VedeniEnergy
Plugged Into The Energy Industry

WHITEPAPER

NOVEMBER 2024

Data Center Energy Demand Growth

Meeting the Rising Power Needs of the Digital Era

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INTRODUCTION

Powering the Digital Age

The Energy Challenge of Data Centers

Data Centers' Rising Energy Demand

Sustainable Growth Challenges

Interconnection & Regulation Impact

The modern digital economy relies on an expanding network of data centers to support cloud computing, AI applications, and Internet services. These facilities, known for their significant energy requirements, are growing at an unprecedented pace, reshaping both the technology and energy landscapes. With AI tools demanding massive computational power and cloud infrastructure scaling rapidly, energy consumption from data centers has reached new heights. At the same time, utilities and developers are under pressure to ensure the electricity grid keeps pace with this growth while maintaining reliability and sustainability.

This white paper examines the factors driving the rise in data center energy consumption, explores the challenges utilities face, and discusses how new energy solutions are emerging. It also addresses the impact of interconnection delays and regulatory changes on the development of data center infrastructure.

The Rise of AI, Cloud Computing, and IoT as Drivers of Data Center Growth

Powering the AI Revolution: The Growing Energy Demands of Data Centers

Data centers have become essential infrastructure for AI, cloud computing, and the Internet of Things (IoT). AI models like ChatGPT consume far more energy than traditional software systems because they rely on GPU-powered servers that perform billions of calculations per second. Training these models requires continuous, intensive operations, often taking weeks or months, with significant power needed for computation and cooling. Integrating AI into business operations and consumer applications has spurred massive investments in data centers, resulting in continuous energy demand growth.

Embracing the Cloud: Transforming Business Data and Power Dynamics

In parallel, cloud computing platforms have become businesses' preferred data storage and processing model. Companies are shifting from local servers to cloud infrastructure to improve scalability, reduce IT costs, and enable remote work. The global expansion of cloud services is leading to the development of hyperscale data centers, which are far more extensive and energy-intensive than traditional facilities. The same trend applies to IoT, which relies on interconnected devices continuously transmitting data to data centers for processing, further increasing power needs.

The Energy Challenge of Edge Computing

Edge computing, which involves processing data closer to its point of origin to reduce latency, adds another layer of complexity. While edge data centers are smaller, their distributed nature means more power is consumed across numerous locations, creating new challenges for utilities to provide consistent energy supplies across regions.

Data centers drive AI, cloud computing, and IoT growth but face surging energy demands and distribution challenges.

The Role of Cooling Systems and Energy Efficiency Challenges

Optimizing Data Center Cooling From Air to Liquid Systems

Virtual Twins A Game-Changer for Cooling Efficiency

Cooling systems represent a significant portion of data center energy use. AI and high-performance computing systems generate tremendous heat, necessitating constant cooling to avoid equipment failure. Traditional air-cooling systems are still widely used but consume substantial energy to maintain optimal temperatures. In response, many data centers are adopting liquid cooling solutions, which are more efficient but still energy-intensive.

Virtual twin technology has emerged as a promising tool to improve cooling efficiency. By creating a digital replica of a data center's operations, virtual twins enable operators to simulate energy use and identify inefficiencies. This approach offers predictive insights into energy management, helping companies optimize cooling load distribution across systems and reduce consumption. However, achieving meaningful improvements requires significant capital investment and expertise, limiting such technologies' adoption.

UTILITY CHALLENGES

Generation, Transmission, and Labor Constraints

Utilities are under immense pressure to meet the growing demand from data centers. In many regions, power providers are already struggling to maintain reliability amid an aging infrastructure and increased electrification. The pace at which data centers are expanding often outstrips the ability of utilities to build new power plants or transmission lines. For instance, some utilities have had to ration electricity or delay new service connections due to inadequate infrastructure, especially in urban areas where demand is highest.

Building new generation and transmission capacity is not a simple task. Whether renewable or conventional, power plant development takes years and involves significant regulatory approvals. Utilities also face financial constraints, as meeting data center demand could require a 10–19% increase in revenue over the next decade, potentially leading to higher energy costs for consumers. Compounding these issues is a shortage of skilled labor, with an estimated 400,000 trade workers needed to support infrastructure projects such as transmission lines and power distribution units.

Direct Contracting and Onsite Solutions

Innovative Energy Solutions for Modern Data Centers

Given the limitations of traditional utilities, data center operators are increasingly turning to alternative energy strategies. Power purchase agreements (PPAs) with renewable energy developers offer a way to secure long-term power at predictable rates. PPAs also align with corporate sustainability goals, enabling companies to claim they are powered by 100% renewable energy. Nuclear power is becoming an attractive option as well. The decision to reopen the Three Mile Island nuclear plant specifically to supply electricity to Microsoft data centers exemplifies how commercial consumers seek reliable, low-carbon energy sources outside traditional utility contracts.

The Rise of Behind-the-Meter Solutions in Data Centers

In addition to direct contracting, many data centers are adopting behind-the-meter solutions, such as solar installations and battery storage systems. These systems provide energy independence, reduce reliance on the grid, and enhance resilience during outages or peak demand periods. Microgrid systems, which combine onsite generation with battery storage, allow data centers to operate autonomously, further mitigating risks associated with grid disruptions.

