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WHITEPAPER:
DIGITAL INFRASTRUCTURE OVERVIEW & OPPORTUNITIES

PHOENIX MERCHANT PARTNERS

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Abstract

Building upon Phoenix's previous whitepapers on the **U.S. Payments Industry** (October-2023) and **Battery Energy Storage Systems** (February 2024), the objective of this report is to present an overview of opportunities in **Digital Infrastructure**, a sector that represented a growing trend over the past decades. This paper covers:

- An overview of Datasphere components, including the evolution of data sources and their quality
- A short summary of the role of data connectivity as driver of the real-time data economy
- A description of the data center economy, its growth projections and development constraints
- A review of opportunities for middle market businesses across the data center ecosystem

Our review supports our perspective on the investment opportunities within data infrastructure, characterized by a broad value chain experiencing significant growth. Specifically, we target the data center space, with its combination of physical components, business services and operators.

Digitalization and the Datasphere

The process of **Digitalization** - applying digital technologies across business processes, organizational activities and all aspects of everyday life - has been accelerating steadily since the information revolution began in the mid-20th century. Advances in digital transmission, processing, storage, and interface technology have been key growth drivers. However, central to this digital transformation is the integration of data across all areas of human activity.

The global environment of interconnected digital data is referred to as the **Datasphere**. It encompasses all data generated, processed, and stored across various digital devices, networks, and platforms. The Datasphere represents the vast and continuously expanding universe of digital information that drives decision-making and communication in today's world.

Under the Datasphere, three primary locations are defined[1], between which content is created and information flows in a constant stream.

Figure 1 – For Illustrative Purposes Only

	Primary Data Locations
Core	• Enterprise and cloud data centres as well as operational facilities (e.g. running electric grid and telephone networks). • Provides centralized long-term storage, deep-level analytics, system management and control, and regulatory compliance.
Edge	• Regional data centres, cell towers, and dedicated servers/gateways located near end users and devices. • Provides real time analytics, temporary/cached data storage and messaging. Enables content providers to reduce latency
Endpoints	• All devices on the edge of the network, including smart phones, industrial sensors, connected cars, IoT devices, and wearables • Creates a constant flow of embedded data that increases demand for real time data processing and transmission

[1] IDC: "The Digitalization of the World from Edge to Core", May-2020

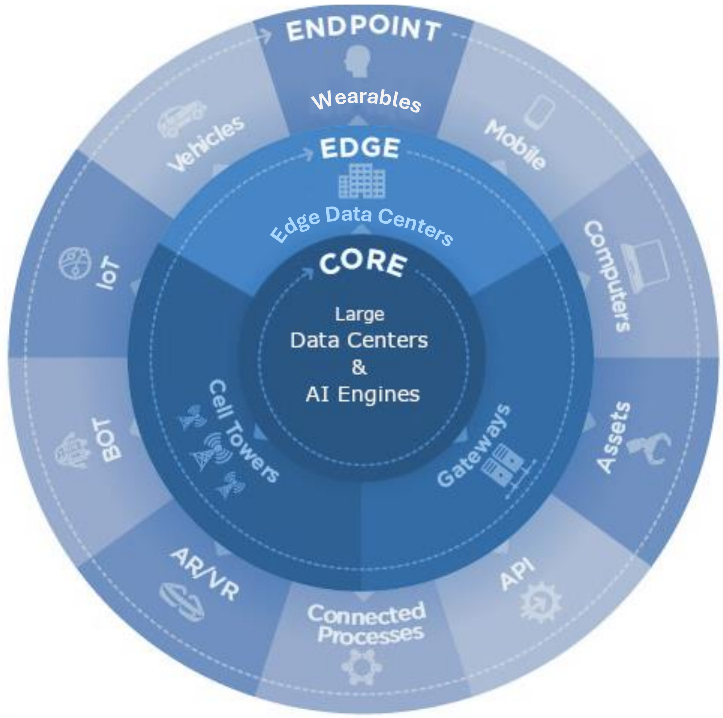
Data has become a fundamental building block of today's economy, its significance continues to grow as:

- Companies capture, categorise, and analyze data at every step of their supply chain and production processes;
- The proliferation and interconnection of sensors across the Internt of Things (IoT) enable automation of complex tasks;
- Enterprises collect vast amounts of customer data to provide personalized services; *and*
- Consumers integrate social media, entertainment, e-commerce and health monitoring services into their daily life.

This increasing reliance on data is driving the exponential expansion in the size of the global Datasphere.

