ENERGY INDUSTRY GROUP

Overcoming the Challenges to Securing Power for Middle-Market Data Centers

As of February 6, 2025

While much of the focus in 2024 was on moves from big tech hyperscalers to secure power in the short-to-medium term, mid-market players in the colocation and hyperscale data center segments have faced additional challenges to meet their needs. As development becomes more challenging, these players are being forced to contemplate more active involvement in their development and energy strategy.

2024 saw frequent headlines announcing increased usage patterns for generative AI and new and innovative efforts from tech companies to build the data centers that fuel that growth. The data center market has experienced significant growth with overall global data center storage capacity increasing at 18.5 percent[1] CAGR from 2023 to 2027. As demand for data centers has grown, the challenge to build them has shifted from primarily a real estate and fiber access question to one of access to power. With hyperscale data centers and large colocation facilities requiring 100MW[2] of power on a near 24/7 basis, with some projects approaching 1GW, power demand from data centers is also projected to grow ~ 60–100 percent in the U.S. over the next four to six years.[3 4 5]

Recent developments in complex artificial intelligence, including large language models and deep learning algorithms, require significantly more computing than previous methods, a driving force in the explosion in data center development as tech companies race to develop the facilities to handle training data and inference needed to win the AI race.

While hyperscale data centers used for generative AI have dominated the headlines of big tech moves in the race of energy for data centers, most estimates consider AI to drive only ~ 20–40 percent of data center demand. The Internet of Things' demand for lower latency is driving the development of smaller data center facilities closer to end users, commonly referred to as the edge market. Other segments of the market have also continued to grow including colocation facilities used for cloud hosting as more companies migrate their systems to cloud-based architectures. Increasingly, smaller enterprises are also moving away from the largest cloud providers as privacy concerns surmount the ease of use offered by hyperscalers.

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The "mid-tier" operators that serve these segments face unique challenges. Unlike their larger counterparts, these providers don't have the luxury of building new facilities in rural areas with interconnect availability and/or colocated power. Lacking the capital of hyperscalers, mid-tier operators typically don't invest in large new facility builds like public cloud providers. Their facilities are instead located near cities, closer to the enterprises they serve. As a result, these operators can face higher variability in energy costs from their grid offtake.

[1]Kimberly Steele, "Growth of AI creates unprecedented demand for global data centers," JLL, January 31, 2024, https://www.jll.ca/en/newsroom/growth-of-ai-creates-unprecedented-demand-for-global-data-centers

[2]Chandana Patnaik, "Data Center Power: Fueling the Digital Revolution," Data Center Knowledge, March 22, 2024, https://www.datacenterknowledge.com/energy-power-supply/data-center-power-fueling-the-digital-revolution

[3]Andrew Batson, "U.S. Data Center Report – Midyear 2024," JLL, August 27, 2024, https://www.us.jll.com/en/trends-and-insights/research/na-data-center-report

[4]U.S. Dept. of Energy, "Clean Energy Resources to Meet Data Center Electricity Demand," https://www.energy.gov/policy/articles/clean-energy-resources-meet-data-center-electricity-demand

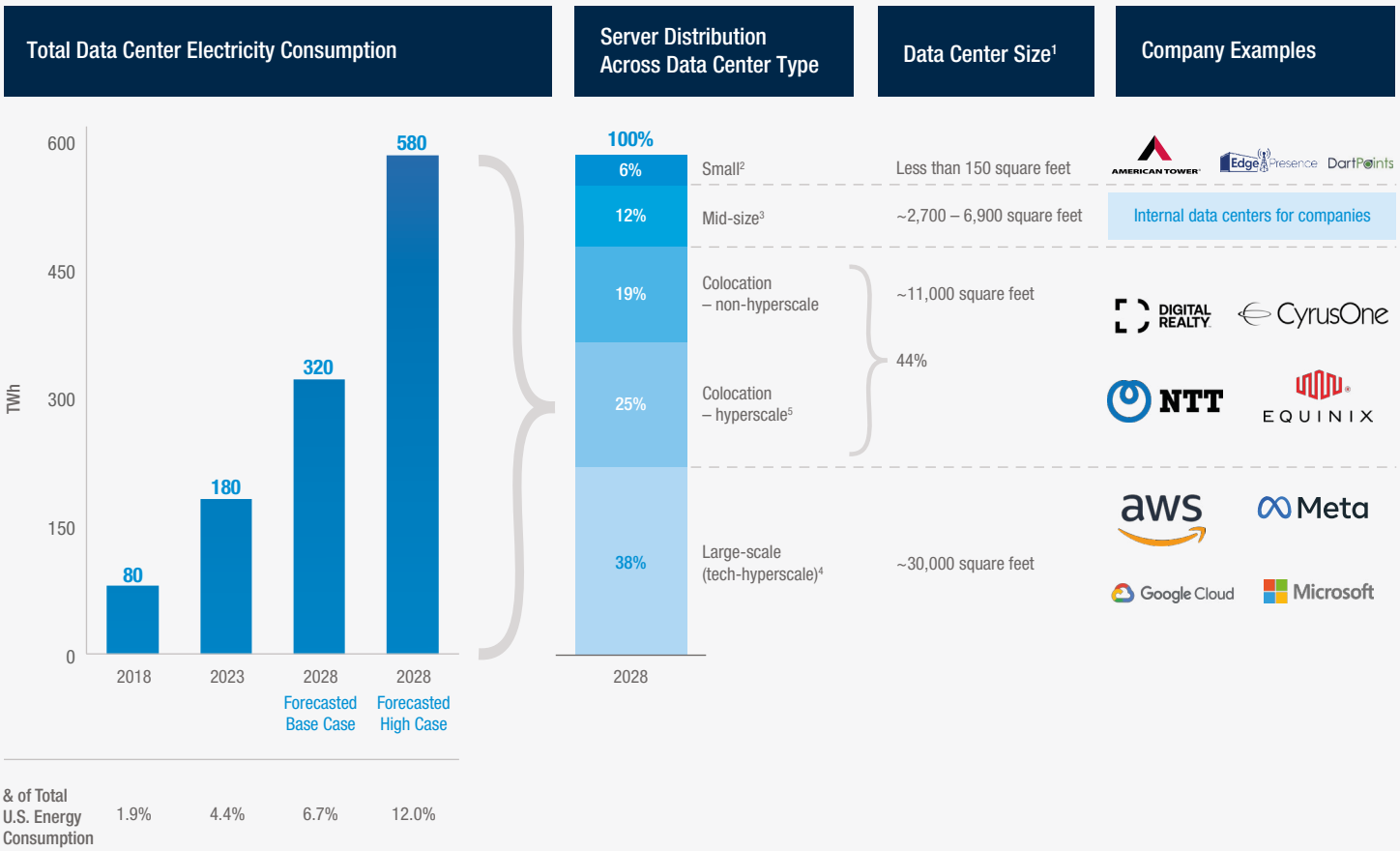
[5]Cy McGeady, "Powering the Commanding Heights: The Strategic Context of Emergent U.S. Electricity Demand Growth," Center for Strategic and International Studies, October 28, 2024, https://www.csis.org/analysis/powering-commanding-heights-strategic-context-emergent-us-electricity-demand-growth

