Design of Modern Data Centers

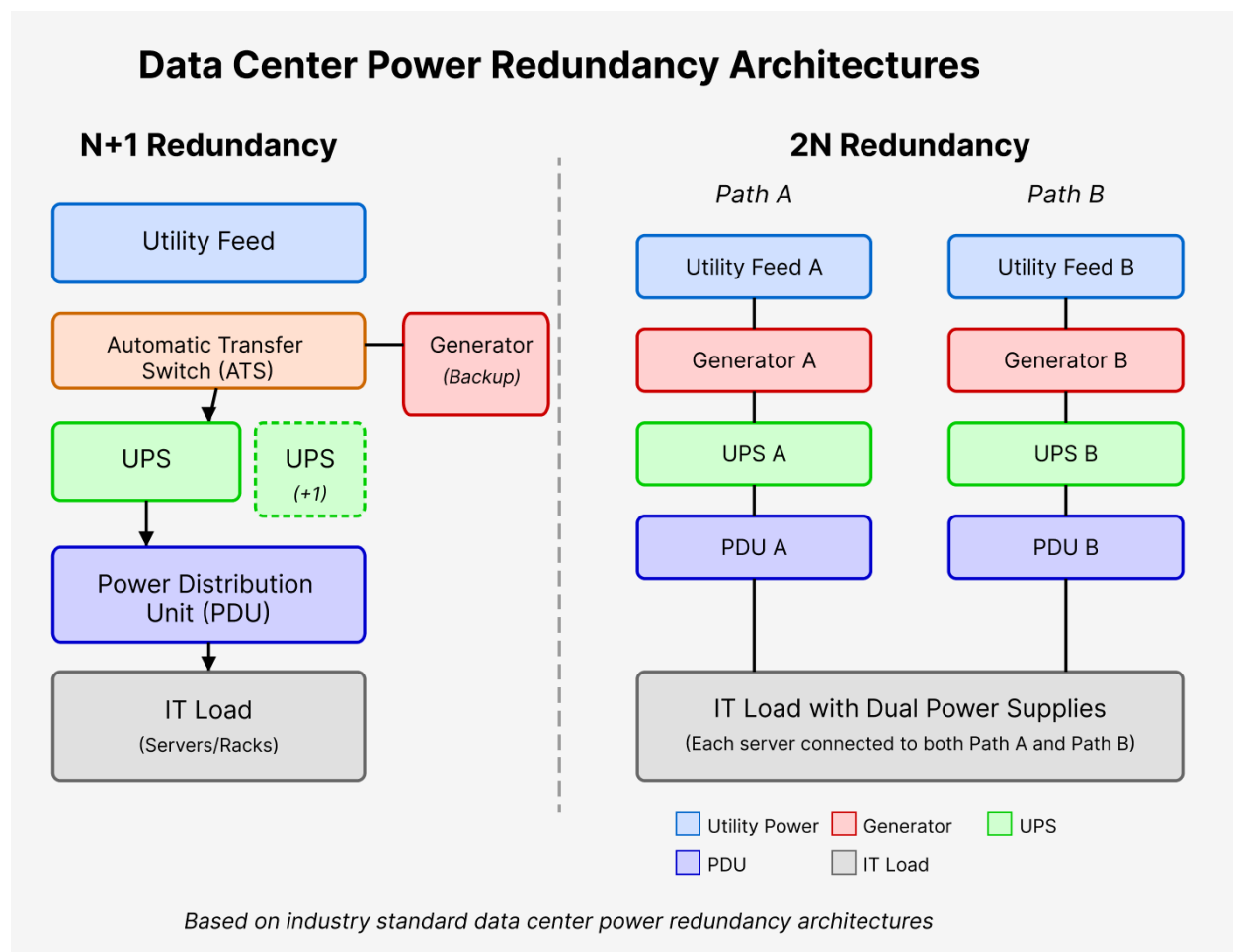
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### Architectural and Structural Considerations

Modern data centers exhibit unique architectural and structural characteristics that distinguish them from typical industrial or commercial buildings. They can be designed as single-story structures, often starting at a height of around 30 feet, or as multistory facilities extending even higher.<sup>30</sup> Once construction is complete, data centers typically require a relatively small number of employees for ongoing operations, resulting in minimal long-term impacts on local traffic, schools, and other public services.<sup>30</sup> Consequently, the need for parking spaces and plumbing fixtures in data centers is generally less than what is mandated by industrial building codes.<sup>30</sup>

In contrast, data centers necessitate a more robust and intricate infrastructure, both underground and above ground, to support their intensive power and cooling requirements.<sup>30</sup> Unlike traditional warehouses and factories, data centers often feature external electrical and mechanical equipment. Furthermore, many modern data centers require multiple layers of redundancy across their critical systems to ensure continuous operation.<sup>30</sup> Given the sensitive nature of the data and equipment housed within, security measures in data centers are significantly more stringent than in typical industrial buildings, often including 24/7 surveillance and tightly controlled access points.<sup>30</sup> These specific architectural and structural demands must be carefully considered during the planning and design phases of data center development, impacting space utilization, infrastructure needs, and overall security protocols.

### Power Infrastructure Requirements



Power infrastructure is arguably the most critical component of a data center, often

representing the largest single operating expense.<sup>40</sup> The specific power requirements of a data center are primarily driven by the capabilities and constraints of its IT equipment and the demands of the workloads being processed, with a notable increase in power-intensive workloads due to the widespread adoption of AI.<sup>41</sup> Modern GPUs, which are essential for AI and high-performance computing, are significantly more power-dense than traditional CPUs, leading to a dramatic rise in average data center power densities.<sup>41</sup>