Figure 2 – For Illustrative Purposes Only

Data Propagation between Primary Locations



Source: IDC Data Age Study 2025

Total annual data created at the edge, core, and endpoint device levels is predicted to exceed 200,000 exabytes by 2026, having grown at a compound annual growth rate (CAGR) of 21.2% since 2021[2]. Volume expansion is driven by data mobility, AI/cloud analytics, and social media requirements. This includes both structured and unstructured data, with unstructured data dominating, accounting for more than 90% of the data created each year.

The Evolution of Data Creation

While large data creation has historically been driven by consumer-creators (e.g., content on social media platforms), the growth in volume is increasingly resulting from **Business-Creators**. Businesses are sharing data with counterparts and sets of devices supporting business processes. By 2025, 60% of the world's data will be generated by businesses activity[3].

Another significant data trend is the rise of **Real-Time Data** processing (i.e. streaming). Consumer appetite for real-time apps and services, such as e.g. location tracking, transport, retail deliveries, and payments, is well established. However, most real-time data - up to 95%[4] - will be produced by a broad range of IoT sensors, which control newly automated industrial, business and P2P processes.

Recent advances in **Artificial intelligence** have launched the next wave of productivity gains. In particular Generative AI, which requires vast data sets for training and inference, could expand to 10-12% (c. $1.3Tn)

[2] IDC: "High Data Growth and Modern Applications Drive New Storage Requirements in Digitally Transformed Enterprises", Jul-2022

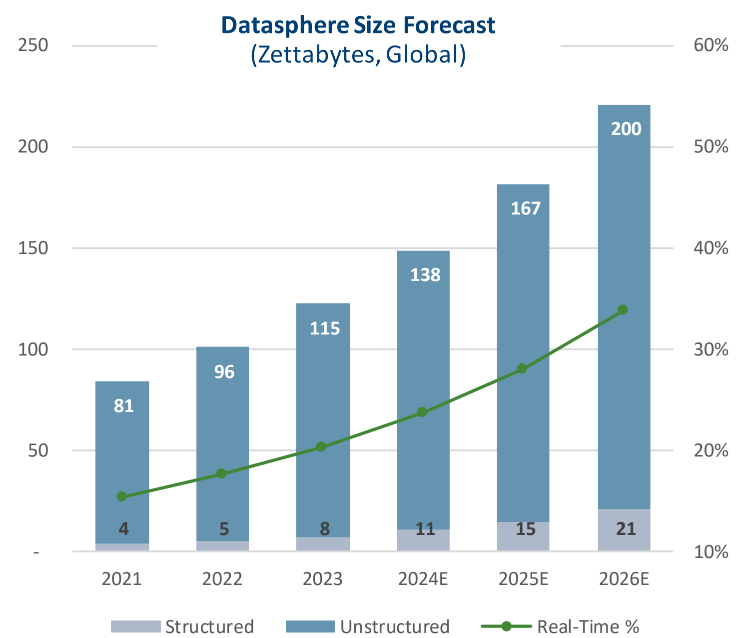
[3] Medium: "The reality of megatrends = 175 ZB of data by 2025", 09-May-2019

[4] IBM: "Build a better data lake", Apr-2018

of information-technology hardware, software, services, and gaming expenditures by 2032[5]. Servers and storage in core locations (i.e. public cloud data centers) are expected to see high demand as companies build out AI infrastructure to handle their increased generative-AI workloads

As data within industries starts to become available in real time, the effective application of AI will rely on industry-wide implementation of real-time streaming APIs as data interfaces between user endpoints and the AI foundation models at the core.

Figure 3 – For Illustrative Purposes Only



Structured	Un-Structured
Organized in a fixed format or schema	Not organized in a predefined structure
Stored in databases and spreadsheets	Found in text documents., images, video etc.
Can be easily queried and analysed	Requires advanced techniques for analysis
Fits well in traditional data models	Doesn't fit well in traditional models
Easy to process, manipulate and visualize	Often requires Natural language Processing
Well-suited for numerical calculations	Contains valuable data but unformatted
Typically generated by structured systems	Generated by humans and digital interactions

Source:
IDC Global DataSphere and StorageSphere Structured and Unstructured Data Forecast, 2022-2026

The Role of Connectivity

Existing connectivity technologies continue to evolve with **5G Networks** offering significant improvements in bandwidth/latency, and supporting a greater density of connected devices. **Fiber Optics** networks continue to expand, while the next generation of **Wi-Fi** will improve speeds in the last mile of access.