To offset these challenges, mid-tier operators tailor their design to specific clients' demands. Hyperscalers build in flexibility to accommodate any type of traffic, designing robust, higher cost facilities. More agile smaller mid-tier data center tenant operators deploy the specific racks, storage and networking components that match the compute job requirements of specific clients. Increasingly, modular rack design makes these deployments even more affordable. As cloud privacy concerns grow among enterprises, these private cloud solutions are growing in popularity.

In addition to winning share, tailored private cloud solutions help mid-tier operators optimize their energy usage. Some mid-tier operators offer private cloud solutions at less than 50 percent of the cost of robust hyperscale public cloud deployments, driven by lower margin requirements and less flexibility. Innovative players are leveraging this cost advantage to invest in cooling systems, high efficiency transformers, smart sensors and software that maximizes the amount of power consumed by equipment.

EXHIBIT 1

Data Center Segments Driving the Increase in Power Center Energy Demand[6 7 8 9 10]



[1]Based on average square feet per module.

[2]Includes Telco Edge (small network hubs by telcos), Commercial Edge (network closets and microdata centers for digital and supply chain operations), SMB (internal deployments for small and medium businesses), and Enterprise Branch

[3]Includes data centers run by enterprises internally for their own use and data centers run by telecom/cable companies to support internal services.

[4]Data centers built by companies that deploy internet services and platforms at massive scale.

[5]Data centers built by colocation companies providing wholesale and retail colocation.

[6]Joe Burns, "Colocation data center market balloons as operators face labor woes: JLL", Facilities Dive, September 3, 2024, https://www.facilitiesdive.com/news/jll-data-center-midyear-colocation-demand-hiring-retention-challenges/725910/

[7]Arman Shehabi et al., "2024 United States Data Center Energy Usage Report," December 19, 2024, https://eta.lbl.gov/publications/2024-lbnl-data-center-energy-usage-report

[8]"Hyperscale Operators and Colocation Continue to Drive Huge Changes in Data Center Capacity Trends," Synergy Research Group, August 7, 2024, https://www.srgresearch.com/articles/hyperscale-operators-and-colocation-continue-to-drive-huge-changes-in-data-center-capacity-trends

[9]Berkeley Lab, "2024 United States Data Center Energy Usage Report," December 2024, https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf

[10]"Hyperscale Operators and Colocation Continue to Drive Huge Changes in Data Center Capacity Trends," Synergy Research Group, August 7, 2024, https://www.srgresearch.com/articles/hyperscale-operators-and-colocation-continue-to-drive-huge-changes-in-data-center-capacity-trends

Another strategy that mid-tier operators are leveraging to reduce overhead costs is colocation with other providers. Colocation has nearly doubled in size within the last five years with occupancy increasing at more than 30 percent[5] annually. The global edge market is expected to reach $317 billion by 2026.[11] Drivers behind this growth include artificial intelligence, Internet of Things and 5G networks that require low latency. Low latency is achieved through processing data closer to the source, which is spearheading the need for more geographically dispersed data centers. With digital transformation increasing at a CAGR of 23.7 percent[12] between 2024 and 2030, colocation and edge data centers are uniquely positioned to provide fast processing near the source of data consumption.

Industry growth is underscored by institutional investment in data centers, with many investors launching joint ventures with tech companies and data center developers to fund hyperscale data center development. For example, Microsoft and BlackRock have recently launched a $30 billion data center investment fund,[13] and KKR has launched a $50 billion partnership to fund data center growth.[14] JLL estimates that between 2025 and 2030, more than 65 GW of new data center capacity will be added globally, representing a combine asset value of more than $650B.[15]

While the global market for data centers across all segments is growing at a compound annual growth rate of 15.9 percent[16] in the next three years, the U.S. currently leads the world in data centers, with over 5,300[5] spread throughout various states today. This growing footprint is estimated to consume over 5 percent[5] of the country's total generation by 2030. Supplying that consumption with power has become one of the top issues for data center developers cited by executives interviewed for this article,[17] as grid operators across the U.S. face interconnection delays and the need for new capacity and reliability upgrades. Historically, data centers' energy strategy has mainly been a cost center focused on working with the utility in the geography selected for development and running a backup power source, such as diesel generators. However, as grids have been challenged, connecting to the utility grid is often leading to increased cost and years-long delays, delays which can be costly in the fast-moving world of new deployment.[18]

In reaction to these challenges and supported by their scale and willingness to pay, tech companies building hyperscale data centers have focused on an all-of-the-above energy strategy, notably marked by signing a series of innovative agreements to secure clean power — repowering nuclear plants, signing off-take agreements with advanced nuclear players to make a play for power in the 2030s, working with regulators to establish a series of unique tariffs to get new power online (e.g., Fervo), and developing partnerships with renewable developers and investors to anchor new development (e.g., Intersect Power, TPG, Google).

