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Sector Insights

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Generative AI transforming data center landscape

There has been a great deal of investor attention around the development of generative artificial intelligence (AI), but it has been primarily focused on the most visible beneficiaries. In our view, the scale of investment taking place and its impact on the broader environment for a range of companies remains somewhat underappreciated. In this report, we discuss one such area of potential opportunity for investors — data centers. The world is generating data at breakneck speed, fueled in part by the adoption of generative AI at both the consumer and enterprise level. Data centers come into play as the foundation for storing, managing, and analyzing this growing inventory of information, and we expect substantial market growth with material impacts in a range of sectors.

What's inside

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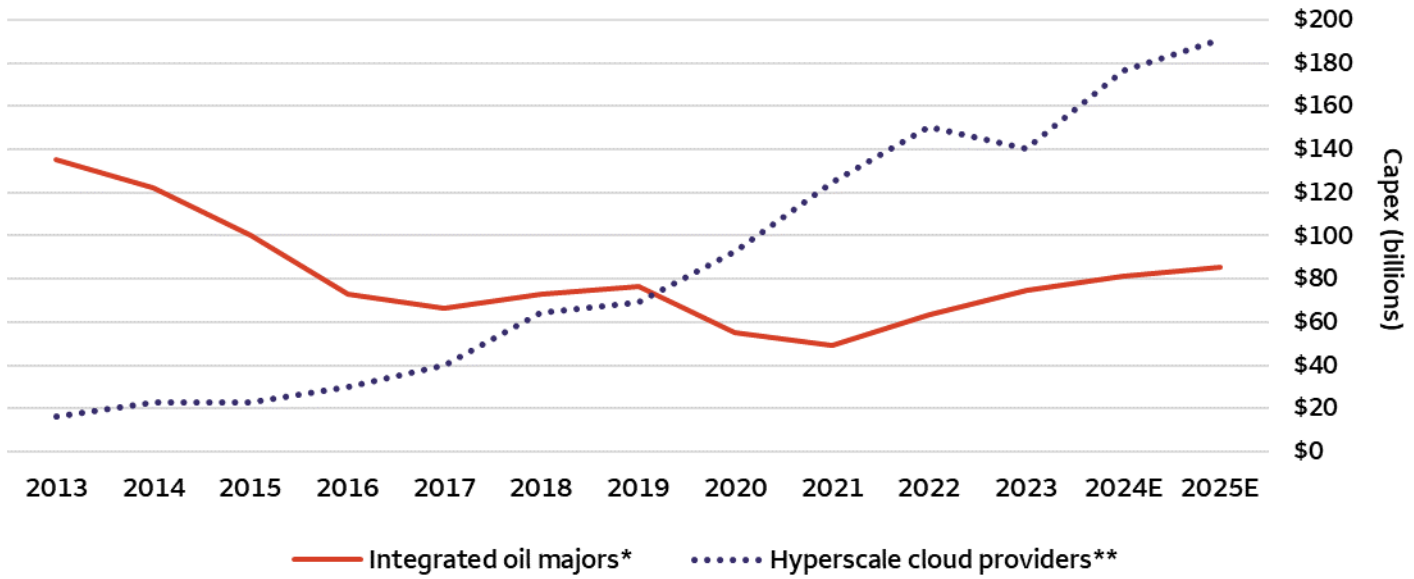
Translating AI into bricks and mortar

We believe investor attention has been primarily focused on the most visible beneficiaries of the material uptick in investment required to support the development of generative AI[1] — namely certain leading semiconductor firms and a small number of hyperscale cloud service providers (hyperscalers)[2]. But, we believe the scale of investment taking place and its impact on the broader environment for a range of companies remains somewhat underappreciated. For some perspective on the scale of this investment, we would note that consensus estimates for 2025 capital expenditures (capex) for the four largest hyperscalers suggest these companies will spend more than twice what the four largest integrated oil majors will spend on capex in the same year.