Advances in connectivity are a prerequisite for the real-time data economy, enabling seamless data propagation between endpoints, edge and core. The combination of low latency bandwith, data processing/storage capacity, and artificial intelligence analytics is unlocking new capabilities in major commercial domains, including "mission-critical" applications that demand absolute reliability and responsiveness. Example use cases include[6]:

- **Connected Mobility:** In current autonomous vehicle implementations, a substantial amount of data processing from sensors and lidar systems (generating ~4 terabytes data[7] per day, per car) is done locally within the vehicle. However, advancements in road infrastructure, such as dependable high-

[5] Bloomberg: "Generative AI races toward $1.3 trillion in revenue by 2032", 08-Mar-2024

[6] McKinsey: "Connected world – An evolution in connectivity beyond the 5G revolution", Feb-2020

[7] Intel Corporation: "Data is the new Oil – AutoMobility LA", Nov-2016

speed connectivity (e.g. 5G), hold the potential to shift these tasks to the edge or cloud. This transition can reduce hardware costs while facilitating vehicle-to-vehicle, vehicle-to-network, and even vehicle-to-pedestrian communication.

- **Networked Healthcare:** Approximately 30% of the world's data volume is generated by the healthcare industry[8]. Hospitals produce ~50 petabytes of data annually[9], including clinical notes, lab tests, medical images, sensor readings, genomics, and operational data. However, much of this data goes unused. Despite the industry's growth, we believe there is significant untapped potential in data technology, presenting opportunities for investment in the sector's transformation. Potential applications leveraging data connectivity include:
  - Remote patient monitoring, alerting patients and caregivers to needed preventive measures.
  - Integrated command centers for real-time hospital operations management.
  - AI-powered decision support tools for accurate diagnoses based on real-time information.

Looking ahead, the introduction of 6G network technology – projected for commercial launch by 2030 – will enable additional real-time data applications. For example, it can support the development of non-terrrestial wireless networks, advancing airborne connected mobility such as unmanned and personal aerial vehicles[10].

Unstructured Data

As of 2020, 90% of data generated by enterprises was unstructured, encompassing text, presentations, audio, and images that constitute a large part of daily digital activity.

However, unstructured data is often neglected, as it is created, stored, and managed across multiple applications, tools, and silos.

Only half of an organization's unstructured data is analyzed to extract value, and just 58% of this data is ever reused more than once[11].

The emergence of AI-powered Unstructured Data Processing (UDP) tools enables businesses to unlock unstructured data. Dedicated AI tools facilitate the automated mining, integration, storage, tracking, and indexing of raw unstructured data, transforming it into meaningful insights. Examples include:

- Intelligent Document Processing (IDP) systems combine techniques such as intelligent character recognition and natural language processing to extract data from text-based documents.
- Video content analysis, uses advanced AI algorithms and computer vision to monitor, analyze and manage video inputs (e.g. facial recognition software).

Major cloud providers have expanded their services to support data lakes from unstructured data, offering a range of storage solutions integrated with AI services to capture the inherent value of the data.

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[8] RBC Capital Markets: "The healthcare data explosion", accessed Jun-2024

[9] World Economic Forum: "4 ways data is improving healthcare", 05-Dec-2019

[10] Frontiers in Communications and Networks: "Urban Air Mobility – A 6G Use Case?", Aug-2021

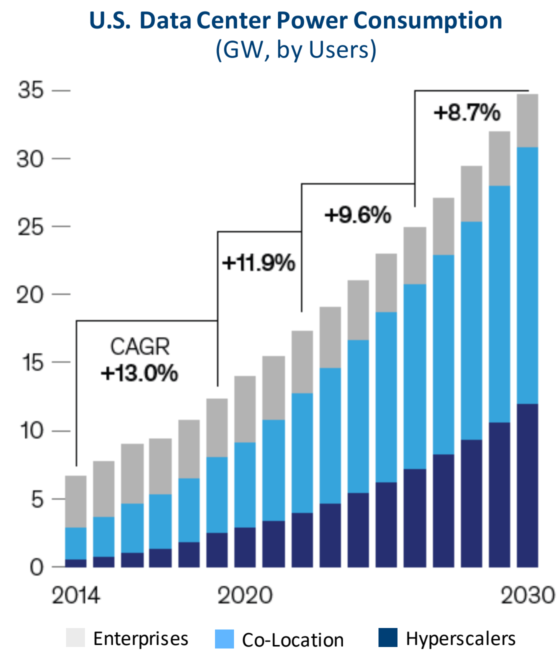
[11] IDC: "What every executive needs to know about unstructured data", Aug-2023