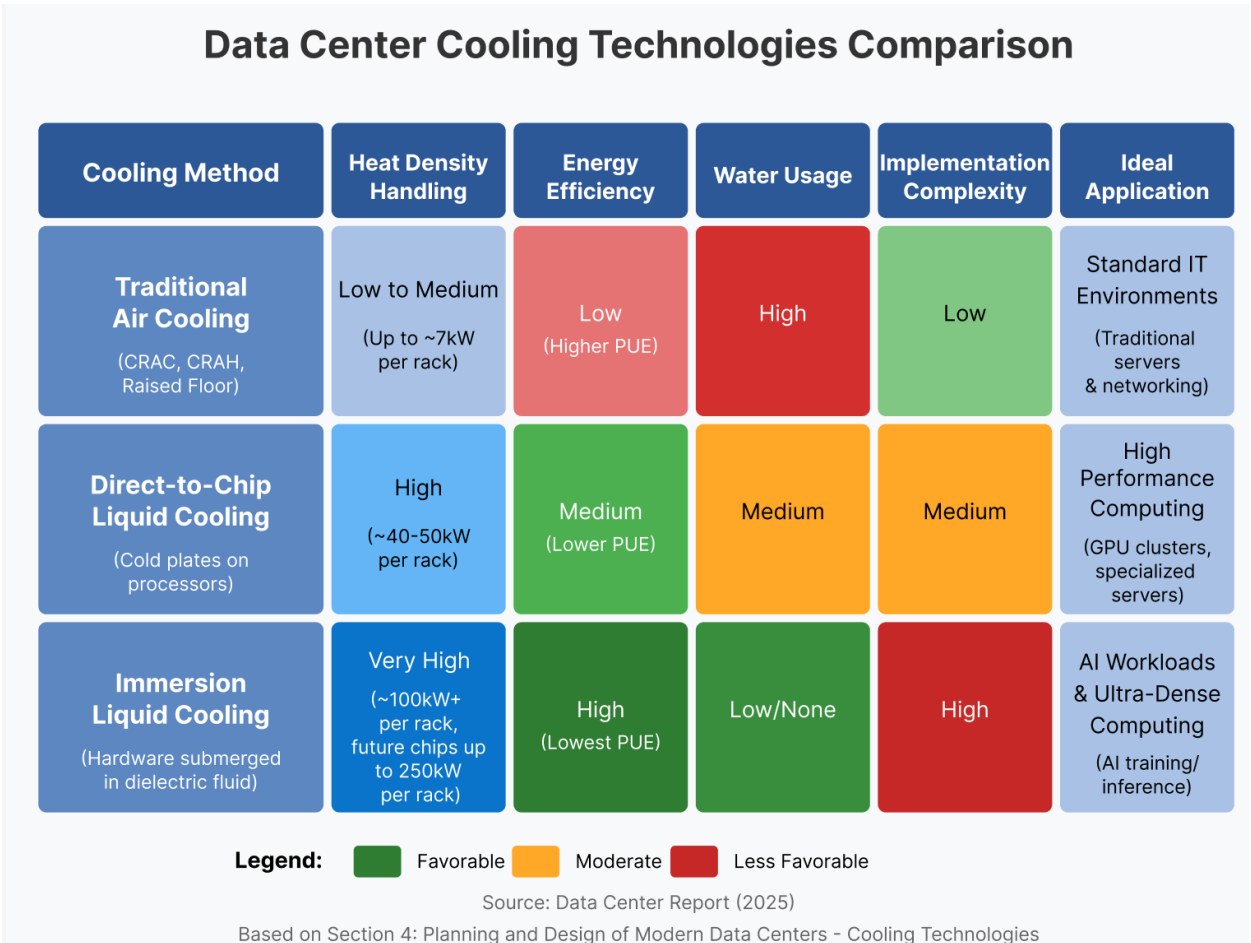
Data centers utilize both alternating current (AC) and direct current (DC) power. AC power is more commonly used as it seamlessly integrates with existing electrical grids and infrastructure.<sup>42</sup> Different voltage levels are employed for specific applications within a data center, with lower voltages typically powering IT equipment like servers and networking gear, while higher voltages are used for power distribution across the facility.<sup>42</sup> Ensuring a continuous and reliable power supply necessitates redundant power systems, which often include uninterruptible power supply (UPS) systems that provide immediate backup power and backup generators that can supply electricity for extended periods during utility outages.<sup>43</sup> Data centers employ various levels of redundancy, such as N+1, 2N, 2N+1, and 3N/2, depending on the desired level of uptime.<sup>42</sup> Power distribution units (PDUs) play a vital role in managing and distributing electrical power to the numerous pieces of IT equipment within the data center.<sup>42</sup>

The total power requirements for a data center can vary significantly based on its size and design, ranging from less than 1 MW for smaller facilities to over 100 MW for the largest hyperscale deployments, with the majority of activity currently concentrated in the 5-20 MW range.<sup>47</sup> Hyperscale data centers, designed to support the massive computing needs of cloud service providers, can demand anywhere from 20 to over 100 MW of power.<sup>43</sup> Notably, data centers optimized for AI workloads typically exhibit a much higher power draw per rack compared to conventional data centers, often exceeding 50 kW per rack compared to the more traditional 7 kW per rack.<sup>40</sup>

The design of the power infrastructure in a data center must prioritize reliability, redundancy, and scalability to effectively support the demanding needs of modern IT equipment, particularly in the context of AI and high-density computing. The choice between AC and DC power distribution, as well as the specific implementation of different redundancy levels, depends on the individual requirements and priorities of the data center, balancing factors such as efficiency, cost, and the desired level of operational uptime.

Cooling Technologies

Effective cooling is paramount in data centers to dissipate the significant heat generated by the operating hardware and to maintain optimal environmental



conditions for reliable performance.<sup>19</sup> The power consumed by cooling systems can be substantial, in some cases equaling the power consumption of the IT equipment itself.<sup>43</sup> While traditional air cooling methods, such as Computer Room Air Conditioners (CRAC), Computer Room Air Handlers (CRAH), and raised floor cooling, have been widely used, they may struggle to efficiently manage the increasing heat loads associated with modern high-density environments.<sup>50</sup>

In response to these challenges, liquid cooling technologies are gaining significant traction within the data center industry. These technologies, including direct-to-chip cooling, immersion cooling, and rear door heat exchangers, offer superior efficiency in handling higher power densities and can lead to substantial reductions in energy

waste.<sup>8</sup> Liquid cooling has been shown to be significantly more effective at cooling electronics compared to air -based methods.<sup>54</sup> Implementing efficient cooling solutions is essential not only for maintaining optimal equipment performance but also for reducing overall operational costs and minimizing the environmental impact of data center operations.<sup>50</sup>

Strategies such as hot aisle/cold aisle containment are employed to optimize airflow within the data center, improving cooling efficiency and reducing energy consumption.<sup>50</sup> Additionally, the use of free cooling techniques, which leverage ambient outside air or evaporative cooling, can significantly reduce the reliance on energy-intensive chillers, leading to substantial energy savings.<sup>63</sup>