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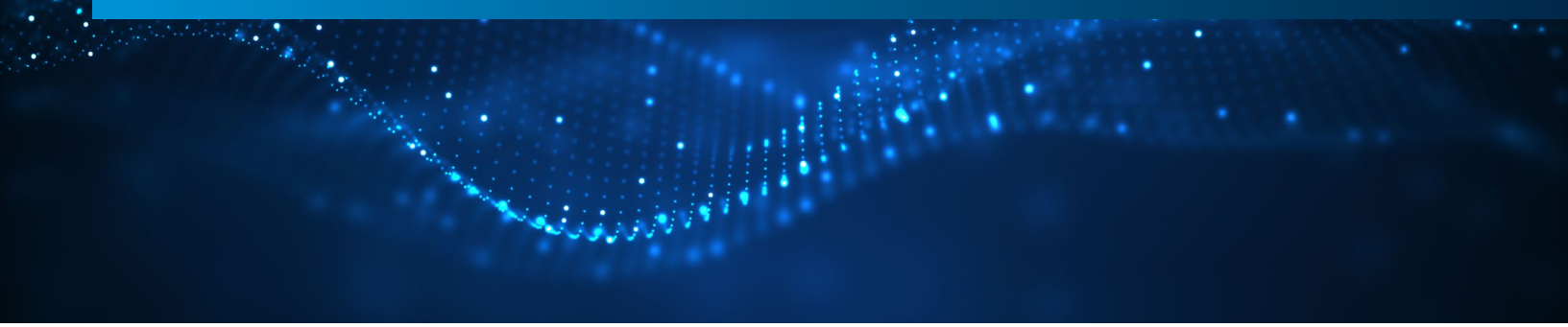


[11]"U.S. Data Center Report – Midyear 2024," https://www.us.jll.com/en/trends-and-insights/research/na-data-center-report

[12]"U.S. Digital Transformation Market Size & Outlook", Grand View Research, Accessed January 29, 2025, https://www.grandviewresearch.com/horizon/outlook/digital-transformation-market/united-states

[13]James Walker, "Microsoft, BlackRock Launch $30B AI Data Center Investment Fund," Data Center Knowledge, September 18, 2024, https://www.datacenterknowledge.com/investing/microsoft-blackrock-launch-30b-ai-data-center-investment-fund

[14]Justin McGowen, "KKR and ECP's $30bn partnership to address US data center energy 'bottleneck'," Infrastructure Investor, October 31, 2024, https://www.infrastructureinvestor.com/kkr-and-ecps-50bn-partnership-to-address-us-data-centre-energy-bottleneck/

[15]"2025 Global Data Center Outlook", JLL, January 2025, https://www.us.jll.com/en/trends-and-insights/research/data-center-outlook

[16]John Sanger and Kaushik Sriram, "Global Data Centre Insights 2024," Alvarez & Marsal, November 22, 2024, https://www.alvarezandmarsal.com/insights/global-data-centre-insights-2024

[17]Alvarez and Marsal's Energy team experts interviewed 10+ data center and energy developers in 2024. The interviews covered wide-ranging topics in an open format.

[18]Morgan Stanley calculated the value for even a single year of "time advantage" at $3.8/watt, a value that is >10 percent of the entire cost of the Data Center. "Powering Gen AI: The Mathematics of Time," Morgan Stanley, June 2024, https://www.morganstanley.com/im/publication/insights/articles/article_thebeatjune2024.pdf

> To procure energy/support development, leased hyperscale developers and mid-market data center players have adopted some similar strategies to the tech-owned hyperscalers while navigating unique challenges.

Meanwhile, the nontech and other developers of hyperscalers and mid-sized data centers across the other segments that would have previously focused on colocation or other strategies are having to reevaluate their data center development and energy strategy — also forcing them to play a more

active role than previously considered. To be successful in procuring energy and support development, leased hyperscale developers and mid-market data center players have needed to adopt similar strategies to the tech hyperscalers while navigating unique challenges.

These developers are facing five core challenges.

> Big tech companies are pioneering innovative energy procurement strategies — including advanced nuclear agreements, renewable partnerships and creative regulatory tariffs — to ensure reliable power well into the future.

Developing an energy strategy.

Securing the power capacity needed to efficiently and cost effectively build data centers has required an innovative and often "all-of-the-above" energy strategy. Data center developers' energy teams have needed to determine requirements, plausible jurisdictions, options for primary and backup power, and possible partnerships to support adequate power development. Both hyperscalers and middle-market companies face the same needs to develop energy strategies, but the ability for tech hyperscalers to take on risk and invest $100 million+ up front has allowed them to shorten otherwise lengthy development processes by up to three to four years. Hyperscalers have also been willing to create partnerships for future first-of-a-kind capacity (e.g., Google and Kairos Power) or to renew operations at nuclear plants at above market power costs (e.g., Microsoft and Constellation Energy). While pursuing these strategies may be outside of the strategic goals and constraints for middle-market players, there are a range of strategies that may be feasible including: developing new on-site capacity, developing partnerships with renewables and other energy developers to source energy, procuring power from cooperatives, IPPS or utilities that may be able to unlock extra capacity with strategic investment to the grid, among others. Conducting the analysis to determine the optimal strategy and support its execution goes beyond the traditional real estate and power price analysis. Innovative data center players outside of the hyperscalers are developing creative strategies to overcome the financial constraints inherent in the middle-market segments.