The Data Center Economy

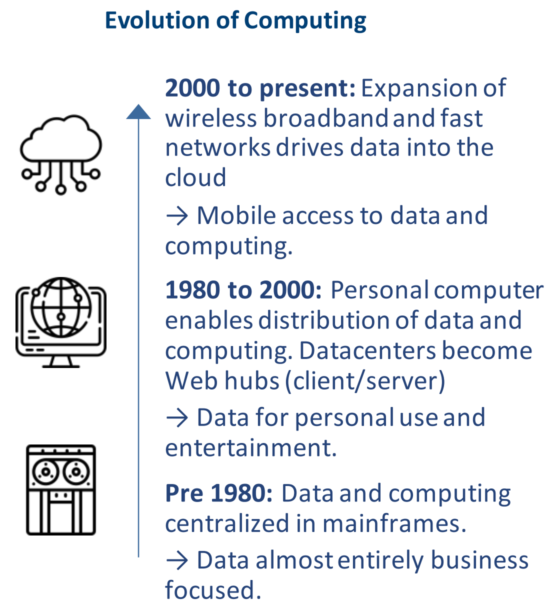
The rapid acceleration of data volume is the result of decades of evolution in computing, marked by swings between centralization and distribution of resources (*see Figure 4*). The transition to centralized cloud computing is the latest trend, with global spending projected to reach $725 billion in 2024. Over the past two years, the primary segments driving cloud service growth have been (i) Software as a Service (SaaS), growing at a 17% CAGR, and (ii) System Infrastructure as a Service (IaaS), growing at a 30% CAGR[12].

Growth projections for data center capacity range between 3-8 GW[13, 11] annually for the next five years, driven by the convergence of two computationally and data-intensive trends: Cloud Services and Generative AI.

Figure 4 – For Illustrative Purposes Only



Source: McKinsey



Source: IDC

Data centers are typically owned and operated by large corporations, such as cloud vendors, or by co-location companies, each applying their specific service model.

- **Co-Location Model:** A data center accommodates various customers who lease space, including power, cables, and cooling, and deploy their own IT equipment. Depending on the required level of customization—standardized space for **retail co-location** versus bespoke infrastructure for **wholesale data centers**—commitment durations range from 1-20 years. Customers can interconnect with other companies and service providers within the same facility to scale their digital ecosystems.
- **Hyperscaler Model:** Data centers are >10,000 sqf (20–50 MW power) and designed to the technical and operational specifications of hyperscale cloud vendors (e.g. Amazon, Microsoft, Google, IBM). Customers typically don't connect inside the data center. Instead, a network extension is placed into a nearby colocation data center, allowing companies in that facility to interface with the hyperscaler.

[12] J.P. Morgan: "Data Center Deliberations; Credit Implications of a Growing Mega-Trend", 17-Jun-2024

[13] McKinsey: "Investing in the rising data center economy", Jan-2023

Data Center Growth Framework

Expansion of the data center sector is constrained by several physical factors that can extend the development timeframe, including.

Figure 5 – For Illustrative Purposes Only

	Physical Development Constraints
Power[13]	• Data centers are large energy consumers. Their current 3% share of US power demand is projected to increase to 8% by 2030, equivalent to ~47 GW of incremental generation • A combination of 40% renewable sources and 60% natural gas is envisioned to meet the increasing demand • Given their net-zero objectives, data center operators focus on green energy by offering long-term offtake agreements (PPAs) to renewable energy suppliers
	• Total US power demand is expected see a 2.4% CAGR through 2030 vs. ~0% over the last decade, with data center consumption accounting for ~0.9% of this growth • To accommodate increased demand, expanding power generation capacity is essential. Challenges may arise in grid interconnection, permitting, and supply chains (e.g. copper shortages)
Cooling	• The capacity of a data center is dictated by how efficiently it cools the equipment. Cooling is a crucial driver of profitability, accounting for ~40% of a data center's energy bill[12] • Water cooling is the primary method of dissipating energy, on current capacity US data centers consume >75 bn liters of water per year[11].
Location	The location choice involves balancing access to inexpensive power, availability of cooling water, proximity to network interconnection points (IXPs), and affordable land with commercial infrastructure

Data center supply may struggle to meet demand for some time, potentially helping avoid the traditional cycle of overbuilding and creating overcapacity during the boom period.