Capital expenditures for hyperscale cloud providers outpacing integrated oil majors



Sources: FactSet and Wells Fargo Investment Institute. Based on calendar year data; 2024 and 2025 data represent consensus estimates from FactSet. *Four largest global integrated oil majors by market capitalization (BP p.l.c, Chevron Corporation, Exxon Mobil Corporation, Royal Dutch Shell Plc). **Four largest cloud infrastructure companies by market capitalization (Alphabet Inc., Amazon.com, Inc., Meta Platforms Inc, Microsoft Corporation). Forecasts and targets are based on certain assumptions and on views of market and economic conditions which are subject to change.

Investors are accustomed to energy companies spending heavily on capex. After all, refineries, oil fields, offshore rigs, and liquified natural gas plants are a tangled web of large machines, engines, pipes, and valves. The largest portion of cost involved in constructing data centers is graphics processing units (GPUs) and the supercomputers that contain them, but the amount of other content should not be underestimated. This includes but is not limited to: cabling; steel racks; cooling (liquid and air); electrical equipment (both inside and outside the box); and backup generators. Secondarily, aggregates are required to lay the foundation and power generation to support the facility. As for medium-term growth prospects, we would note that in January 2023, McKinsey & Company projected that U.S. data center electricity consumption would grow roughly 10% annually from 2023 – 2030.

1. For an overview of the topic of generative AI more broadly and its implications, please refer to our Special Report titled "The ascent of generative AI — What investors should know".

2. Hyperscalers: A small group of companies who operate large networks of large data centers to facilitate cloud computing.

Understanding data centers

What is a data center?

At its core, a data center is a facility that houses complex computer systems, primarily racks of servers, data storage, memory, and other networking and communication equipment. The simple purpose of the data center is to store data that can easily be accessed when prompted by some user on the network. The other key functions of the data center are to manage, process, and distribute that data upon request. Location is a key component of a data center as operators need to take into account energy and construction costs; network access and reliability; and proximity to high-risk areas that are suceptible to natural disasters.

There are four primary types of data centers: on-premise, co-location, hyperscale, and edge. Data centers and, more specifically, hyperscale data centers, are becoming a more important component within the overall infrastructure, especially as emerging technologies like generative AI develop and are deployed on a larger scale. Hyperscale data centers are just that — larger in size and scale. These types of data centers generally have many more components and equipment inside the facility and typically process much larger sets of data. Hyperscale data centers often require more equipment inside the facility (including servers, storage, and cooling systems) because they tend to generate an increased amount of heat. Further, given the mission-critical nature of hyperscale data centers, redundancies and back-up processess are built into the infrastructure in case of an emergency such as a power outage, natural disaster, or even a security breach. Given the amount of power required to run a hyperscale data center and, more specifically, an AI-specific data center, operators need to design them to maximize efficiencies and are likely to position the data center near a power supply location on the power grid.

Why has data center demand picked up?

In the past, traditional AI has been helpful in making predictions of outcomes and focusing on a narrow task, such as accurately identifying and categorizing images. Generative AI, on the other hand, offers broader applications — it works off of text prompts and enables machines to generate unique and new content using trained data. A few examples of this unique content include images, videos, music, essays, language, conversations, and even automating the writing of software code itself.