Navigating new approaches to the stakeholder ecosystem.

As energy strategies for data centers have become more complex, so too have the actions required to navigate the stakeholder ecosystem. While previously interconnecting to the grid was the primary requirement to work with the local utility, executing on the options in your energy strategy may require sophisticated questions and analysis that can range from technical analysis of line ratings and load studies to new financial and regulatory structuring for partnerships involving multiple entities. While some utilities and investors have adapted to structure their teams and data to support the

analysis required, many data center developers have found that they have needed to proactively conduct analysis and know what follow-up questions to ask to ensure a collaborative partnership that enables innovative approaches to getting new power online. Moreover, some of the newer arrangements that tech-owned hyperscalers have begun to pioneer involve new approaches to rates and regulatory questions that may require new capabilities to navigate successfully. While the middle-market segment players may benefit from tech-owned hyperscaler willingness to establish new precedents across jurisdictions, they will also need to rethink and retool their stakeholder engagement team to maximize the effectiveness of their strategies.

Importance of the Economic Development Ecosystem

Building new capabilities for the economic development ecosystem to support new power capacity that can enable new data centers and other industrial scale load is a critical goal for public sector state energy and economic development institutions. Data center and energy developers interviewed for this Perspective cited the complexity and range of permitting, siting and other utility and regulatory processes that limit the effectiveness of other public sector engagement mechanisms and extend the length of development to six to seven years for middle-market companies and developers. One developer cited a case where permitting and other power challenges increased the cost such that it cancelled out the effect of a recent tax abatement meant to support economic development. Leading state ecosystems are engaging as an active counterparty to develop alignment across the RTOs, grid planner, regulators, communities and economic development organizations to ensure timely access to data such as capacity maps and the creation of the right forums to support stakeholder discussion.

How to approach supply chain and capital delivery to minimize delays.

Shortages and delays for critical electrical equipment for data centers continue to increase, with the National Infrastructure Advisory Council reporting in June 2024 that the lead time for transformer procurement had increased to 120 weeks in 2024,[19] with similar shortages for other key equipment such as medium voltage switch gear. Geopolitical uncertainty around supply chains may also increase the importance of domestic production, which is currently limited, with the U.S. providing only around 20 percent[20] of the transformer market as well as lower production capacity for grain-oriented electrical steel that serves as a core input. In our interviews, data center developers expected supply chain challenges. Middle-market data center players should consider approaches such as a buyer's club to develop sufficient scale to secure orders and manufacturing capacity and support efforts for standardization of specs. Establishing fundamental procurement and EPC management best practices will also be crucial to minimize addressable costs and delays.

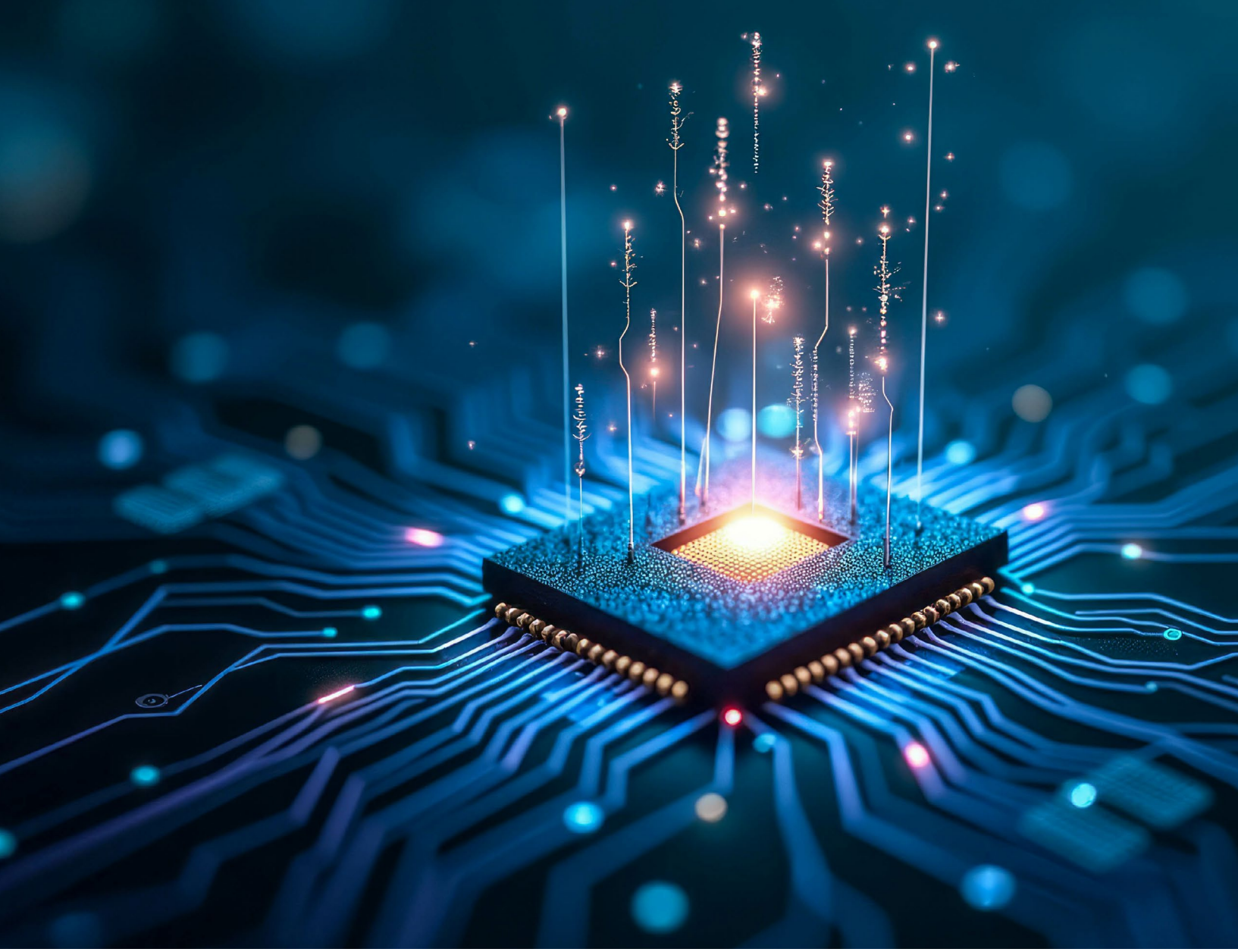
Deploying best-in-class operations and design to maximize efficiency from the build.