Efficient and innovative cooling technologies are becoming increasingly vital in

## Data Center Cooling Technologies Comparison

Criteria	Traditional Air Cooling (CRAC/CRAH)	Hot/Cold Aisle Containment	Direct-to-Chip Liquid Cooling	Immersion Cooling
Maximum Power Density	5-15 kW/rack	15-30 kW/rack	50-80 kW/rack	100+ kW/rack
Energy Efficiency (PUE)	1.4-2.0	1.2-1.6	1.10-1.30	1.03-1.15
Water Usage	High (with chilled water)	Medium-High	Low-Medium (closed loop)	Very Low (dielectric fluid)
Relative CapEx	Low	Low-Medium	Medium-High	High
Relative OpEx	High	Medium	Low-Medium	Low
Complexity/Maintenance	Medium	Medium	High	Medium-High
Space Requirements	High	Medium	Low	Very Low
Best For	Legacy infrastructure, low-density computing	Medium-density traditional data centers	High-density computing, AI workloads	Extreme density, AI/HPC workloads

### Key Insights:

- Traditional air cooling methods struggle to efficiently handle high-density racks typical of AI workloads (40-140kW per rack)
- Liquid cooling technologies offer superior efficiency in dissipating heat, with up to 1,000x the thermal conductivity of air
- While liquid cooling solutions have higher initial costs, they provide significant OpEx savings through reduced energy consumption
- The shift toward liquid cooling is being driven by increasing rack densities, particularly for AI-optimized data centers

*Based on information from Data Center Report, 2025*

modern data centers, particularly given the higher heat densities associated with AI workloads. The growing adoption of liquid cooling indicates a clear need for more effective heat dissipation and improved energy efficiency. Data centers are exploring a variety of cooling strategies, ranging from optimizing airflow management to

implementing advanced liquid cooling systems, to strike a balance between performance, energy efficiency, and sustainability objectives. The specific choice of cooling technology often depends on factors such as the density of the IT equipment, the prevailing climate, and the data center's overarching sustainability goals.

### Sustainability in Data Center Design

Sustainability has evolved from a secondary consideration to a core imperative in the design and operation of data centers. This shift is driven by increasing awareness of environmental issues, growing pressure from clients, investors, and regulators, as well as a broader societal expectation for environmentally responsible practices.<sup>1</sup> Green data centers, which prioritize environmentally -conscious operations alongside high -performance computing, are emerging as increasingly attractive assets.<sup>1</sup>

A comprehensive approach to sustainability in data center design involves various strategies, including the utilization of renewable energy sources, the implementation of energy -efficient hardware and cooling systems, a focus on water conservation, efforts to reduce waste generation, and the recycling of waste heat.<sup>15</sup> The Power Usage Effectiveness (PUE) metric is commonly used to measure the energy efficiency of data centers, with a lower PUE indicating greater efficiency.<sup>42</sup> Many data center operators are setting ambitious goals for achieving 100% renewable energy coverage across their global operations.<sup>61</sup> Water conservation is another critical aspect of sustainable design, with some data centers employing waterless cooling systems or implementing rainwater capture and reuse strategies to minimize their water footprint.<sup>19</sup> The principles of a circular economy, which emphasize the reuse and recycling of resources, are also being increasingly embraced within the data center industry.<sup>61</sup> Furthermore, green building certifications such as LEED and Energy Star serve as important benchmarks for demonstrating a commitment to environmental sustainability.<sup>67</sup>

Sustainability is no longer an optional add -on but a fundamental requirement in data center design and operations, driven by environmental imperatives, regulatory pressures, and the growing expectations of stakeholders. Data centers are increasingly adopting a holistic approach to sustainability, encompassing the efficient management of energy, water, and waste. The focus on key performance indicators like PUE and WUE underscores the industry's commitment to measuring and continually improving its environmental performance, providing a framework for tracking progress towards ambitious sustainability goals.

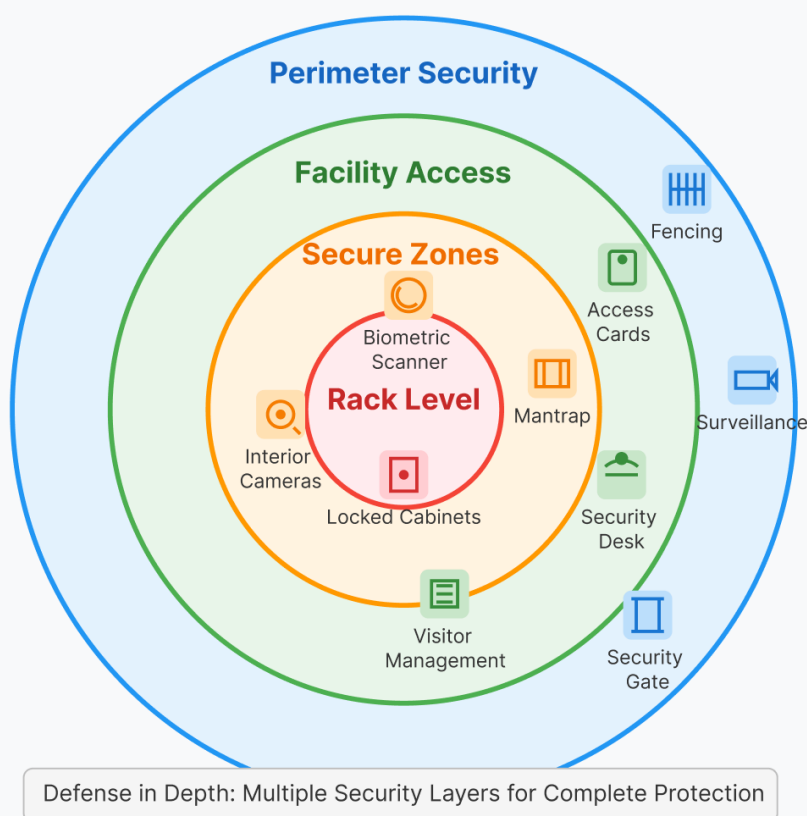


## 5. Critical Elements of Data Center Security

### Physical Security Measures

Establishing robust physical security measures is the first and often most critical line of defense for protecting data center assets. This begins with careful location identification, aiming to minimize proximity to high-risk areas and considering the likelihood of natural disasters.<sup>77</sup> Perimeter security forms the initial barrier, typically involving sturdy fencing, walls, and comprehensive surveillance systems.<sup>77</sup>

