CAMUS encord ZERO LAB PRINCETON UNIVERSITY

Flexible Data Centers: A Faster, More Affordable Path to Power

How flexible grid connections and bring-your-own capacity speed up the path to grid power and ensure data centers cover incremental costs

December 2025

Executive Summary

Authors & Acknowledgments

Modeling and analysis for this study was conducted in summer and early fall of 2025. Inputs and assumptions reflect the best available data from public sources at the time. Camus, Princeton and encoord are independent organizations, and all paper conclusions and analyses are their own.

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The authors wish to acknowledge members of the Google Energy team for their valuable feedback and input on earlier drafts of this report.

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Suggested Citation

Carlo Brancucci, Dylan Cutler, and Jesse Jenkins. Flexible Data Centers: A Faster, More Affordable Path to Power. Camus, encoord, and Princeton ZERO Lab, December 2025.

Images courtesy of Adobe Stock unless otherwise noted.

Acknowledgements

This report benefited greatly from input and review by contributors throughout the industry, including:
Doug Middleton, Tesla Energy
Duncan Campbell, Scale Microgrids
Ethan Tiao, Emerald AI
Fiona Dearth, Generate Capital
Garretson Oester
Kate R. Sherwood, ZeroEnergy
Logan Goldie-Scot, Generate Capital
Pam Maines, ZeroEnergy
Sean Jones, Tesla Energy
Varun Sivaram, Emerald AI

The conclusions reflected in this study are not intended to represent the views of the contributors. We appreciated their help in providing useful context and guidance, which the authors used to shape the research.

Research Sponsors

This research was funded by Google LLC (Google), who reviewed the analysis prior to publication.

EXECUTIVE SUMMARY

Flexible Data Centers: A Faster, More Affordable Path to Power

Across the United States, data centers face mounting delays in connecting to the electric grid[1] – with timelines of 3 to 7 years[2], far longer than the 18-24 month construction timeline for a new data center. This study demonstrates a practical path to accelerate access to grid power. By combining **flexible grid connections** with **bring-your-own capacity (BYOC)** arrangements, data centers can reach full operation years sooner while maintaining reliability and improving affordability for all customers.

The challenge

Two bottlenecks dominate the data center interconnection process. **Transmission constraints** occur when lines cannot carry additional power without upgrades, while **generation constraints** arise when the system lacks sufficient accredited generation capacity to provide firm service for new load. Both constraints are often binding. In PJM, the most recent capacity auction reached its price cap[3] while transmission upgrades often face multi-year delays. Traditionally, the only remedies are to wait for new infrastructure or shift development to a different location—neither of which meets the speed-to-power needs of today's AI-driven data center buildout.

The opportunity

Flexible grid connections and BYOC programs provide a two-part solution that directly addresses these bottlenecks. Under a **flexible grid connection**, a data center receives both firm (uninterruptible) service and conditional firm service[4], where a portion of the load uses grid power in normal conditions and relies on on-site or co-located resources - including demand-side flexibility - during limited periods of system stress. Through **BYOC** programs, the data center directly procures the accredited capacity needed to meet firm-service requirements— through clean energy PPAs[5], VPPs, or on-site resources—rather than waiting years for utility procurement or ISO queue processes.

Together, these mechanisms replace the traditional "build first, connect later" model with a different approach: **connect now, operate flexibly during the hours the grid is constrained**. This approach aligns the data center's need for rapid access to power with the utility's or ISO's obligations to maintain reliability and ensure affordability. Flexible connections address transmission bottlenecks, while BYOC addresses generation bottlenecks.

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[1] Source: 403 Large Loads Letter (October 2025, Department of Energy)
[2] Sources: Virginia Data Centers Face Seven-Year Wait for Power Hookups - Bloomberg; The United States Needs Data Centers, and Data Centers Need Energy | ITIF; Can US infrastructure keep up with the AI economy? | Deloitte
[3] Source: PJM capacity prices set another record with 22% jump | Utility Dive
[4] We use "conditional firm service" to describe a contractual arrangement that provides conditional access to the grid, where a portion of a large load may be curtailed during limited periods of system stress to maintain system reliability. Similar arrangements are referred to as "non-firm," "flexible connections," or "flexibility commitments." Our usage most closely aligns with published definitions of non-firm or flexible connection agreements as described in Non-Firm Grid Connections
[5] A detailed definition and explanation of bring-your-own capacity is included on page 12

