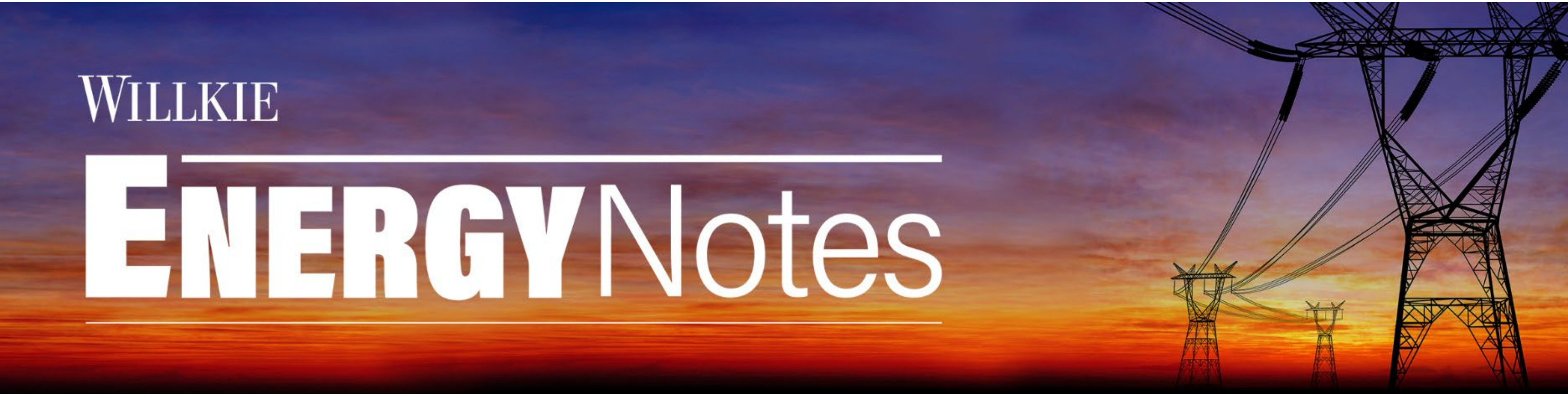

On-Site Power for Data Centers: Series Introduction

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AUTHORS

Danielle Garbien | Eric Pogue | J. Holt Foster, III | Dale Smith
Wesley Smith | Noah Pollak | Blake H. Winburne | Addison Miller Perkins
Samantha Anderson

Increased U.S. demand for AI, data and cloud storage services, cryptocurrency, and expanded computational services has fueled the development of data centers, which require increased energy load and capacity to operate these facilities twenty-four hours a day, seven days a week. Data centers possess several key features requiring significant electricity including: servers, cooling systems, backup power supply to manage power outages, data replication across several machines for disaster recovery, temperature-controlled facilities to extend life of equipment and easier implementation of security measures for compliance with data laws. Rapid growth in accelerated servers caused current total data center energy demand to more than double between 2017 and 2023, with such demand only continuing to increase in 2025 and beyond.[1] Further, as AI continues to grow, energy requirements to meet the expected demand are expected to continue to increase at an exponential rate.

1. The Power Market

Energy demand in the United States is at an all-time high, even without considering the new load requirements introduced by data centers. Over the last 10 years, power demand growth in the US was essentially stagnant.[2] Although power demand increased in lockstep with population and economic growth, such increase has, in recent history, effectively been offset by improvements in efficiency and structural changes in the economy, such as the

1 https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf (page 6).
2 https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf (page 6).

transition from manufacturing to service sectors, which tend to consume less energy.[3] Due to a variety of factors, including general electrification (vehicles, appliances, etc.) growth of domestic manufacturing and the aforementioned data center boom, energy demand is soaring—the era of flat U.S. electricity consumption is over.

Based on the U.S. Department of Energy's ("DOE") 2024 Report on U.S. Data Center Energy Use, data centers consumed about 4.4% of total U.S. electricity in 2023. Total data center electricity usage climbed from 58 Terawatt-hours ("TWh") in 2014 to 176 TWh in 2023, and it is estimated there will be an increase between 325 to 580 TWh by 2028.[4] By 2028, data centers are expected to consume approximately 6.7% to 12% of total U.S. electricity supply; an additional 4.5% of supply will be accounted for by AI.[5] A recent Goldman Sachs presentation titled "Generational Growth: AI, data centers and the coming US power demand surge" estimates that **47 GW of incremental power generation capacity** will be required to support U.S. data center power demand growth cumulatively through 2030.[6]

2. Procuring Power

To put Goldman's 47 GW information in perspective, 1 GW of power is produced by the average nuclear power plant in the U.S., 294 utility-scale wind turbines or 1.887 million photovoltaic panels.[7] Less than 1 GW of power is produced by a typical combined-cycle gas turbine (CCGT) plant.