Data Center Economics

The CapEx costs of a data center typically amount to ~$10 million/MW[15]. Site expenses, incl. the land, structure, power infrastructure and cooling, cover ~40% of these cost, while core IT equipment, such as processors, servers, cabling and their installation accounts for the remaining ~60%. The majority of these expenses occur during the initial deployment stages (*see Figure 6*).

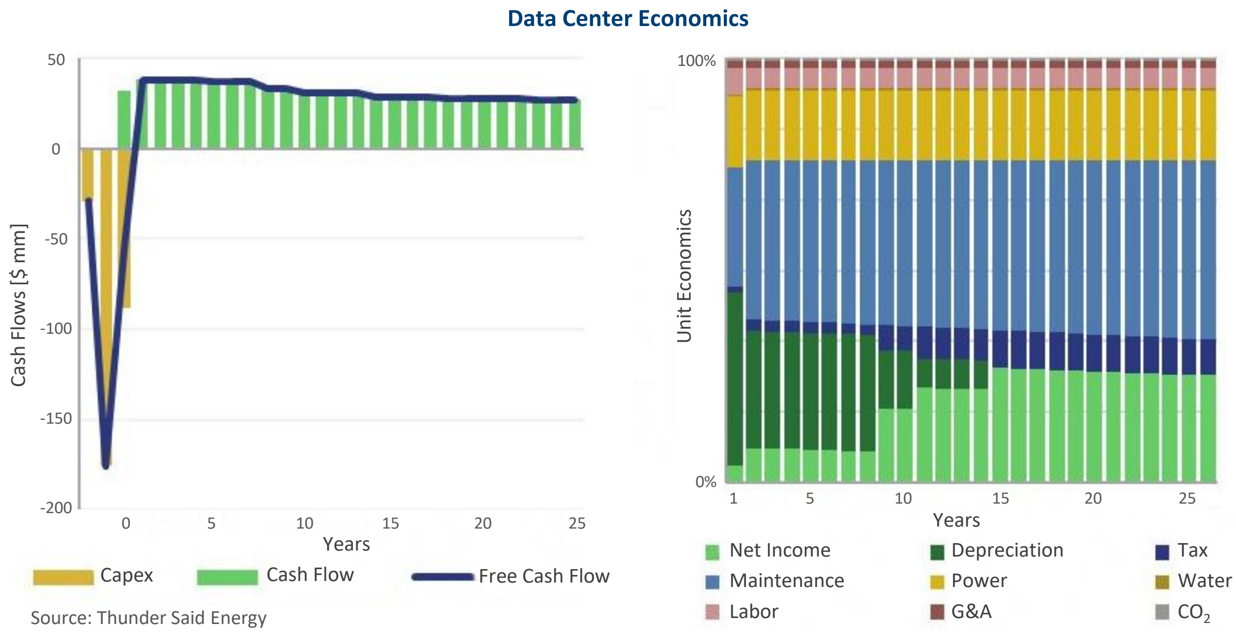
Operating expenses are primarily driven by maintenance (~40%), electricity (~20%), labor, water, and G&A costs. In total, a mid-sized 30 MW data center needs to generate annual revenues of ~$100m to achieve a 10% IRR on invested capital over a 25 year service life.

Reliability plays a critical role in the financial performance of data centers. Fluctuations in uptime and utilization can have a greater influence on overall profit margins than electricity prices[14]. Therefore, data centers are categorized into tiers based on their annualized expected downtime, ranging from basic Tier-I facilities (28.8 hours downtime p.a.) to highly fault tolerant Tier-IV centers (<0.5 hours). This emphasis on service stability poses challenges for higher tier data centers, when considering the direct use of renewable electricity sources, which require advanced management of power intermittency.

[14] Goldman Sachs: "AI, data centers and the coming US power demand surge", 28-Apr-2024

[15] Thunder Said Energy: "Data-centers: the economics?", 2024

Figure 6 – For Illustrative Purposes Only



Opportunities for the Middle Market

While the bulk of growth will benefit major semiconductor manufacturers, cloud service providers, and energy utilities delivering hyperscale data infrastructure, substantial opportunities exist for middle-market companies offering specialist upstream products and services within a complex value chain.

