Grid Solutions

Accelerating the Energy Transition:

DATA CENTER MARKET ANALYSIS

GE VERNOVA

INTRODUCTION

Data centers – and the information they store – are becoming increasingly integral to the way the world turns. Simultaneously, data center energy usage is witnessing skyrocketing demand of **up to 18% CAGR on the back of AI uptake***, and this trend is not projected to change anytime soon. Growth in demand means growth in development, cost, resources, and more. With this growth also comes an increase in the information within this infrasctructure, and that data must remain concurrently secure and accessible.

GE Vernova collaborates with data centers to assess their power requirements and leverage our expertise and portfolio to expedite the delivery of power requirements. GE Vernova's Grid Solutions business offers data center solutions ranging from turnkey high-voltage substation engineering and design to high-voltage equipment, including switchgear, transformers, grid automation and power quality solutions. Our extensive electrification products provide consistent and reliable power throughout the entire lifecycle of a data center - all while helping with grid congestion and maintaining profitability and environmental responsibility.With our extensive experience in executing such substations for both transmission and distribution utilities, we are able to help the data center industry overcome many of the grid challenges being faced in the midst of the energy transition.

The Evolution of the Data Center Industry

The data center of the present is not the data center of the past. Once referred to as a "mainframe", the world's first data center was developed by the University of Pennsylvania in order to store the Electronic Numerical Integrator and Computer (ENIAC) – the world's first general-purpose computer – in 1945. Back then, computer systems were very different than the ones we know today: they were required to be in specialized environments due to necessary equipment like connection cables, racks, raised floors, and more. Because of this equipment, these "server rooms" expended a lot of power to mitigate overheating. Over time, security became an additional focus due to the expensive nature of computers and corresponding technology, and because computers were at that time often used by the military. As the technological boom followed, information technology (IT) operations not only soared, but also changed in complexity. Organizations required control rooms and those control rooms were soon referred to as data centers.

The data center market reached a major peak in the late 1990s and early 2000s, during the dot-com era, as companies were in need of high-speed, reliable Internet connectivity. The scope and requirements of data centers changed and continue to transform to this day. The evolution of data centers driven by cloud computing, Internet of Things (IoT), 5G, artificial intelligence (AI), and machine learning (ML) is taking the industry into an unfathomed dimension. Yesterday's solutions are no longer valid for today's challenges and a new model is needed.

Current Trends

As the world faces growth in globalization, increased prioritization of sustainability objectives, climate change, digitalization, and more, the requirements for the modern data center are changing. There is intensified demand for enhanced performance and energy efficiency, better information security, cost management, mitigation of grid congestion, and more. Moreover, data center power usage is seeing a considerable surge. While complex on its own, what makes this even more challenging is the advocacy towards renewable energy integration. It is at this juncture that grid operators, stakeholders, energy providers, and data center developers converge.

The data centers industry went through a massive growth pattern in the past decade due to cloud computing transformation, hyperscale development, 5G networks, and other technological and socioeconomic changes. This technological evolution introduced challenges to the data centers operators in terms of sustainability, cost effectiveness, and reliable operation. Per Seagate.com, data center growth is expected to go up to 175 zetabytes (where one zetabyte equates to one billion terabytes) by 2025. With this efficiency supporting growth, the expansion of the digital infrastructure will still be challenged by the energy needed to support this growing segment. Utilities are facing numerous challenges as the growth of data continues to expand.

Market Snapshot

MARKET SIZE

>800TWh

Expected electricity demand of data centers (includes traditional data center, AI data centers and cryptocurrencies)

IEA

MARKET INSIGHTS

EXPONENTIAL GROWTH IN DATA GENERATION

>180 ZB

*Expected beyond 2025 (Statista)

ACCELERATING CLOUD COMPUTING ADOPTION

$2.5T

*Global Cloud Services Market by 2031

https://www.forbes.com/sites/forbestechcouncil/2023/07/24/powering-the-growth-of-cloud-computing-infrastructure-challenges-and-solutions/

BIG DATA ANALYTICS

Organizations are increasingly leveraging big data analytics to derive insights and make business decisions

EDGE DATA CENTERS

23%

*CAGR expected between 2023 and 2028

Processing data closer to the source or end-user device, is gaining popularity for applications requiring low latency or real-time processing.