### Data Center Defense in Depth: Layered Physical Security



Strict access control protocols are essential for regulating who can enter the facility and specific areas within it. These protocols often include the use of access cards, biometric authentication systems such as fingerprint or iris scanners, and meticulously managed visitor management systems.<sup>77</sup> Multi-factor authentication, requiring more than one form of identification, is becoming a standard security practice.<sup>78</sup> Comprehensive video surveillance systems with 24/7 monitoring are

crucial, often incorporating advanced features like night vision and facial recognition capabilities.<sup>77</sup> Implementing the principle of least privilege, granting only necessary access, and utilizing anti-tailgating systems to prevent unauthorized entry are also important security measures.<sup>78</sup> Secure procedures for the disposal of end-of-life equipment are necessary to prevent data breaches.<sup>78</sup> Furthermore, environmental security measures, including robust fire detection and suppression systems, efficient drainage to prevent flooding, and regular HVAC system maintenance to mitigate overheating risks, are critical for protecting the physical infrastructure.<sup>77</sup> Adopting a layered security approach, also known as defense in depth, provides multiple levels of protection.<sup>79</sup> Regular security audits to identify vulnerabilities and comprehensive personnel training on security protocols are vital for maintaining a strong security posture.<sup>77</sup>

A robust physical security strategy for data centers relies on a multi-layered approach that integrates various measures from perimeter control to internal access management and environmental safeguards. The emphasis on continuous monitoring, audits, and training underscores the need for a proactive and adaptive security posture. The increasing use of advanced technologies like biometrics, AI-powered surveillance, and automated access control reflects the industry's commitment to enhancing physical security and mitigating risks effectively.

### Cybersecurity Strategies and Technologies

In addition to robust physical security, a comprehensive cybersecurity strategy is essential for protecting data and systems within a data center. This typically includes the deployment of network security infrastructure such as firewalls, intrusion detection and prevention systems (IDS/IPS), and Virtual Private Networks (VPNs) to secure network perimeters and prevent unauthorized access.<sup>90</sup> Encryption is a critical technology for safeguarding sensitive data both while it is being transmitted and when it is stored.<sup>93</sup>

The implementation of a Zero Trust architecture, which operates on the principle of assuming no user or device is inherently trustworthy and requires continuous verification, is a key cybersecurity strategy.<sup>86</sup> Artificial Intelligence (AI) and Machine Learning (ML) technologies are increasingly being leveraged for threat detection and the identification of anomalous activity within data center networks.<sup>61</sup> Conducting regular security audits and penetration testing are vital practices for proactively identifying and addressing potential vulnerabilities in the data center's cyber defenses.<sup>77</sup>

Ensuring that all employees receive regular security awareness training is crucial for mitigating the risk of human error, which remains a significant vulnerability in cybersecurity.<sup>94</sup> The implementation of strict access controls and network segmentation are necessary to isolate sensitive data and limit the potential impact of a security breach.<sup>96</sup> Role-Based Access Control (RBAC) is a common method for managing user permissions and restricting access to only necessary data and systems.<sup>96</sup> Having a well-defined incident response plan in place is essential for effectively managing and mitigating the impact of security breaches when they occur.<sup>78</sup> Cybersecurity strategies must also extend to the physical infrastructure of the data center, including systems like HVAC and UPS, as these can be potential targets for cyberattacks.<sup>95</sup> Additionally, managing the security risks associated with third-party vendors who may have privileged access to data center networks is a critical consideration.<sup>106</sup>

Cybersecurity in data centers demands a comprehensive and layered strategy that addresses both internal and external threats. The integration of advanced technologies like AI and the adoption of frameworks such as Zero Trust are crucial for staying ahead of the constantly evolving landscape of cyber threats. Furthermore, the incorporation of cybersecurity considerations into the physical infrastructure and the diligent management of third-party vendor security demonstrate a holistic approach to safeguarding the data center environment.

## 6. Data Center Leasing Models and Operational Best Practices

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### Comparison of Different Leasing Models

The data center market offers a variety of leasing models to accommodate the diverse needs of tenants. These models include colocation (which can be further categorized into retail and wholesale), hyperscale leases designed for large cloud providers, and build-to-suit options where a facility is constructed to the specific requirements of a tenant.<sup>21</sup> Wholesale leases typically follow either a triple net (NNN) or a modified gross structure. In an NNN lease, the tenant pays a base rent plus their pro-rata share of all operating expenses, while a modified gross lease includes at least some portion of the operating expenses in the base rental rate.<sup>110</sup> Retail colocation leases often utilize a gross or all-in lease model, providing the tenant with a predictable monthly rent that includes all operating expenses and power costs.<sup>111</sup> Another option available to enterprises is a sale-leaseback arrangement, where they sell their existing data center facility to an investor and then lease it back for their continued use.<sup>112</sup> Joint venture agreements can also be structured, offering aligned

interests and the potential for cost reduction between the data center provider and the tenant.<sup>110</sup>

The typical lease duration for data centers ranges from 3 to 10 years, with longer lease terms often accompanied by more favorable pricing and other conditions.<sup>108</sup>

### Data Center Leasing Models Comparison

Leasing Model	Typical Tenant Size	Level of Control	Operating Expenses	Typical Lease Term	Scalability/Flexibility	Cost Structure
<b>Retail Colocation</b>	Small to medium (Few racks to 100 kW)	Low - Shared infrastructure, defined services	Landlord responsible (included in "all-in" pricing)	3-5 years	High - Easy to add racks/power	Higher per kW, predictable monthly costs (gross/all-in model)
<b>Wholesale Colocation (NNN)</b>	Medium to large (500 kW - 5 MW)	Medium - Dedicated space, some customization	Tenant pays base rent plus pro-rata share of all operating expenses	5-10 years	Medium - Expansion options typically defined in lease	Lower per kW, less predictable due to variable expenses
<b>Wholesale Colocation (Modified Gross)</b>	Medium to large (500 kW - 5 MW)	Medium - Dedicated space, some customization	Some operating expenses included in base rent	5-10 years	Medium - Expansion options typically defined in lease	Lower per kW than retail, more predictable than NNN
<b>Hyperscale Lease</b>	Very large (10+ MW)	High - Significant customization, often entire facility	Varies, often similar to wholesale models	7-15 years	Medium to Low - Large upfront commitment	Lowest per kW, economies of scale
<b>Build-to-Suit</b>	Large to very large (5+ MW)	Highest - Facility designed to tenant specifications	Negotiable, often similar to wholesale models	10-20 years	Low - Major long-term commitment	Complex structure, often includes development costs
<b>Sale-Leaseback</b>	Varies - Based on existing facility	Medium to High - Continuing operations in sold facility	Negotiable, typically similar to wholesale models	10+ years	Low - Commitment to existing facility	Capital infusion from sale, ongoing lease payments

**Note:** Lease terms, operating expense arrangements, and other details can vary significantly based on market conditions, tenant requirements, and provider offerings. This comparison represents typical structures in the data center market.