Data Center Supply Chain and Operations

Data center capex spending in the U.S. is expected to be material through 2027 at ~$125 bn per annum[11]. This expenditure covers the IT hardware, software, industrial equipment (incl. mechanical, electrical, and plumbing) as well as physical infrastructure for new facilities and upgrades to existing sites (*see Figure 7*). Infrastructure areas that present opportunities to specialist middle market suppliers include,

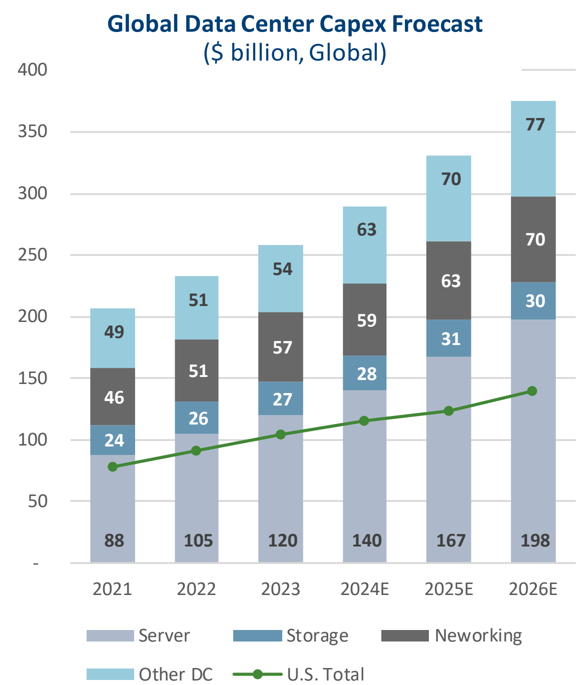
- **HVAC:** AI computing hardware consumes significantly more power than traditional data center servers, making liquid cooling - or combinations with air cooling - the dominant technology. Companies specializing in scalable liquid cooling solutions stand to gain from the increasing demand for AI and high-performance computing.
- **Backup Power:** Data centers typically short-term battery backup (5 – 15 minutes) combined with diesel generators for uninterruptible power supply (UPS)[16]. However, the focus on renewable energy, characterized by intermittent supply, along with advances in battery technology, is prompting data center operators to consider Battery Energy Storage Systems to ensure continuous power supply and

[16] Schneider Electric: “Understanding BESS for Data Centers”, 08-Mar-2024

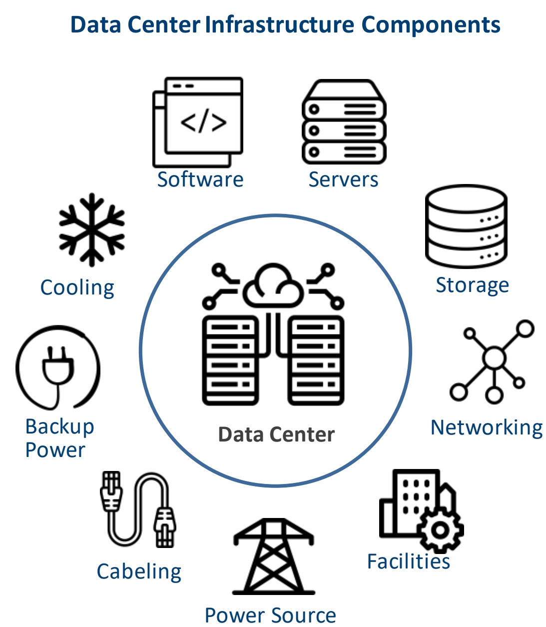
contribute to grid stability[17]. Companies specializing in power system integration can benefit from this trend.

- **Cables and Switches:** The backbone of data centers lies in their network and connectivity, facilitated by a variety of cables ranging from fiber optics to copper, and tailored to specific needs. Advanced connectivity solutions providers stand to capitalize on the demand for increased network speeds and bandwidth, driven by large generative AI training models, requiring a fiber rich architecture.

Figure 7 – For Illustrative Purposes Only



Source: Dell'Oro Group



Source: Phoenix Merchant Partners

Phoenix believes that the current data infrastructure build-out presents substantial lending opportunities across the data center supply chain. We particularly focus on middle market, high-technology and business service companies offering specialized solutions for specific data center components.

Retail and Hybrid Co-location Data Centers

Retail data centers provide space, power, and cooling, along with a comprehensive range of services. These include networking (peering, carrier-neutral connectivity) and business services such as disaster recovery, data backup, compliance support, and cybersecurity.

A hybrid data center combines on-premises, private, and public cloud resources, enabling customers to manage and deploy workloads across multiple environments. Providers offer hybrid cloud management and data/application integration services, allowing the flexibility to scale resources while maintaining mission critical data at co-location facilities and not on cloud.