One additional challenge has been ensuring adequate cooling and overall efficiency. Legacy data center designs have faced challenges in securing adequate water for cooling. Many data centers located in geographies with less expensive power due to favorable renewables locations or other sources of energy have hot climates and require significant liquid cooling to reduce power demand for other cooling technologies. Unfortunately, many of these areas also face water scarcity issues, meaning developers and public sector and utility stakeholders need to explore alternate arrangements to ensure the most efficient and sustainable deployment of cooling, such as using reclaimed water from wastewater treatment plants for cooling. Such strategies can support liquid cooling, leading to an ~ 10 percent[21] decrease in power load demand. Many leading operators are now moving away from traditional liquid cooling and taking advantage of waterless or low-water cooling techniques that are closed-loop systems with refrigerant. Another core approach has been to deploy the

[19]"Addressing the Critical Shortage of Power Transformers to Ensure Reliability of the U.S. Grid," National Infrastructure Advisory Council, June 2024, https://www.cisa.gov/sites/default/files/2024-06/DRAFT_NIAC_Addressing%20the%20Critical%20Shortage%20of%20Power%20Transformers%20to%20Ensure%20Reliability%20of%20the%20U.S.%20Grid_Report_06052024_508c.pdf

[20]Zachary Skidmore, "Hitachi Energy CEO warns of transformer shortage," Data Center Dynamics, November 6, 2024, https://www.datacenterdynamics.com/en/news/hitachi-energy-ceo-warns-of-transformer-supply-shortage/

[21]"Quantifying the Impact on PUE and Energy Consumption When Introducing Liquid Cooling Into an Air-cooled Data Center," Vertiv, February 15, 2023, https://www.vertiv.com/en-emea/about/news-and-insights/articles/blog-posts/quantifying-data-center-pue-when-introducing-liquid-cooling/#:~:text=PUE%20is%20essentially%20a%20measure,reducing%20demand%20on%20server%20fans



latest in software technologies in the software stack to optimize efficiency; more detail on this approach is outlined in the sidebar discussion on Operational Efficiency and the Data Center Software Stack.

> Hiring special-skilled people — those with sufficient industry knowledge to meet the breadth and depth of complex energy — is a problem for all-size companies, as well as utilities and regulators.

Supporting the specialized talent needs required to execute on these strategies:

While tech companies have grown their energy teams with specialized experts over the last 10 years, other players will also need to continue to build out their energy and operations capabilities. However, many companies as well as utilities and regulators have faced challenges finding people to hire, people with sufficient industry knowledge to meet the breadth and depth of complex energy topics required. As one executive told us, “Everyone is always looking at cost, spreadsheets, accounting, but we need to also be looking at efficiency and productivity because growing the workforce will be a challenge.”

EXHIBIT 2

How Hyperscalers and Middle-Market Companies Are Addressing Core Challenges[22 23 24 25 26 27 28 29]

Core Challenge	Strategies Employed by Self-Owned Hyperscalers	Potential Approach for Mid-Market Companies
Developing an Energy Strategy *Securing power capacity to build and run data centers*	▪ Leveraging significant upfront investments ▪ Developing firstof-a-kind partnerships (e.g., Google and Kairos Power) ▪ Renewing operations at nuclear power plants above market power costs (e.g., Microsoft and Constellation Energy)	▪ On-site capacity development ▪ Partnerships with renewable energy developer ▪ Strategic investments in grid infrastructure ▪ Procuring power from cooperatives, IPPS or utilities
Navigating New Approaches to the Stakeholder Ecosystem *Data center developers must navigate increasingly complex stakeholder systems, requiring advanced technical, financial and regulatory analysis to execute energy strategies and enable innovative power solutions.*	▪ Structuring teams and data to conduct necessary financial and technical analysis in collaboration with utilities and regulatory bodies (e.g., AWS committed funding for power utilities in Virginia and Washington to explore adding SMRs to existing energy stations and, in exchange, secured the right to purchase power from four SMR installations.[1])	▪ Ensure that strategic approach to power considers innovative approaches to public sector and regulatory engagement. ▪ Prepare team to work with investors and regulators to explain new approaches to development.
Approaching Supply Chain and Capital Delivery to Minimize Delays *Data center developers face critical equipment shortages and geopolitical risks in supply chains, leading to extended lead times and reliance on limited domestic production.*	▪ Disintermediating OEMs and engaging directly with commodity suppliers[2] (e.g., Google cut out OEMS and shared server specs directly with ODM, such as Quanta and Wistron.[3]) ▪ Leveraging technology (IoT, blockchain and advanced analytics) to create end-to-end visibility and transparency across future supply chain networks.[4] ▪ Diversifying supplier base and promoting collaborative practices.[4]	▪ Create a buyers' club to achieve scale, secure orders, ensure manufacturing capacity and drive spec standardization. ▪ Establish procurement and EPC management best practices to reduce costs and avoid delays.
Deploying Best-in-Class Operations and Design to Maximize Efficiency From Build *Data centers in hot, low-cost energy regions face water scarcity challenges for liquid cooling.*	▪ Increasing use of recycled wastewater (e.g., AWS in Virginia and California[5]). ▪ Deploying innovative technologies that don't heavily consume water (e.g., Nvidia's direct-to-chip cooling[6]).	▪ Implement water-efficient cooling technologies (e.g., Novva Data Centers' water-free cooling systems[8]) or newer waterless or low water solutions ▪ Deploy latest software technologies in software stack
Supporting Specialized Talent Needs Required to Execute on Strategies *Organizations struggle to find qualified talent with deep industry expertise to address complex energy challenges.*	▪ Expanding energy teams with specialized experts (e.g., Microsoft hired Jay Parikh, a chief engineer for Meta's data center projects.[7])	▪ Hire energy team and/or targeted hires with specialized talent focused on core needs for targeted strategy.