The Impact of Interconnection Delays on Data Center Development

Overcoming Grid Interconnection Challenges for Data Centers

Accessing the transmission grid through ISO and RTO interconnection processes is a significant challenge for data centers. These processes involve complex technical evaluations and regulatory approvals, often resulting in lengthy delays. Data center projects have sometimes been delayed for years, forcing operators to explore alternative energy solutions or relocate to regions with more favorable interconnection policies.

The Data Center Interconnection Hurdle

The delays discourage data centers from relying solely on grid power, prompting a shift toward behind-the-meter and onsite resources. However, these solutions come with their own challenges, including high capital costs and the need for specialized expertise. Moreover, the lack of transmission capacity limits the ability of data centers to participate in wholesale energy markets, where they could offset some of their operational costs through demand response programs.

Overcoming Challenges in Data Center Transmission Grid Interconnections: Navigating Delays, Costs, and Regulatory Hurdles

ENERGY REFORMS

Policy and Regulatory Developments to Address Energy Challenges

U.S. Government Takes Action to Accelerate Data Center Development in 2024

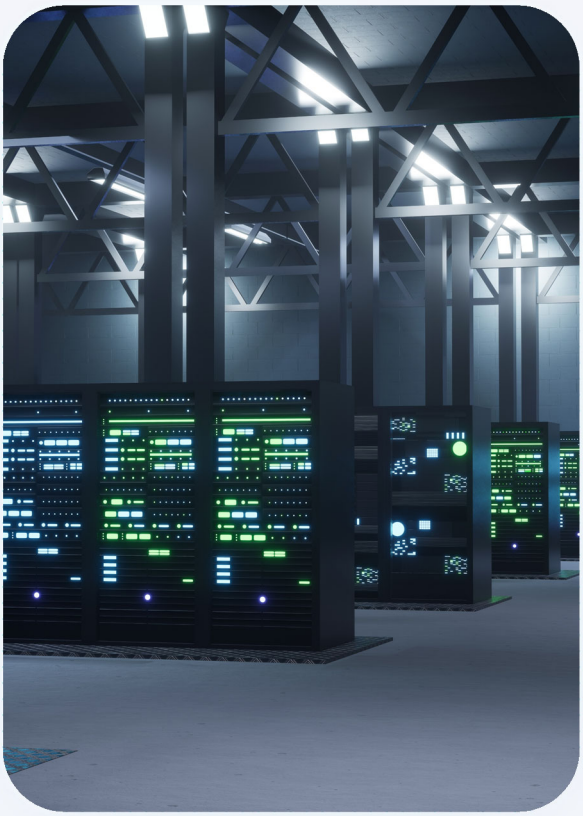
Recognizing the critical role of data centers in the digital economy, governments are beginning to implement policies to streamline infrastructure development. In 2024, the U.S. government established a task force to coordinate efforts between AI companies, data center operators, and utilities. The task force aims to accelerate permitting processes, provide technical assistance, and facilitate the repurposing of retired coal sites for data center use.

Corporations Drive Renewable Energy with Direct Procurement

New legislation is also being considered at the federal level to support the energy needs of data centers. These proposals include funding for research and development in energy-efficient computing and measures to simplify environmental reviews for large-scale infrastructure projects. Policymakers recognize that ensuring a stable and sustainable energy supply for data centers is essential for maintaining U.S. leadership in AI and cloud computing.

Conclusion

The Future of Energy in a Digital Economy



The rapid growth of data centers is transforming the energy landscape, presenting challenges and opportunities. AI, cloud computing, and IoT drive unprecedented energy demand while cooling systems and infrastructure limitations add further complexity. Utilities must adapt quickly but face significant constraints regarding generation capacity, labor shortages, and financial resources. As a result, data centers are increasingly turning to alternative energy solutions, including direct contracting and onsite generation.

The delays in interconnection processes underscore the need for greater coordination between data centers and energy providers. Policymakers have started to address these issues, but more efforts are needed to ensure that the energy sector can support the continued expansion of digital infrastructure. With the right mix of innovation, investment, and regulatory reform, the energy and technology sectors can meet the challenges of the digital age and build a sustainable path forward.

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AI Data Center Infrastructure Initiatives

About Vedeni Energy

Vedeni Energy offers specialized services designed to help businesses navigate the complexities of the modern energy landscape. Our offerings are tailored to meet the unique needs of utilities, independent power producers, regulatory bodies, and other stakeholders, ensuring success through strategic insights, expert guidance, and innovative solutions.

Vedeni.Spark+, a service provided by Vedeni Energy, is designed to help startups and established companies secure the capital funding necessary for growth and success. Our team of seasoned advisors works closely with clients to develop tailored funding strategies that align with their business goals and financial requirements.

Vedeni Energy's **Vedeni.IQ+** service provides actionable wholesale electric power market intelligence that enables clients to make informed decisions confidently. Our expert analysis and reporting distill complex energy market information into clear, concise insights, helping organizations elevate their market strategies, influence policy, and identify new opportunities.

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