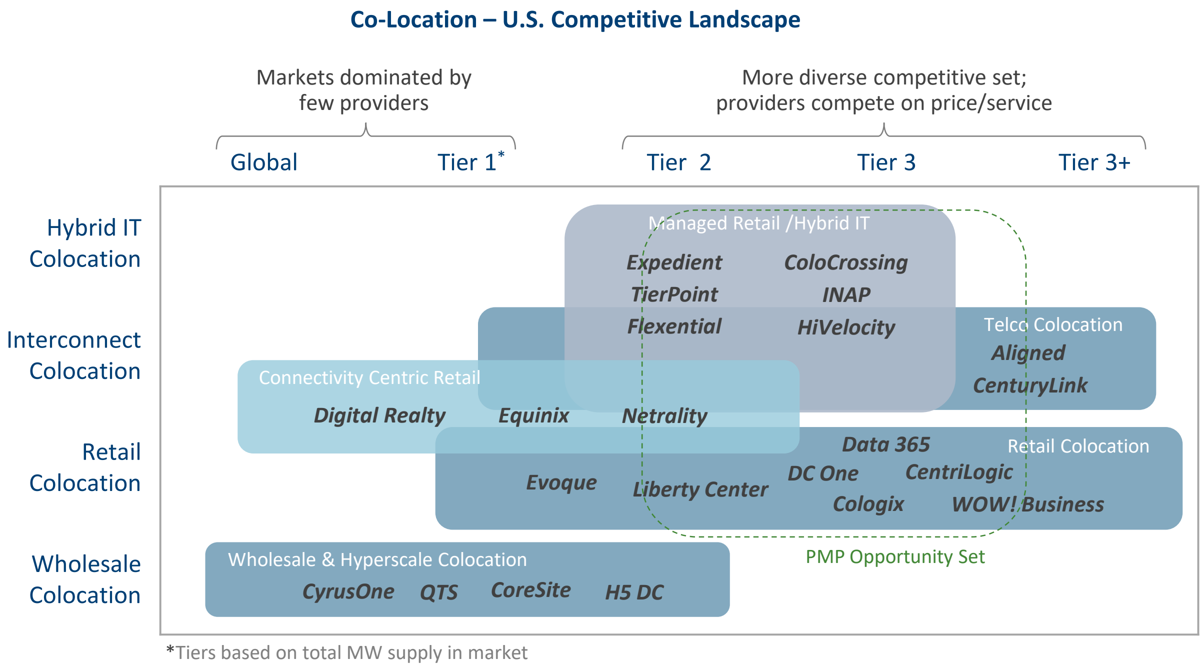
Both business models serve a broad range of customers, including mid-market and enterprise clients from data-rich industries such as healthcare, transportation, finance, education, media and advertising, and

[17] Phoenix Merchant Partners: "Battery Energy Storage Systems – Overview & Opportunities" Feb-2024

business services. Operators typically fall into the Tier 2/3 size category (*see Figure 8*), running multiple data centers, often interconnected, across major population centers.

Consolidation within the data center sector remains an ongoing trend, with smaller players aiming to build scale and larger providers optimizing their service portfolios. M&A transaction values in the U.S. have reached $15 billion year-to-date (first five months of 2024)[18], driven by strategic buyers pursuing joint ventures, regional roll-up transactions, take-privates and recapitalizations[19].

Figure 8 – For Illustrative Purposes Only



Phoenix views the rising demand for data capacity, geographic expansion across population centers, and ongoing consolidation activities as an opportunity for lending in the retail and hybrid co-location space. We believe our capability to tailor dedicated capital solutions to strategic buyers and operators positions us strongly to capitalize on sector growth.

Edge Data Centers

In contrast to the more recent focus on generative AI applications, which demand increasingly larger and better interconnected cloud data centers for model training and inference, the concurrent trend of real-time computing has been driving the growth of distributed edge data centers.

Smaller (<2 MW power) data centers, often located around urban areas, have the potential to reduce latency, overcome intermittent connections, and store and compute data closer to users.

These characteristics make them ideal for many data-heavy applications that rely on decentralization and speed. The growth of edge data centers is closely linked with the evolution of wireless communication.