[22] "Amazon signs agreements for innovative nuclear energy projects to address growing energy demands," Amazon, October 16, 2024, Amazon enlists nuclear small modular reactors in push for net carbon-zero

[23] "How suppliers can look at the hyperscale data center market," McKinsey, October 26, 2018, How suppliers can look at the hyperscale data center market | McKinsey

[24] "Semiconductors Swim with Seven Whales," EE Times, July 25, 2019, Semiconductors Swim with Seven Whales - EE Times

[25] "Top Data Center Construction Challenges and Solutions," ENCOR Advisors, October 8, 2024, Top Data Center Construction Challenges and Solutions - ENCOR Advisors

[26] "AWS using reclaimed wastewater for data center cooling at 20 locations," Data Center Dynamics, November 23, 2023, AWS using reclaimed wastewater for data center cooling at 20 locations - DCD

[27] "Novel Ideas to Cool Data Centers: Liquid in Pipes or a Dunking Bath," WSJ, August 11, 2024, Novel Ideas to Cool Data Centers: Liquid in Pipes or a Dunking Bath - WSJ

[28] "Microsoft Hires Engineer Who Kept Facebook Data Centers Humming," BNN Bloomberg, October 31, 2024, Microsoft Hires Engineer Who Kept Facebook Data Centers Humming

[29] "Novva's Fifth US Data Center Redefines Sustainability," JSA, November 29, 2023, Novva's Fifth US Data Center Redefines Sustainability - JSA

Conclusion

Data center development has rapidly evolved in response to emerging technologies, changing enterprise requirements and increasing sustainability concerns. From hyperscale facilities required to power generative AI models, to smaller edge and colocation centers providing faster, low-latency services closer to consumers, the market's demand spectrum is more diverse than ever.

Yet this growth has exposed critical challenges, most notably in power availability. Big tech companies like Google, Microsoft and others have taken the lead, pioneering innovative energy procurement strategies — including advanced nuclear agreements, renewable partnerships and creative regulatory tariffs — to ensure reliable power well into the future.

Meanwhile, middle-market developers and operators are caught in a balancing act. They face limits on large-scale capital investment but must still meet the unique needs of clients who value privacy, lower latency and cost-effective cloud solutions, while working in some cases to support the fast-growing hyperscale market. These middle-market players continue to compete by tailoring infrastructure — using modular rack designs and customized computing approaches that enhance efficiency and reduce overhead. As enterprise privacy concerns continue to rise, this strategy is gaining traction, positioning mid-sized operators for success if they can address the obstacles to securing power.

The road ahead for everyone is complicated by grid constraints, supply chain delays, and the pressing need for specialized talent that can navigate complex technical and regulatory landscapes. Ultimately, flexibility and strategic thinking are key. Where hyperscalers can absorb higher costs, invest in first-of-a-kind technology, and field large teams of energy experts to negotiate precedent-setting agreements, smaller providers must adopt creative, collaborative approaches to achieve the same power. Whether developing flexible strategies, forging alliances with new stakeholders or pooling resources to secure critical equipment, mid-tier data center developers will need to continue to find new ways to thrive in an environment shaped by both opportunity and constraint.

As the demand for data processing continues to grow, all segments of the data center sector will remain a critical backbone of digital infrastructure. Success hinges on each player's ability to balance power, cost and sustainability — ultimately shaping how efficiently we usher in the next wave of AI-driven innovation.

> Mid-market players compete by tailoring infrastructure — with modular rack designs and customized computing approaches that enhance efficiency and reduce overhead.

Operational Efficiency and the Data Center Software Stack

Data center providers have two approaches where power usage effectiveness (PUE) optimization can be pursued (see Exhibit 3). The use of various cooling techniques across the facility and rack design to reduce thermal dissipation is one approach. Leveraging the latest in software technologies in the software stack is the other.

A software stack is the collection of software used to operate and manage a data center, with an energy management system (EMS) overseeing the operations needed to manage the data center. The rest of the stack is comprised of the software associated with components inside, and any external power providers. The EMS can be commercially obtained and/or developed in-house. Like the technology advances in compute capabilities, new software technologies have the potential to improve efficiency, ultimately optimizing a data center's PUE.

Historically, software was either nonexistent or purely focused on delivering a set of functionality. Early generations of backup power supplies would be either on or off. Networks always maintained the same hardwired connections. To keep up with the 24/7 growing need for data center capacity and capabilities, a software layer was added to such components to continue delivering necessary functionality and to provide scalability.

Data center providers can now begin to explore their software stack to identify areas of optimization, ultimately reducing their PUE. While the software sophistication across the stack may vary, there are several new software technologies which can be leveraged to optimize aspects of data center operations.