Rental rates for data center space are frequently reported on a per kilowatt (kW) or per megawatt (MW) basis, reflecting the power-intensive nature of these facilities.<sup>21</sup> Notably, hyperscale cloud service providers are increasingly opting to lease rather than own the data center capacity they require, indicating a shift in their asset management strategies.<sup>21</sup>

The variety of data center leasing models available provides significant flexibility for different types of tenants, accommodating their diverse needs for control over the facility, predictability of costs, and level of operational involvement. Understanding these different models is crucial for both data center providers and potential clients to identify the most suitable arrangement that aligns with their specific objectives and requirements. The increasing preference among hyperscale providers for leasing data center capacity suggests a strategic move towards off-balance-sheet financing and greater operational flexibility, which has significant implications for the overall data center ownership landscape.

### Operational Best Practices

Achieving operational excellence in a data center necessitates a holistic approach that prioritizes data security, energy efficiency, business continuity, and optimized performance.<sup>60</sup> Implementing proactive maintenance practices, including preventive, reliability-centered, and predictive maintenance, is essential for ensuring maximum uptime and preventing unexpected failures.<sup>114</sup> Maintaining stable indoor environmental conditions, specifically temperature, humidity, and airflow, is critical for the reliable operation of IT equipment.<sup>114</sup> Robust testing protocols for backup power systems and other critical infrastructure components are necessary to ensure their readiness in the event of an emergency.<sup>114</sup> Data center operators should either employ adequately trained and skilled staff to manage and maintain the facilities or consider outsourcing these functions to experienced external teams.<sup>114</sup> Maintaining a clean operating environment and adhering to good data hygiene practices are also important for preventing equipment issues and optimizing performance.<sup>114</sup> Comprehensive emergency preparedness and well-tested disaster recovery plans are vital for minimizing the impact of unforeseen events such as power outages or cyberattacks.<sup>114</sup>

The utilization of sophisticated monitoring and automation tools, such as Data Center Infrastructure Management (DCIM) and Building Management Systems (BMS), is a best practice for gaining real-time insights into data center operations and optimizing efficiency.<sup>115</sup> Efficient allocation of resources and the avoidance of over-provisioning

are key to maximizing efficiency and controlling costs.<sup>115</sup> Adherence to relevant industry compliance standards and regulations, including ISO 27001, HIPAA, PCI DSS, and SOC 2, is crucial for ensuring the security and integrity of data and operations.<sup>117</sup> Measuring and actively managing Power Usage Effectiveness (PUE) and ensuring effective airflow management are fundamental for optimizing energy consumption.<sup>65</sup> Data center operators should be selective in their choice of suppliers and strive to build strong, collaborative relationships with them.<sup>119</sup> Implementing rigorous security policies and access control measures is paramount for protecting both physical and digital assets.<sup>120</sup> Finally, establishing and consistently following standard operating procedures for various routine and critical tasks is essential for maintaining consistency and reliability.<sup>121</sup>

Achieving operational excellence in data centers demands a comprehensive strategy that integrates the physical infrastructure with well-defined processes, skilled personnel, and advanced management technologies. The increasing adoption of automation, AI-driven tools, and data analytics for monitoring and optimization reflects a significant trend towards more intelligent and efficient data center operations, ultimately reducing the potential for human error and enhancing overall performance.

## 7. Sustainable and Alternative Power Solutions

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### Growing Demand for Renewable Energy Sources

The data center industry is experiencing a significant surge in demand for sustainable power solutions, with a particular emphasis on renewable energy sources.<sup>1</sup> Renewable energy sources such as wind, geothermal, and solar power present promising market growth opportunities for developers of green data centers.<sup>1</sup> Enthusiasm for nuclear power, including the development and deployment of Small Modular Reactors (SMRs), is also gaining considerable momentum as a clean and reliable alternative to traditional power generation for data centers.<sup>5</sup>

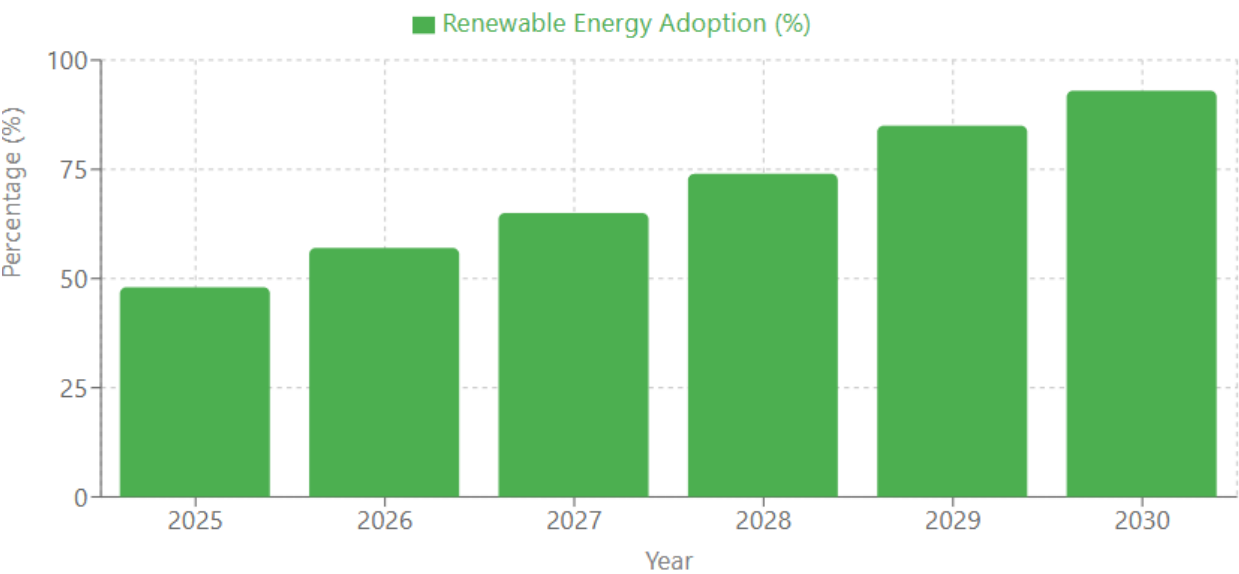
Many prominent technology companies are making substantial investments in renewable energy initiatives to meet their ambitious sustainability goals, with several committing to achieving 100% carbon-free operations by the year 2030.<sup>11</sup> Data center companies are increasingly entering into renewable energy Power Purchase Agreements (PPAs) to secure access to clean energy and offset their environmental impact.<sup>126</sup> Recognizing the growing importance of sustainable power, the US Department of Energy is actively encouraging the development of AI data centers on



federal lands that have access to existing energy infrastructure, including both nuclear and renewable energy resources.<sup>124</sup> Projections indicate that data centers will consume a significant and increasing portion of the total electricity generated in the United States by 2028, further underscoring the critical need for the development and deployment of clean energy solutions within the sector.<sup>13</sup>