IOT & CONNECTED DEVICES

>65B

(Frost and Sullivan)

*Globally devices expected by 2026

AI/ML ADOPTION

The adoption of artificial intelligence (AI) and machine learning (ML) technologies is increasing across various industries, driving demand for powerful computing resources to train and deploy AI models. Data centers provide the infrastructure required for running AI/ML workloads at scale.

CHALLENGES

The data center industry has undergone considerable growth in the past decade, and with this growth come challenges for data centers owners, developers, and operators. Difficulties include, but are not limited to, increasing energy needs, long wait times for utility feeds, transmission & distribution (T&D) constraints, decarbonization, environmental consciousness for water usage and liquid cooling, and cybersecurity. In this section, we will review these operational challenges, power stability interruption, and sustainability objectives, as they relate to the energy sector.

Challenge 1:

POWER SHORTAGES FOR DATA CENTER EXPANSION

Average data center energy demand is increasing significantly due to factors that include the development of AI & ML, post-pandemic applications deployment, and higher and faster computing requirements (where interconnections of up to 1 GW are necessary). Conventionally, power utilities have been the primary source of power for data centers, while relying on diesel gensets for backup. But data center growth is outpacing grid resources, creating long wait times for power, proving that the current model may not be sustainable.

In the U.S., data center operators expect more than **double-digit growth in the near-term***. However, despite record development in new energy sources, available capacity is at a record low. But power availability issues are reflective of transmission and distribution issues, not necessarily power generation.Additionally, and quite simply, data alone drives data center growth. While most of us cannot imagine a life without the Internet, the global number of online users grows exponentially every day. With more consumption comes more data, and billions in annual revenue for the global economy. And this data needs to be stored (and powered) somewhere.

Challenge 2:

DATA CENTER EXPANSION, SUSTAINABILITY, AND POLICY DRIVERS

The carbon footprint of data centers stems from their significant energy consumption, as well as the emissions from the production and disposal of IT equipment. Data centers require tremendous amounts of electricity to power servers as well as large quantities of water to cool down the heat that is generated by these servers, networking equipment, infrastructure expansions, T&D losses, and backup power systems.

Consequently, there is an urgent need for data centers to have their own unique sustainability roadmap driven by the fact that data centers are notable consumers of energy and water. There is a substantial need to address the increased environmental impact associated with future emissions and water use.

The decarbonization challenge is driven by three major trends:

TREND 1

Increased power requirements for emerging applications such as AI and ML: the rapid expansion of these applications puts stress on data centers like never before. While it is evident that power consumption is rising significantly, this is particularly seen in hyperscale facilities. **Microprocessors, for instance, have seen a 50% increase in power consumption in less than three years.** Grid solutions, power purchasing agreements (PPAs), investing in dedicated microgrids, energy monitoring management, power usage effectiveness, and renewable energy sources that enhance efficiency in data centers are therefore critical.

TREND 2

Sustainability as a competitive advantage: data centers represent **3% of global electricity supply and are responsible for 1% of energy-related GHG emissions***. Data center operators are motivated to reduce their carbon footprint through the use of renewable energy, recyclable materials, and innovative cooling systems that minimize water and energy consumption. The increase in renewable energy will require an expansion of grid infrastructure, and in tandem, the unprecedented demand for digital infrastructure will need innovative solutions and alternative ways for utilities and data centers to become self-sufficient and generate their own power (off-grid) but also to replace diesel generators typically used for power back-up such as hybrids and aero-derivative gas turbines, power batteries, and a combination of microgrids.