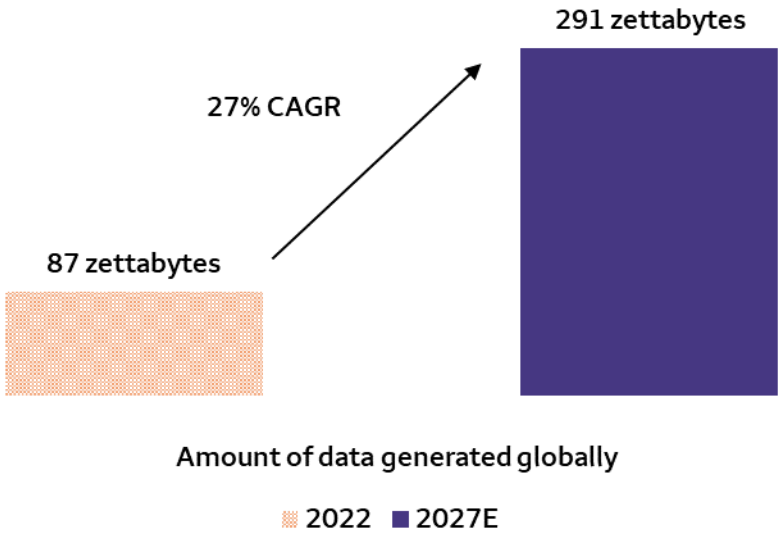
Following the successful rollout of ChatGPT in November 2022, the rapid adoption of generative AI along with the ongoing adoption of cloud computing has been driving higher levels of demand for data centers. The ongoing digital transformation of the economy, cloud computing, and generative AI is contributing to an abundance of data generated by enterprises and consumers, which is driving a unique set of demands on the modern data center. Enterprises are demanding their data be more distributed, cloud based, and on demand at any moment in time. We believe key secular trends including the digital transformation of the economy, generative AI, cloud computing, the Internet of Things, and autonomous driving are all helping drive worldwide data center marketplace expansion over the near to intermediate term.

Popular large language models based on generative AI (including ChatGPT-4) are trained on massive amounts of existing text and images from the worldwide web. The world is generating data at breakneck speed, fueled in part by the adoption of generative AI at both the consumer and enterprise level. Data centers come into play as the foundation for storing, managing, and analyzing this growing inventory of information. As data analytics and data-intensive generative AI large language models gain traction in the marketplace, we believe this should help support future demand for data centers.

Why are data centers increasingly resource intensive?

AI-focused data centers typically use more expensive servers that are powered by leading-edge GPU chips for training large language models compared to traditional enterprise servers supported by a central processing unit (CPU) chip. The compute-intensive nature of generative AI workloads compared to traditional information technology (IT) workloads is presenting new challenges for overall IT infrastructure, particularly in the form of higher levels of energy consumption. The power-hungry nature of these workloads requires significant amounts of computing, storage, and networking infrastructure. According to a large utility company, the server rack power density required to train a generative-AI-based large language model can require up to five to seven times more power than server racks used for traditional IT workloads in a data center.[3] Meanwhile, inference workloads for generative-AI-based large language models use two to three times as much power as a traditional server. For a brief introduction to training and inference workloads used in AI based large language models, please see the Appendix section of this report.

Growth of data expected to accelerate markedly



Sources: Vertiv 2023 Investor Conference. Date: November 29, 2023. CAGR = compound annual growth rate. E = estimate

Investment implications and specific investment ideas

We believe the strong and growing activity in this end market is supporting select companies across multiple sectors. Yes, the primary impact is found in Information Technology and Communication Services (both rated neutral by Global Investment Strategy). But we believe investors should also be aware of the investment implications for companies in the Industrials and Materials sectors (both rated favorable by Global Investment Strategy). In subsequent pages, we provide individual security recommendations across a range of sectors followed by more details on sector-level implications.