The escalating energy demands of data centers, particularly driven by the rapid expansion of AI applications, are fueling a significant transition towards sustainable

Renewable Energy Penetration in Data Centers



Key Insights:

- Many leading technology companies are committed to achieving 100% carbon-free operations by 2030
- Growing adoption of Power Purchase Agreements (PPAs) to secure clean energy
- Increased focus on renewable sources including wind, solar, and geothermal power
- Rising interest in alternative power solutions like hydrogen fuel cells and small modular reactors

Note: Projection based on industry trends and commitments as reported in data center industry outlook reports. Actual adoption rates may vary based on technological developments, regulatory changes, and market conditions.

power solutions. Renewable energy sources, along with nuclear power, are emerging as viable and increasingly preferred alternatives to conventional fossil fuels, aligning with both environmental stewardship and the potential for long-term cost stability. The increasing prevalence of Power Purchase Agreements demonstrates a proactive approach by the data center industry to secure renewable energy and actively reduce

its overall carbon footprint.

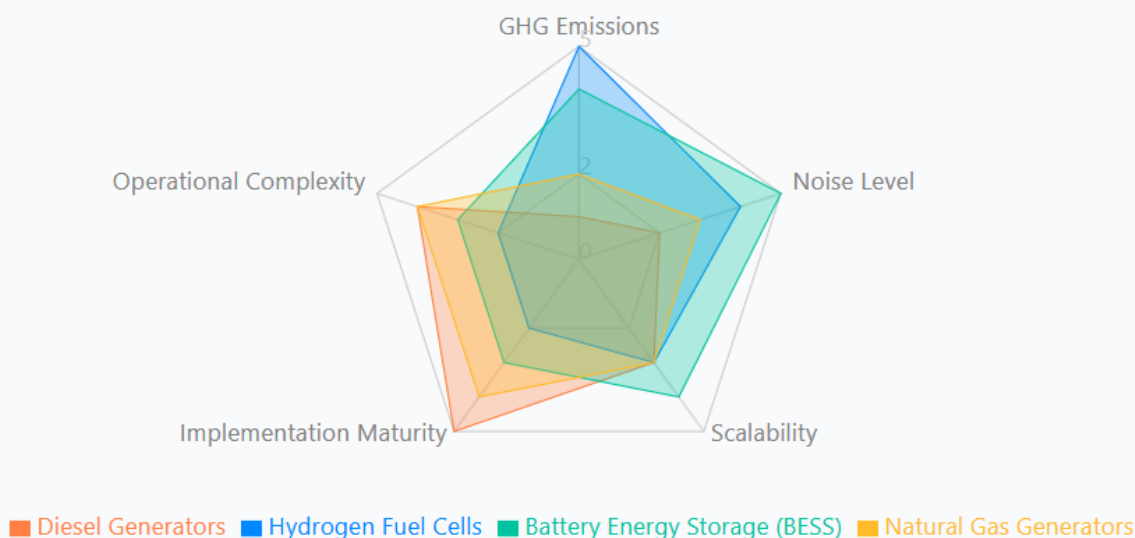
### Hydrogen Fuel Cells as a Clean Power Alternative

Hydrogen fuel cells are being actively explored as a promising clean, efficient, and rapidly deployable energy source for data centers, with the significant advantage of producing only water as a byproduct of their operation.<sup>15</sup> Both Proton Exchange Membrane Fuel Cells (PEMFC) and Solid Oxide Fuel Cells (SOFC) are under consideration for their suitability in data center applications, offering benefits such as

### Alternative Backup Power Solutions vs. Diesel Generators

Based on data from the Data Center Report, comparing traditional diesel backup against emerging alternatives

#### Overall Comparison (Higher is Better)



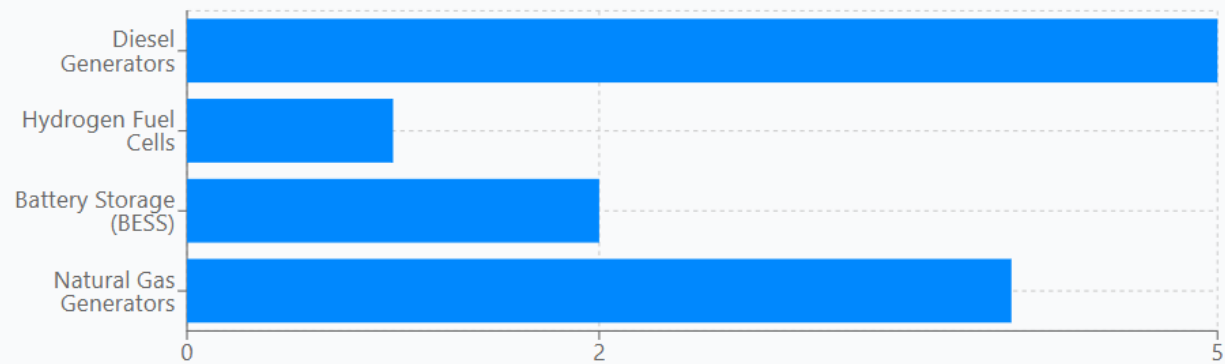
quick start-up times and high energy efficiency.<sup>140</sup> Notably, major technology players like Microsoft, in collaboration with Plug Power, have conducted tests on multi-megawatt hydrogen fuel cell systems specifically designed for providing backup power to data centers.<sup>140</sup> Furthermore, ECL, a data center developer, has announced ambitious plans to construct a large-scale, off-grid AI data center in Texas that will be powered by hydrogen. This project initially intends to utilize a mix of grey and blue hydrogen, with a long-term goal of increasing the proportion of blue and green hydrogen in its energy mix.<sup>150</sup> In recognition of the potential of hydrogen power, Google has also patented innovative methods for optimizing the fueling and storage of hydrogen for use in data center fuel cell systems.<sup>154</sup>

Hydrogen fuel cells represent a compelling pathway towards achieving zero -emission power for data centers. These systems have the potential to replace traditional diesel generators, which are a significant source of pollution, for backup power applications . Moreover, with further development and infrastructure investment, hydrogen fuel cells could even serve as a primary power source for data centers striving to achieve carbon neutrality. The ongoing research, development, and real -world pilot projects are demonstrating the growing viability and potential of this transformative technology within the data center industry.