TREND 3

Policies and regulations are adding to the challenge of power shortages which require data center operators to start assessing alternative sources of energy outside the grid. Regulations are constantly being modified to best improve applicable governance. In the case of data centers, energy consumption and emissions are the key criteria of such methodologies. **One example is the Regulation on Ecodesign Requirements for Servers and Data Storage Products EU 2019/424, whose objective is to limit the environmental impact of products** with a set of rules on energy efficiency while taking into account circular economy aspects such as the extraction of critical raw materials, secure data deletion, and the latest firmware.

To attract investment and remain competitive, it will be crucial for operators to navigate these trends strategically, ensuring they can meet the evolving needs of the digital economy while maintaining sustainable and efficient operations.

Challenge 3:

INVESTMENTS AND FINANCING OF DATA CENTER INFRASTRUCTURE

Power purchase agreement (PPA) structures provide an interesting opportunity for data center operators. PPAs are long-term agreements that set price certainty for both the “buyer” and the “seller”. In the case of data centers, PPAs enable partnerships with renewable energy projects or grid developers. In Europe (specifically in countries such as UK, France, Ireland, and Finland), there are number of renewable projects (wind, solar, and hybrids) in mid- to late-stage development that are looking for electricity PPAs which would support these projects in becoming bankable. The ideal partnership model would be between an energy provider and a data center project, creating value for both the projects.

Data centers are becoming progressively complex, with longer development cycles, higher costs, and rising resource needs. Finding innovative financing solutions to support data center development partners through development loans and equity investments with flexible financing terms would help support current and future projects.

Key Considerations

Substantial studies are required in the design and development of data centers. From a power perspective, it is imperative to have a reliable electrical power system that will ensure uninterrupted power supply. Besides being vital to a data center’s second-by-second operation, it is critical for the security of the data it holds. This requires due diligence across all phases of data center development to ensure a level of required reliability at optimal cost and within desired project timeline.

Typical considerations for greenfield projects would include:

1. **Location of the data center**. Data center operators typically have a reasonable idea of the location for their next data center project. However, within any given market, identifying the most appropriate site is challenging. It is imperative to perform specific evaluations that can shortlist optimal sites within a desired market that primarily includes analysis regarding headroom availability for demand connections and current connection queues, health of the local network and its reliability, electricity price forecasts if sourced from grid or local generation, land availability (particularly if co-located with own electricity supply resource), and availability of renewable power.

2. Assessment of the **required infrastructure** in terms of electricity generation source/supply, grid equipment, back-up options, and digital control solutions that would enable the power supply to the center. Numerous studies are performed for ideal sizing of all equipment and to ensure that it can work in an integrated way.
3. **Reliability and economics of the overall project** and its timeline of completion, including any supply chain issues, are evaluated and shortlisted to obtain the most robust technical and economically feasible option. This includes:
    a. The volume of energy and its associated costs are significant: approximately 40%-45% of the overall data center costs are related to its electrical infrastructure and operation (which equates to about $7 million to $12 million per MW of IT load). Therefore, evaluation of PPAs, LT tariff agreements, and the investment cost of alternative options need to be assessed and compared against offered benefits.
    b. As opposed to the historical model of data center operation (with backup capacity sitting idle for over 99% of the year), there is an opportunity to earn revenue from onsite infrastructure by providing energy (at times of low onsite demand) as well as ancillary services to the grid.
    c. Another key consideration at this stage is to re-evaluate the carbon footprint of the project over its lifetime.

This assessment and option filtering, based on comprehensive studies, must clearly identify which of the three options – grid connected, hybrid or island – will be most efficient, reliable, and cost-effective. Once the data center design outline is established, the next step is determining where the power feed will come from. As per conventional channels, data centers are powered via a grid-connected substation.

Data Center Configurations

Grid-connected: A grid-connected data center derives it power from a utility power provider with idle backup power in the event of an electrical blackout. This is a pure dispatching model where the data center imports as much electricity as required from the grid. This would typically be capped by contractual terms and substation sizing. This model is known as load following and unless shedding terms are agreed between the utilities and the data center, there is no load management instruction coming from the grid.