EXHIBIT 3

Maturity of Technologies that Impact Operational Efficiency

Technology	Maturity	Relevance
AI and ML[30]	Growing	Operational efficiency and tenant support
Large Language Models (LLM) as Operating Systems[31]	Emerging	Optimize energy use, manage workloads
Information and Operation Technology Convergence	Growing	Enhanced energy management
Cognitive Digital Twins	Deploying	Optimize energy use through near-real-time energy simulation
Advanced Processors and Networking Systems[32]	Deploying	Lower power components
Quantum Computing[33]	Emerging	New computing paradigm

[30]Michael Crook, "2025 Data Center Trends and Predictions," Corning, October 31, 2024, https://www.corning.com/optical-communications/worldwide/en/home/the-signal-network-blog/2025-data-center-trends-and-predictions.html

[31]"Ana Rojo-Echeburúa, "LLM OS Guide: Understanding AI Operating Systems," DataCamp, September 25, 2024, https://www.datacamp.com/blog/llm-os

[32]Yonggang Wen, "Top 10 Data Center Trends in 2025: A Researcher Perspective," Cloud Application and Platform Group, School of Computer Science and Engineering, NTU, Singapore, January 1, 2025, https://www.ntu-cap.org/2025/01/top-10-data-center-trends-in-2025-a-researcher-perspective/

[33]Matt Vincent, "8 Trends That Will Shape the Data Center Industry In 2025," Data Center Frontier, January 6, 2025, 8 Trends That Will Shape the Data Center Industry In 2025

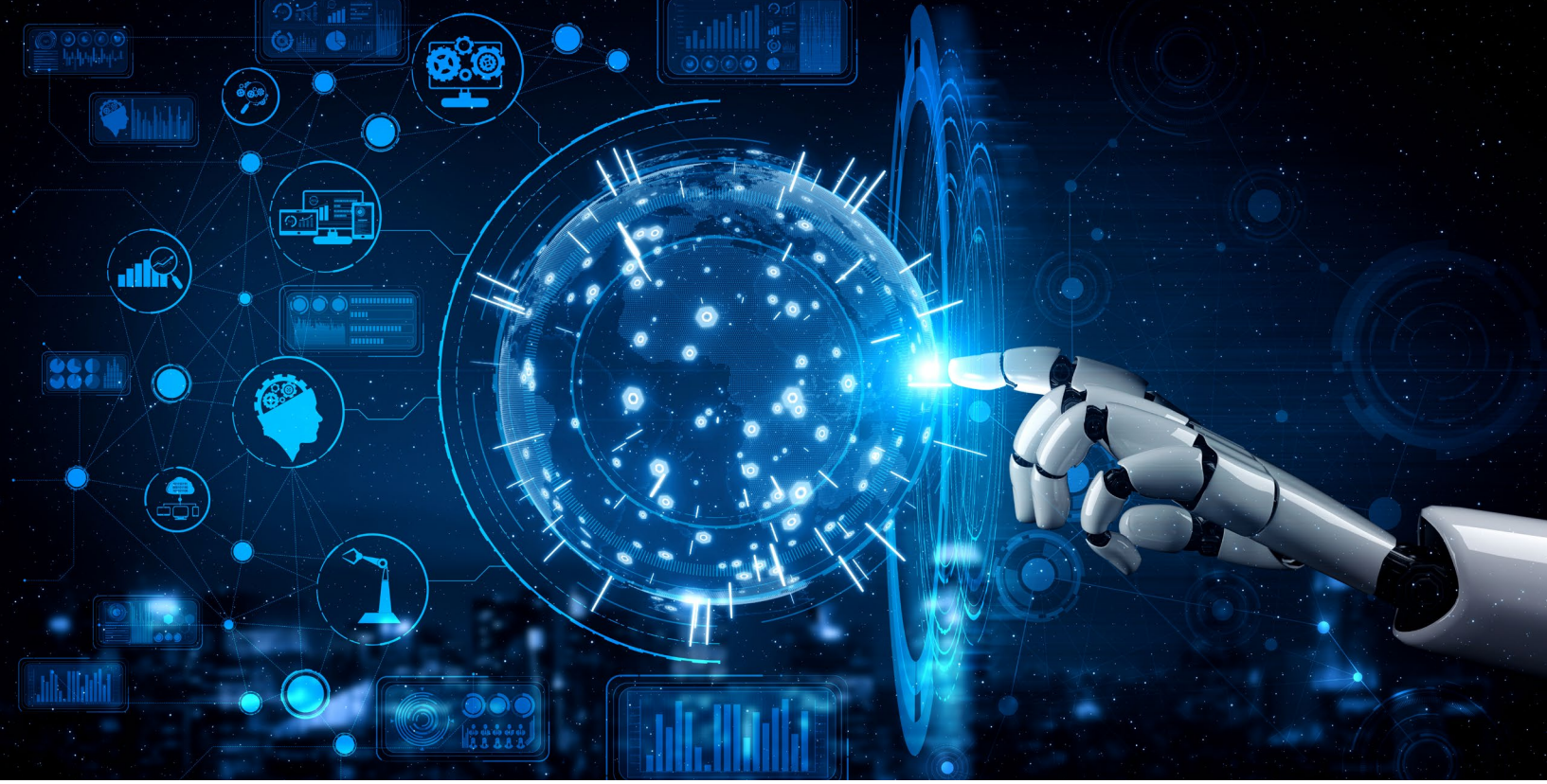
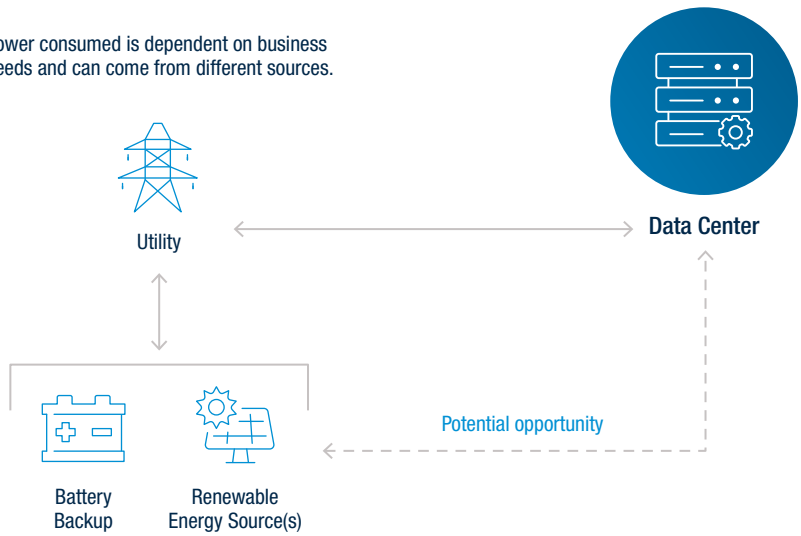