3. S&P Global, "Power of AI: Surging datacenter load has Dominion bracing for AI's added demand," October 17, 2023.

Investment ideas and corresponding policy areas

Ticker	Company Name	Sector	Price	Market cap (billions)	Hyperscalers	Semiconductors and Related	Semiconductor Investment	Data Center Equipment	Related Infrastructure
GOOGL	Alphabet Inc. Class A	Communication Services	$150.77	$1,874.5	X				
META	Meta Platforms Inc Class A	Communication Services	$509.58	$1,299.1	X				
AMZN	Amazon.com, Inc.	Consumer Discretionary	$178.87	$1,858.0	X				
CAT	Caterpillar Inc.	Industrials	$358.11	$178.8				X	
ETN	Eaton Corp. Plc	Industrials	$316.58	$126.5				X	
FERG	Ferguson Plc	Industrials	$221.27	$45.2				X	
TT	Trane Technologies plc	Industrials	$300.29	$68.2				X	
EMR	Emerson Electric Co.	Industrials	$112.45	$64.3					X
MSFT	Microsoft Corporation	Information Technology	$428.74	$3,185.7	X				
ORCL	Oracle Corporation	Information Technology	$127.79	$351.2	X				
AMD	Advanced Micro Devices, Inc.	Information Technology	$179.65	$290.3		X			
ANET	Arista Networks, Inc.	Information Technology	$306.42	$95.8		X			
AVGO	Broadcom Inc.	Information Technology	$1,353.47	$627.2		X			
CSCO	Cisco Systems, Inc.	Information Technology	$49.78	$201.6		X			
MRVL	Marvell Technology, Inc.	Information Technology	$66.54	$57.6		X			
NVDA	NVIDIA Corporation	Information Technology	$942.89	$2,357.2		X			
TSM	Taiwan Semiconductor Manufacturing Co., Ltd.*	Information Technology	$140.54	$729.0		X			
WDC	Western Digital Corporation	Information Technology	$63.94	$20.8		X			
ASML	ASML Holding NV ADR	Information Technology	$979.96	$389.0			X		
AMAT	Applied Materials, Inc.	Information Technology	$210.25	$174.7			X		
SNPS	Synopsys, Inc.	Information Technology	$594.20	$90.6			X		
APH	Amphenol Corporation Class A	Information Technology	$114.42	$68.6				X	
DD	DuPont de Nemours, Inc.	Materials	$75.74	$31.6					X
ECL	Ecolab Inc.	Materials	$229.27	$65.5					X
MLM	Martin Marietta Materials, Inc.	Materials	$607.12	$37.5					X
NUE	Nucor Corporation	Materials	$194.44	$46.8					X
EQIX	Equinix, Inc.	Real Estate	$800.97	$75.8					X

Sources: FactSet, Wells Fargo Investment Institute. Data as of March 22, 2024. *Sponsored ADR.

Sector-level impacts

Information Technology, Communication Services, and Consumer Discretionary

From a high level, we expect the Information Technology and Communication Services sectors to benefit from increasing levels of data center demand. We continue to believe that many of the companies involved in the development of the technologies supporting converging trends and themes (such as AI, augmented and virtual reality, the Internet of Things, and connected devices) are often focused on multiple product lines. In our view, multiple semiconductor, networking, storage, and hyperscale cloud companies will most likely be the ones helping to create the digital infrastructure necessary to support the modern data center.

On semiconductors, we hold a neutral shorter-term view as we balance recent valuation expansion with strong earnings momentum. We do continue to see long-term investment opportunities for companies supporting the highly compute-intensive nature of AI-focused data centers. Modern advances in GPU architecture such as parallel processing have been crucial in powering modern AI servers. GPU chips are used to train the majority of deep neural networks and large language models used to perform deep-learning AI tasks, including generative AI. We believe leading GPU chip suppliers are well positioned to benefit from the proliferation of AI and high-density rack servers in modern data centers. Also, we expect leading semiconductor companies that sell leading edge networking and storage chips to benefit from supporting the networking silicon needs of data centers.

In addition, we believe the current landscape can be characterized as one of deep pockets – that is, the companies with the largest pools of capital and high-quality data sets should ultimately prevail among the multiple long-term technology trends. Simply put, these companies possess the largest amounts of data already gathered through their research and development efforts, while they also often boast the largest piles of cash on their balance sheets.

Hyperscale companies are found within the Software sub-industry of Information Technology and in the Communication Services and Consumer Discretionary sectors, and they continue to spend capital to build out data center infrastructure. We believe there will continue to be significant data center capacity brought online over the next few years, driven by the rapid growth of AI applications and sustainable data center demand. Advancing technologies and end-user applications (such as gaming, streaming, and increased usage of large language models) will continue the trend of rising data center demand. According to Synergy Research Group, hyperscale data center capacity is expected to triple by the end of 2029, driven by high-compute AI-related applications.[4] That expansion could take the form of new data centers or expanded (or retrofitted) locations to increase capacity and handle the high-intensity workloads typical of AI-related functionality.