### **Comparison of Alternative Power Solutions with Traditional Grid Connections and Diesel Generators**

In response to the increasing power demands and reliability concerns associated with traditional grid connections, the data center industry is actively exploring and investing in a diverse range of alternative power solutions. These include microgrids, energy storage systems, fuel cells, and nuclear power, all aimed at meeting the substantial energy requirements of modern data centers. <sup>6</sup> Traditional grid connections, while still the primary source of power for most data centers, are facing growing challenges related to capacity limitations and increasingly lengthy interconnection timelines, which can hinder the speed of development and deployment. <sup>2</sup>

Greenhouse Gas Emissions



Lower score = Lower emissions. Hydrogen fuel cells produce only water as a byproduct, while diesel generators have the highest emissions.

Cost Comparison



Diesel generators have long been the standard for providing backup power in data centers, ensuring operational continuity during grid outages. However, they produce harmful emissions and contribute to the overall carbon footprint of data center operations.<sup>147</sup> As a result, the industry is actively seeking cleaner alternatives to diesel, including hydrogen fuel cells, battery storage systems, biomethane, and hydrotreated vegetable oil (HVO)/biodiesel.<sup>147</sup> Off-grid power solutions, such as microgrids and on-site power generation, are also gaining attention as they offer enhanced energy security and greater independence from the potential instabilities of the traditional power grid.<sup>13</sup>

While traditional grid connections remain the dominant power source for the data center industry, the increasing demands and reliability concerns are driving a significant shift towards exploring and investing in alternative power solutions. These alternatives are being pursued to enhance energy resilience, reduce environmental impact, and potentially achieve lower long-term operating costs. The transition away from diesel generators for backup power is also gaining momentum, spurred by

stricter environmental regulations and ambitious sustainability goals. A variety of cleaner alternatives are being evaluated and implemented, each with its own set of advantages and challenges related to cost, scalability, and overall reliability.

### Regulatory Considerations

#### Diesel Generators

Facing increasing emissions regulations and operational restrictions, especially in urban areas.

#### Hydrogen Fuel Cells

Growing regulatory support, but complex safety protocols for hydrogen storage and handling.

#### Battery Storage (BESS)

Generally favorable regulations with fire safety standards being the primary concern.

#### Natural Gas Generators

Less stringent emissions regulations than diesel, but still subject to fossil fuel restrictions.

## 8. Future Trends in the Data Center Market

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### Impact of Edge Computing on Data Center Architecture and Deployment

Edge computing is emerging as a transformative trend that is fundamentally reshaping the architecture and deployment strategies of data centers. Driven by the rapid growth of the Internet of Things (IoT), the expansion of 5G networks, and the increasing demand for low-latency applications, edge computing involves distributing computing resources closer to the source of data generation. <sup>1</sup> This approach significantly reduces latency, improves the efficiency of bandwidth utilization, and enhances both privacy and security for data processing. <sup>181</sup> The market for edge computing is projected to experience substantial growth, with forecasts indicating a surge to over \$700 billion by 2033. <sup>182</sup>

Edge data centers are typically smaller, more decentralized facilities strategically located closer to the end users and devices they serve. <sup>181</sup> These edge facilities complement traditional, centralized data centers by offloading certain processing tasks and helping to manage peak loads more effectively. <sup>181</sup> The deployment models for edge data centers are varied, ranging from fully functional micro data centers that can operate independently to smaller facilities that are designed to complement

existing cloud or centralized data center infrastructures. <sup>183</sup>

Edge computing is fundamentally altering data center architecture by promoting the deployment of smaller, distributed data centers situated closer to the network's edge. This trend is essential for supporting applications that demand real-time processing and the massive volumes of data generated by IoT devices. While edge computing offers numerous benefits, it also presents both opportunities and challenges for data center operators. These include the need for innovative approaches to site selection,

### Global Edge Computing Market Size Projection

2025-2030 (in billion USD)



#### Key Drivers of Edge Computing Growth

- **Internet of Things (IoT) Expansion:** The proliferation of IoT devices generating massive amounts of data requiring processing closer to the source
- **5G Network Deployment:** Rollout of high-speed, low-latency networks enabling more efficient edge computing implementations
- **Real-time Applications:** Growing demand for applications requiring minimal latency and immediate data processing
- **AI Integration:** Increasing adoption of AI and machine learning capabilities at the edge for faster decision-making

the deployment of robust and energy-efficient hardware, the implementation of effective power and cooling solutions in diverse environments, the establishment of enhanced security protocols across a distributed infrastructure, and the development of efficient remote management capabilities for these geographically dispersed sites.

#### Potential Repurposing of Existing Infrastructure

An increasingly notable trend in the data center market is the potential repurposing of existing, often vacant, commercial properties, such as retail spaces and office buildings, into modern data center facilities. <sup>1</sup> This adaptive reuse strategy offers several key advantages, including a faster time-to-market for new data center capacity, a more sustainable approach by utilizing existing structures, and the potential to revitalize underutilized urban areas. <sup>202</sup> Vacant shopping malls, with their large physical footprints and often existing infrastructure, are being considered as prime candidates for conversion into hyperscale data center solutions. <sup>203</sup> Similarly, existing office buildings and warehouses are also being evaluated and repurposed to serve as data center facilities. <sup>203</sup>

While the repurposing of existing infrastructure presents numerous opportunities, it also comes with its own set of challenges. These can include the need for significant structural modifications to support the weight and layout of data center equipment, substantial upgrades to power and cooling systems to meet the intensive demands of modern IT infrastructure and ensuring full compliance with stringent data center standards and regulations. <sup>211</sup>

The repurposing of existing buildings offers a sustainable and potentially cost-effective alternative to constructing new data center facilities from the ground up, particularly in densely populated urban areas where land is often scarce, and some basic infrastructure may already be in place. While this approach offers several benefits, it is crucial to carefully evaluate the technical and regulatory challenges associated with adapting existing structures to ensure their suitability and compliance for data center use.