A pressing concern for almost every power regulatory authority in the country is how to meet future power demand to avoid black- and brown-outs. Unfortunately for the data center developers, end-users and utilities, however, there is not a "one size fits all" approach to satisfying this demand. Given geographic and timing considerations, a mix of generation resources will be needed to support the required load growth, including fossil fuel fired, renewable, thermal, nuclear, and likely other types of power sources. Given the need for abundant energy sources, coupled with a supply shortage, data centers are investing in behind-the-meter dedicated generation (e.g., natural gas turbines and fuel cells) and battery storage to reduce reliance on the grid. As an added benefit, excess dedicated power generation can be made available to supply power back into the grid during peak demand periods.

3. Capital Considerations

In order to meet data center load requirements, the costs for new generation capacity are anticipated to range from $1,300/kW to $1,600/kW for utility scale wind and solar facilities and $750/kW to $1,000/kW for gas peakers and combined cycle gas turbine facilities, respectively.[8] This cost is expected to result in incremental capital investment in data center development by approximately $50 billion, cumulatively through 2030, to support data center growth.

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3 https://www.eia.gov/todayinenergy/detail.php?id=65264

4 https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf (pages 5-6).

5 https://semianalysis.com/2024/03/13/ai-datacenter-energy-dilemma-race/

6 https://www.goldmansachs.com/pdfs/insights/pages/generational-growth-ai-data-centers-and-the-coming-us-power-surge/report.pdf (page 3).

7 https://www.energy.gov/eere/articles/how-much-power-1-gigawatt#:~:text=To%20help%20put%20this%20number,Need%20a%20stronger%20visual

8 https://www.goldmansachs.com/pdfs/insights/pages/generational-growth-ai-data-centers-and-the-coming-us-power-surge/report.pdf (page 22).

Data center related power generation capacity needs, along with the country's baseline capacity requirements, will significantly increase expected capital expenditures in this market. Combining such data center and baseline capacity requirements with capacity load growth in other industries and the retiring of coal plants, market analysts are predicting the total generation capital expenditures to be $665 billion, cumulatively through 2030, or approximately $95 billion on average annually through 2030.[9]

4. Cost Recovery Considerations

Data centers are traditionally seen as large electricity consumers (i.e., loads) on the energy grid, and are increasingly becoming active participants in grid operations, acting as "grid-side" assets. If capital investments are made on the grid side (as opposed to the consumer side), but the expected energy load from these data centers fails to materialize, ratepayers could be unduly burdened by reimbursing the capital expenditures necessary to build out such grid operations in the form of higher electricity rates. Some utilities are requesting that regulators approve rate structures that transfer all risk of grid infrastructure buildout to data centers to protect consumer rates, but such structures coincide with the potential downside of slowing down deployment in a resource-constrained environment.[10]

5. Key Issues For Future Discussion

Historically, data centers have predominantly depended on the conventional electrical grid to satisfy their substantial energy consumption requirements. To ensure operational continuity during power outages, many data centers employ diesel generators or natural gas systems for redundancy, as these sources deliver rapid and dependable power to mitigate the risk of service disruptions. While renewable energy sources, such as solar and wind are increasingly discussed and incorporated into modern data center designs, their adoption remains limited. This is primarily due to challenges related to reliability, cost-effectiveness, and the intermittent nature of renewable generation, which struggles to match the consistent output of traditional grid systems backed by fossil fuel generators for redundancy. Furthermore, the infrastructure required for large-scale renewable integration often involves significant upfront investment and complex logistical planning. Nevertheless, forthcoming advancements in energy storage technologies, such as lithium-ion batteries, are beginning to address these limitations, enabling data centers to gradually transition toward more sustainable energy profiles. Despite these developments, the traditional electrical grid, supplemented by fossil fuel-based redundancy systems, continues to dominate due to its established speed, reliability and economic advantages.

Later articles in this On-Site Power for Data Centers Series will discuss additional data center issues, including commercial considerations/infrastructure cost, financing of data centers, real property considerations and regulatory considerations.

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[9] https://www.goldmansachs.com/pdfs/insights/pages/generational-growth-ai-data-centers-and-the-coming-us-power-surge/report.pdf (page 22).

[10] https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf (page 69).

If you have any questions regarding this client alert, please contact the following attorneys or the Willkie attorney with whom you regularly work.

Danielle Garbien

212 728 3952
dgarbien@willkie.com

Eric Pogue

212 728 8035
epogue@willkie.com

J. Holt Foster, III

214 233 4513
hfoster@willkie.com

Dale Smith

713 510 1740
dsmith@willkie.com

Wesley Smith

214 233 4527
wmsmith@willkie.com

Noah Pollak

202 303 1017
npollak@willkie.com

Black H. Winburne

713 510 1722
bwinburne@willkie.com

Addison Miller Perkins

202 303 1332
aperkins@willkie.com

Samantha Anderson

713 510 1769
sanderson@willkie.com

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