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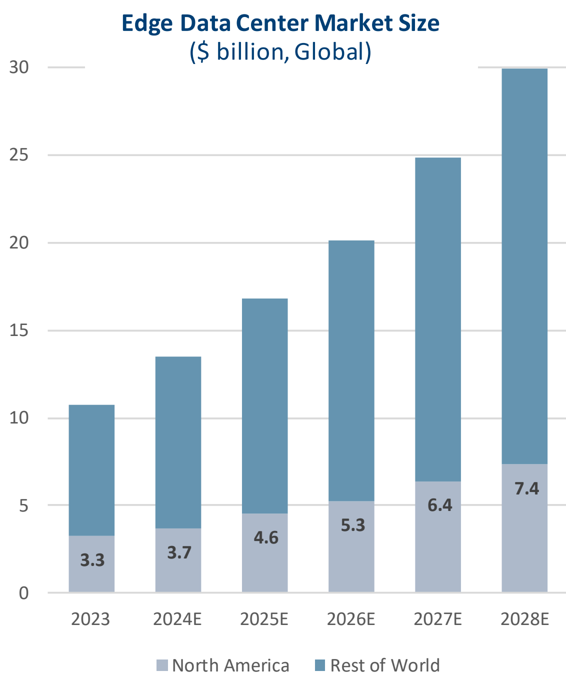
[18] Linklaters: "$22bn invested in data centres so far in 2024 …" 29-May-2024

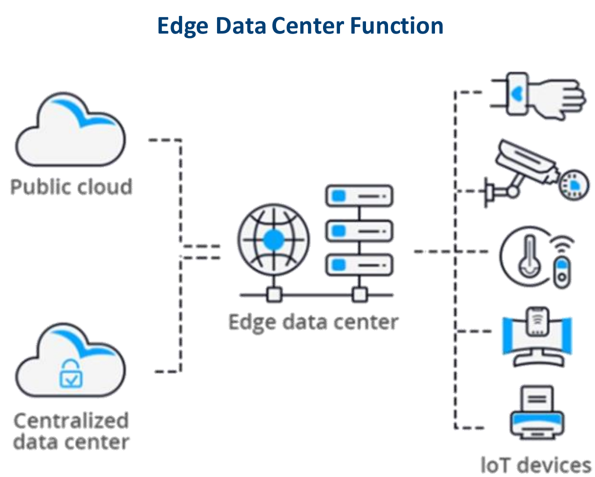
[19] Financier Magazine: "Data center M&A in 2024" Apr-2024

- **5G Networks:** Next-generation telecom services depend on a highly decentralized small cell network, consisting of low-powered radio access points that connect mobile devices to networks. A corresponding network of edge data centers supports numerous 5G use cases, such as autonomous vehicles and smart-city applications that demand high device density.
- **Internet of Things:** The (IoT) is forecast to cover 32bn connected devices globally by 2030 [20], incorporating billions of sensors across various sectors such as transportation, manufacturing, surveillance, inventory and supply chain mgmt., smart grids, agriculture etc. Centralized analysis and reaction to the data from these devices would consume significant bandwidth and result in high latency. Edge data centers enable distributed data (pre)-processing, enhancing response speed.
- **Media Sector:** Entertainment applications like cloud gaming, where a live feed is streamed to multiple devices, and content platforms such as music and video services, are highly sensitive to latency. Decentralized content cashing and processing in edge data centers enhances responsiveness to user traffic demands.

Figure 9 – For Illustrative Purposes Only



Source: Statista



Benefits	Latency Reduction Bandwith Efficiency Localised Data (security)

Source: FS.com

Phoenix believes that specialized operators capable of developing distributed, smaller-scale data centers with corresponding telecom connectivity will benefit from the growth of edge data centers in metropolitan areas, presenting multiple lending opportunities.

[20] Statista: "No. of Internet of Things (IoT) connections worldwide from 2022 to forecast 2033", 12-Jun-2024

Conclusion

The growth of the Datasphere has been accelerating over the past decades. Advances in data technology, such as internet of things, artificial intelligence, and real-time processing - potentially quantum computing? - continue to drive the expansion of the ecosystem. Data centers represent the core infrastructure backing this evolution, with ~$125 bn p.a[11] investment projected for the next three years in the U.S.

Specialist middle-market companies have a significant role in the data economy. Example opportunities include (i) physical data center components and specialized business services, (ii) regional retail & hybrid co-location data centers and (iii) edge data facilities.

The progress in generative AI presents the latest "data" opportunity for middle-market companies. Businesses that lead in capturing AI productivity gains within their industry will shape the potentially transformative impact of this evolving technology.

Phoenix believes the data economy offers multiple opportunities for lenders throughout a broad value chain marked by substantial growth and innovation. Specifically, we find the data center space, with its combination of physical components, business services and infrastructure operators, to be of interest.

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