Hybrid: Although diesel back up power has been common in the data center industry, renewable options are gaining traction to meet sustainability goals and driven by falling prices. This is typically managed by an electricity dispatcher that, coupled with a tariffs and weather forecasting tool, will decide whether to import, export, store, or curtail power based on economics and carbon emission goals. For example, a battery storage could charge during low grid prices and discharge during high grid prices. Note that the load is also not managed in this configuration.

Grid-tied microgrid: Another hybrid option replaces the dispatcher with a microgrid controller and turns the system architecture to a grid-tied microgrid where the controller manages the electricity dispatch as well as the electrical demand of the data center by shutting down or starting up banks of servers. Ultimately, a microgrid is a group of interconnected loads and DERs with clearly defined electrical boundaries that act as a single, controllable entity and can connect or disconnect from the grid. The combination of smart dispatch with load management is a very powerful solution. The microgrid controller can plan ahead of any critical events and island the facility to protect it from grid faults, transfer critical computational calculations to other data centers by shutting down banks of servers, limit associated power consumption, fully charge the batteries, and prepare the aero gas turbines to dispatch.

Remote microgrid: This configuration does not include grid connection or tariffs forecasting, but weather forecasting and day-ahead smart dispatch from local DERs are maintained.

In generating its own power, the data center benefits by buffering against both rising electricity costs and grid instability. This islanding functionality opens new opportunities for data center locations that can be located away from HV distribution networks, situated where weather conditions may reduce the need for excessive cooling, for example, or where real estate availability is greater.

What's Next for the Industry

Morgan Stanley estimates that GenAI power demand will rise rapidly, reaching 224 TWh by 2027 (base case), which is equivalent to >75% of the total global data center power use in 2022.

It is clear that the industry has to ramp up substantially. Faster access to power and grid connectivity will be critical to meet this surging demand.

As the data center industry looks to power its operations more sustainably, they will need to evaluate many options including renewables, battery storage and traditional power sources with carbon capture and sequestration technologies. In tandem, data center operations will benefit tremendously from a "smarter" grid that is fully leveraging digital technologies such as grid orchestration, automation, analytics and predictive maintenance programs.

GE Vernova's Value Proposition

GE Vernova delivers timely and sustainable power generation and supply solutions to the data center ecosystem through early engagement, proven knowledge, and global experience – providing some of the key infrastructure needed to connect data centers to power and alleviate grid congestion challenges worldwide.

We partner to deliver turnkey data center substation solutions and accelerate grid connectivity. We offer project services for the full scope of engineering and design leveraging our portfolio of high-voltage products and a suite of software solutions to improve grid resilience and reliability.

GE Vernova's Grid Solutions capability to conduct full system analysis due diligence will ensure accelerated grid connectivity. Furthermore, our global manufacturing footprint and strong relationships with transmission system operators (TSOs) help ensure that projects stay on budget and schedule.

We are focused on ensuring that our data center customers can remain competitive by accelerating time-to-market, reducing total cost of ownership, improving energy efficiency, and reducing environmental impact.

Learn more about grid solutions for data centers: https://www.gevernova.com/grid-solutions/industries/data-centers.htm

Conclusion

At GE Vernova, we are accelerating our investments into solutions for the rapidly evolving data center market. These solutions stem from technological innovations that are configured to the KPIs of a data center customer, including time-to-market, total cost of ownership, improved energy efficiency, and a reduced environmental impact.

As the data center market continues to evolve, so too does our expertise. At GE Vernova, we pride ourselves on continuous innovation and collaboration to diversify our portfolio, improve the performance of our offering, prioritize our decarbonization targets, and meet customer requirements.

Together, we are accelerating the energy transition. Together, we are changing the world.

**GE Vernova estimates derived from the IEA Electricity Report 2024 and the IDC and Structured Research Reports 2024*

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For more information, visit
gevernova.com/grid-solutions

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