Cloud vendors need to perform a great deal of work to manage the infrastructure of the cloud. In order to provide a reliable network, these companies need to invest heavily in the hardware (servers), virtualization technology, and the overall network infrastructure — that is, the backbone of the cloud. The cloud vendors are tasked with managing and maintaining the overall cloud infrastructure and are responsible for making their cloud services available to their cloud customers. In our view, the largest cloud vendors (which includes Amazon, Microsoft, and Alphabet) should continue expanding their data center footprint to support the growing acceptance and usage of generative AI applications (see chart on page 2).

We believe the ongoing secular shift to the cloud remains one of the most powerful themes within software and represents a generational shift. In our view, we are likely in the early years of a multi-decade transition as businesses realize the efficiency gains and economic benefits of moving large amounts of data from on-premise to the cloud. Revenue derived from cloud businesses continues to rise at a rapid pace and, in our view, the three largest cloud vendors continue to establish their dominance within the space, especially as they continue investing large amounts of capital to build out massive data centers with cutting-edge technologies.

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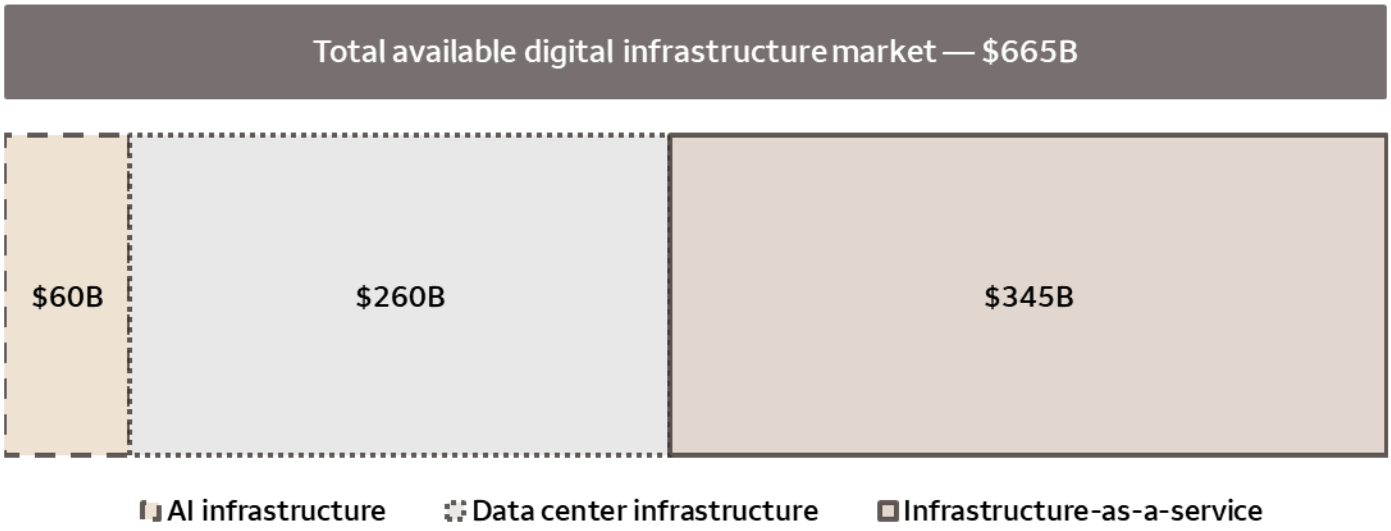
4. Synergy Research Group, "Hyperscale Data Center Capacity to Almost Triple in Next Six Years, Driven by AI", October 17, 2023.

Estimated size of data center market and sub-markets by 2026



Source: Equinix, Inc. 2023 Analyst Day. Data as of June 21, 2023. All figures estimates of market size by 2026.