EXHIBIT 4

Minimizing Power Usage Effectiveness (PUE) Requires Deliberate and Thoughtful Design Across Components Inside

$$PUE = \frac{\text{power consumed}}{\text{equipment power}}$$

Power consumed is dependent on business needs and can come from different sources.



Equipment power is a function of component consumption and wasted energy can be optimized by:

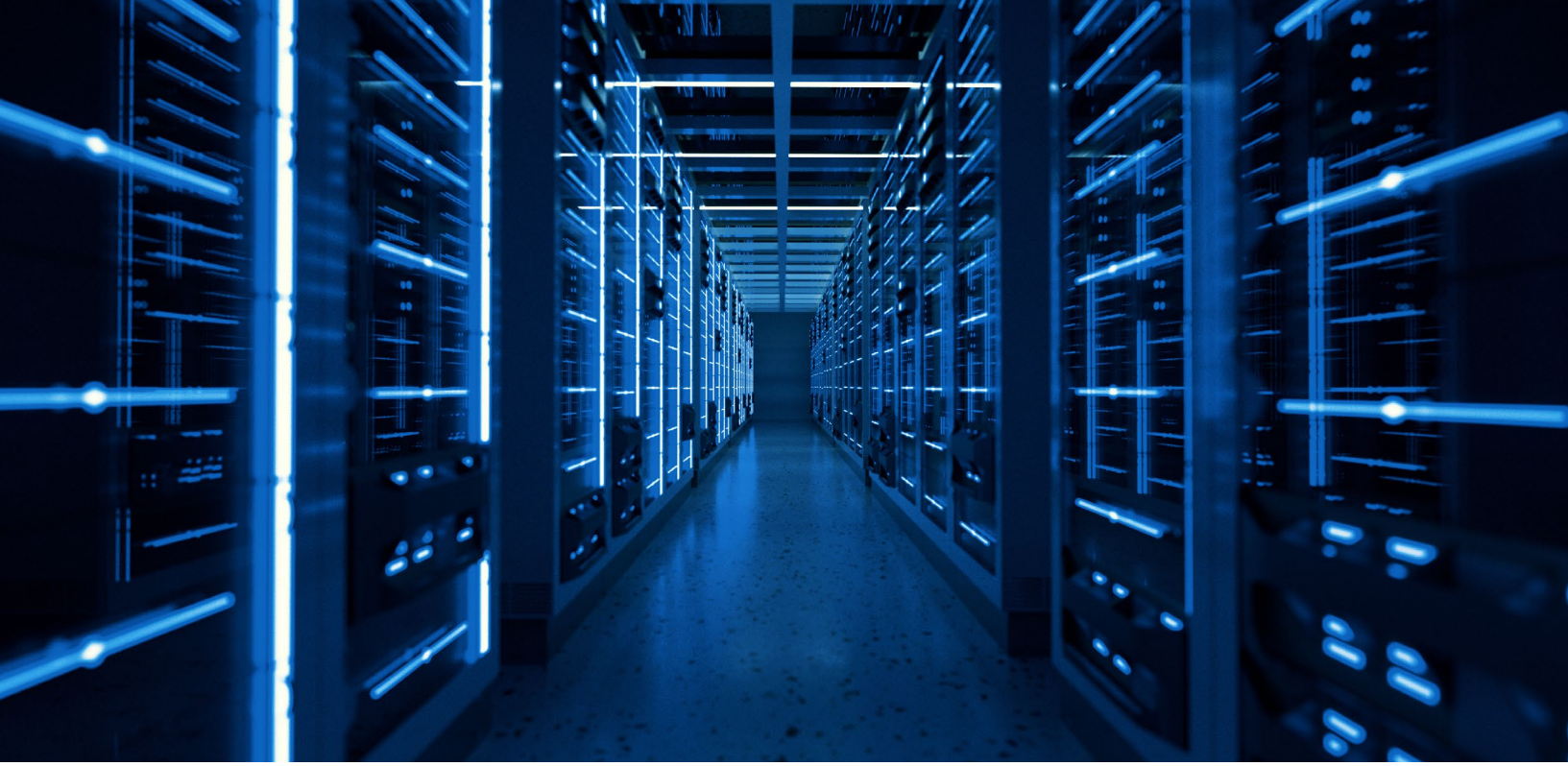
Minimizing wasted energy across non-compute components

Cooling Options

- Building Design
- Air and/or liquid
- Local Battery

Deploying energy-efficient hardware and optimizing thermal profile in rack design

- Compute Processing
- Rack Architecture



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