## Emerging Technologies and Innovations

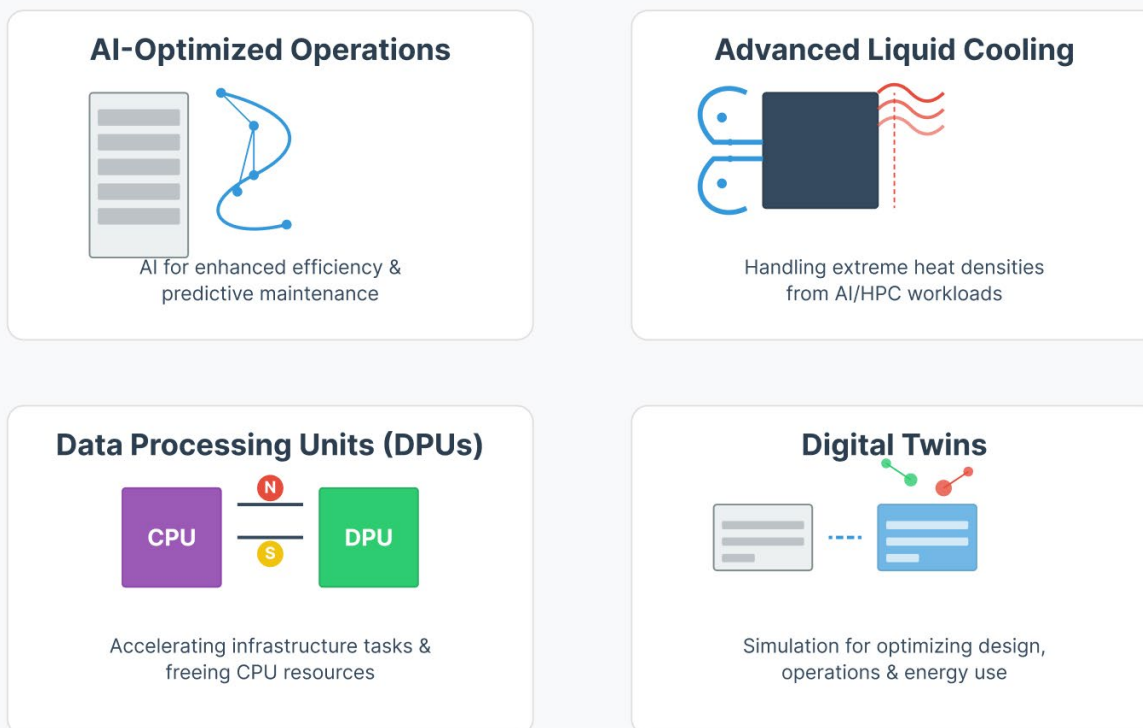
The data center market is characterized by continuous technological advancements aimed at enhancing efficiency, improving performance, and promoting sustainability. Artificial Intelligence (AI) is playing an increasingly significant role in optimizing data center operations, including the intelligent management of cooling systems and power distribution. <sup>15</sup> Liquid cooling technologies are rapidly evolving to effectively manage the higher thermal densities associated with modern computing hardware, particularly in AI and high-performance computing environments. <sup>8</sup> Specifically, direct-to-chip and immersion cooling methods are seeing increased adoption as effective solutions for dissipating the concentrated heat generated by advanced processors. <sup>2</sup>

Data Processing Units (DPUs) are emerging as important components in data center



infrastructure, playing a crucial role in offloading resource-intensive networking and security tasks from central processing units. <sup>102</sup> Software-Defined Networking (SDN)

## Emerging Data Center Technologies & Innovations



Other innovations: SDN (Software-Defined Networking) and HCI (Hyper-Converged Infrastructure)

and Hyper-Converged Infrastructure (HCI) are also gaining prevalence, offering greater flexibility and efficiency in managing data center resources. <sup>180</sup> The use of digital twins, virtual representations of physical data centers, is becoming more common for simulating and optimizing energy efficiency and overall performance. <sup>97</sup>

The data center industry is in a constant state of innovation, with emerging technologies aimed at enhancing efficiency, performance, and sustainability. The increasing adoption of AI for operational optimization, the rapid advancements in liquid cooling technologies to handle high-density workloads, and the development of specialized processing units like DPUs are key trends shaping the future of data centers.

## Market Size Forecasts and Regional Growth Projections

The global data center market is projected to experience substantial growth in the coming years, with forecasts indicating a rise to \$652.01 billion by 2030, representing

a CAGR of 11.2% from 2025.<sup>221</sup> The market for edge data centers is also expected to see significant expansion, reaching \$31.28 billion by 2030 with a CAGR of 19.3%.<sup>190</sup> Similarly, the data center UPS market is projected to grow to \$20.75 billion by 2030, exhibiting a CAGR of 15.17%.<sup>191</sup> Global demand for data center power is expected to increase considerably, reaching an estimated 84 GW by 2027 and 122 GW by 2030.<sup>9</sup>

Currently, North America is the largest revenue -generating market for data centers. However, the Asia Pacific region is anticipated to be one of the fastest -growing markets during the forecast period.<sup>9</sup> Key global data center markets include Northern Virginia, Beijing, London, Singapore, Tokyo, Frankfurt, Shanghai, Sydney, Dallas, and Phoenix.<sup>224</sup> Emerging markets such as Brazil, India, Southeast Asia, and the Middle East are also demonstrating strong growth potential in the data center sector.<sup>225</sup>

The data center market is poised for substantial growth in the coming years, fueled by the increasing volume of data being generated and the widespread adoption of advanced technologies. This growth trend presents significant opportunities for businesses across the entire data center ecosystem. While North America currently holds the largest market share, the strong growth projections for the Asia Pacific region underscore the increasing globalization of the data center market and the importance of understanding regional variations in demand and development.

## 9. Conclusion

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The data center market stands at the forefront of the digital revolution, experiencing rapid and continuous growth driven by the insatiable demand for data processing, storage, and connectivity. The proliferation of AI, the ubiquitous nature of cloud computing, and the expanding universe of IoT devices are key catalysts fueling this expansion. This report has highlighted the critical considerations that businesses must address when navigating this dynamic landscape, from the strategic selection of land with reliable power and connectivity to the intricate planning and design of facilities that prioritize efficiency and sustainability. Security, in both its physical and cyber dimensions, remains paramount, while a diverse range of leasing models offers flexibility to meet varying operational and financial needs. The pursuit of operational best practices is essential for ensuring reliability and maximizing efficiency. Furthermore, the increasing demand for sustainable power solutions and the exploration of innovative alternatives like hydrogen fuel cells signify a growing commitment to environmental responsibility within the industry. Looking to the future, trends such as edge computing and the creative repurposing of existing

infrastructure promise to further reshape the data center market. With significant market growth forecasts and evolving regional dynamics, the data center sector presents a wealth of opportunities for innovation and investment in the years to come.

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