Industrials and Materials

A data center may not be a factory, but if it walks like a duck and quacks like a duck, it might be a duck. To put it in perspective, Amazon recently purchased a 960 megawatt data center (very large in relation to prior generations of data centers) for $650 million. It is important to note that we believe this price tag is largely reflective of the cost to build the facility and its basic utility connections, and it does not include kitting out the facility with server racks. We cite this statistic as it gives some scale to the addressable market that companies in the Industrials and Materials sectors could play in. This may not be quite the outlay for an electric vehicle battery factory ($0.7 – $5.5 billion) or a large semiconductor fabrication plant (a project in Arizona currently carries a first phase price tag of $12.0 billion), but is still a substantial amount of capital expenditure.

When it comes to a breakdown by structural trade area, Dgtl Infra estimates that approximately 35% – 45% of the cost is related to land, building shell, and basic building fit-out. These areas are addressable by companies who supply steel, aggregates, cement, and water equipment and, by extension, construction and engineering firms as well as broad non-residential construction suppliers (such as industrial distributors). Dgtl Infra also estimates that 40% – 45% and 15% – 20% of the remaining cost can be attributed to electrical and HVAC systems respectively. We would note that there are a relatively limited number of scaled suppliers of large electrical equipment, commercial HVAC systems, and diesel generators. We would also note that these figures likely underestimate the amount of incremental demand for data centers — depending on geography, they could require incremental investment in both the electrical grid and power generation, which are again significant end markets for the leading players in electrical end markets.

Bottom line, this is now a meaningful end market for a growing number of companies in the Industrials sector and a tailwind for select companies in the Electrical Equipment, Building Products, and Industrial Machinery sub-industries. Multiple electrical equipment vendors are expanding their facilities to support the broader increase in demand for electrification. HVAC suppliers have expanded their technology portfolios to better serve the cooling needs of this market. Even makers of large-scale diesel generators have announced facility or line expansions targeted for back-up power supply in this area. Based on company disclosures, we believe that for those involved, this end market represents anywhere from a low-single-digits percentage of revenue on the low end to a mid-teens percentage on the high end.

Materials may not be the first sector that comes to mind in relation to AI, yet there are a number of companies within Materials that are seeing significant growth from the AI revolution in various ways. This includes increased demand for materials that are used in the production of semiconductor chips, water handling and recycling within data centers, and steel and construction materials to build data centers. Companies with exposure to these trends are generally diversified across many end markets, and we therefore do not necessarily recommend the Materials sector specifically as an AI-related investment opportunity. However, we do note that AI infrastructure has commonly been cited as one of the most important growth drivers for those companies which have exposure, and we expect for this to remain the case for the foreseeable future. We view this as a testament to the broad-reaching nature of the AI economy and the growth that it is driving across a number of ancillary industries.

Exposure by sector

	Hyperscalers	Semiconductors and related	Semiconductor investment	Data center equipment	Related Infrastructure
Communication Services	X				
Consumer Discretionary	X				
Industrials				X	X
Information Technology	X	X	X	X	
Materials					X

Source: Wells Fargo Investment Institute.

Appendix

Types of semiconductor chips running generative AI applications and data centers

AI software runs on semiconductors. Machine learning algorithms are deployed using both GPUs and CPUs. GPUs have been the silicon of choice used for training deep learning models while general purpose CPUs have historically been used for AI inferencing. However, GPUs have proven useful for both training and inferencing purposes. Modern advances in GPU architecture, such as parallel processing architecture, have been crucial in powering modern AI advancements. GPUs are designed with hundreds of processor cores that use parallel processing architecture to break jobs into separate tasks and process multiple tasks simultaneously, whereas CPUs are typically designed with fewer processor cores and offer high clock speeds compared to GPUs. This allows CPUs to process individual tasks very quickly.

Field-programmable gate array (FPGA) semiconductor chips are also typically used for inferencing applications and less so for AI training. Chip designers can program and reprogram these chips for different AI applications. AI applications in the data center have high memory bandwidth requirements as well as a need for dynamic random access memory (DRAM) chips.

Application-specific integrated circuit (ASIC) semiconductor chips can be designed for either AI training or inference purposes. Although several large-capitalizaton technology companies (including the cloud service providers) continue to use GPUs to power their larger language models, many have internally developed their own custom ASIC chips for AI applications used in data centers.

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