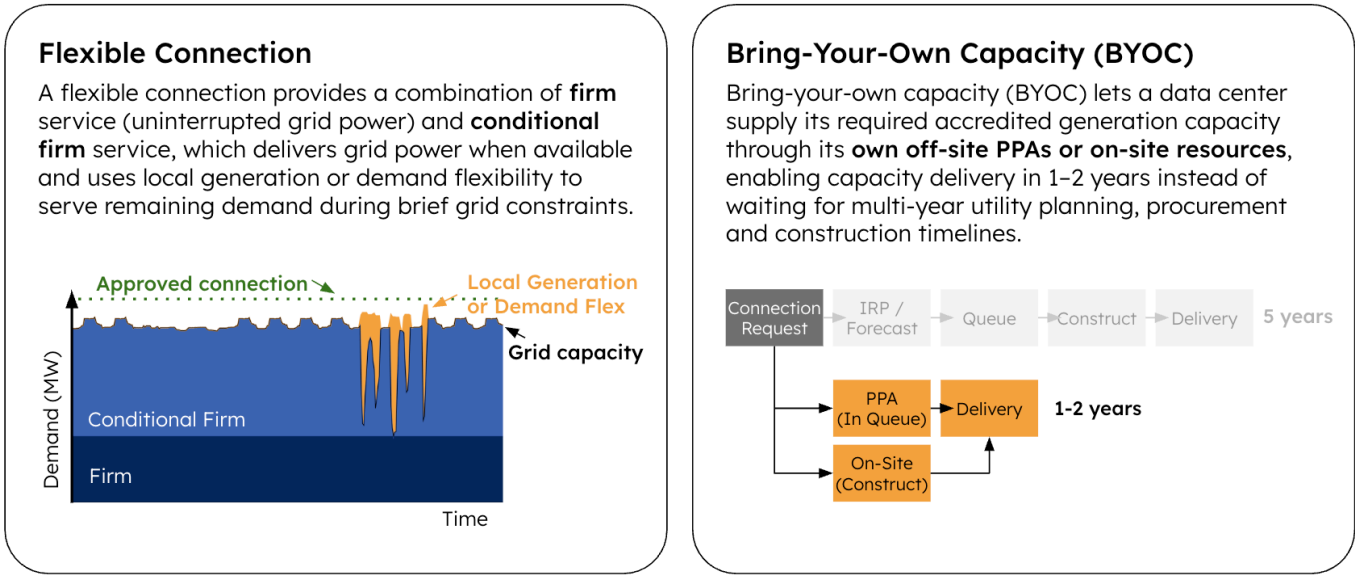


Figure 1: Summary of Flexible Connection and Bring-Your-Own Capacity

The demonstration

To test this integrated approach, Camus led a collaborative analysis with Princeton University's ZERO Lab and encoord. The team used a three-tier methodology—system, utility, and site-level modeling—applied to six real candidate sites within one PJM utility's territory. **Camus** combined the transmission constraints identified by encoord and the system-level capacity findings from Princeton with site-level modeling to determine how an optimal mix of on-site and off-site resources would meet each site's flexibility requirements.

The study combined:

- **encoord's SAInt platform** to simulate available firm transmission capacity and flexibility requirements across hourly time horizons (8760 hours per year) at each site
- **NREL's REopt model** to determine cost-optimal portfolios of on-site flexibility resources
- **Princeton's GenX model** to assess generation capacity requirements and system-level cost and emissions impacts

This is the **first publicly available study** to combine real utility transmission system data, system-level capacity expansion modeling, and site-level capacity optimization to evaluate how flexibility can accelerate data center interconnections.

Just as importantly, **the methodology demonstrated here provides a repeatable blueprint that any utility can follow**, using the tools and data already available for new load studies.

Key finding #1: Flexible data centers can connect 3-5 years faster

A 500-MW data center using flexible grid connection + BYOC can reach full operation in roughly two years; **three to five years faster** than traditional interconnection processes. Across constrained sites:

- Grid power was available for **more than 99% of all hours**
- On-site resources (e.g. batteries, generators, load flex) were dispatched **40–70 hours per year**
- Transmission constraints led to **7–35 curtailed hours annually**, with events lasting 4–16 hours
- Generation shortfalls added **~32 hours per year**, concentrated in extreme weather events

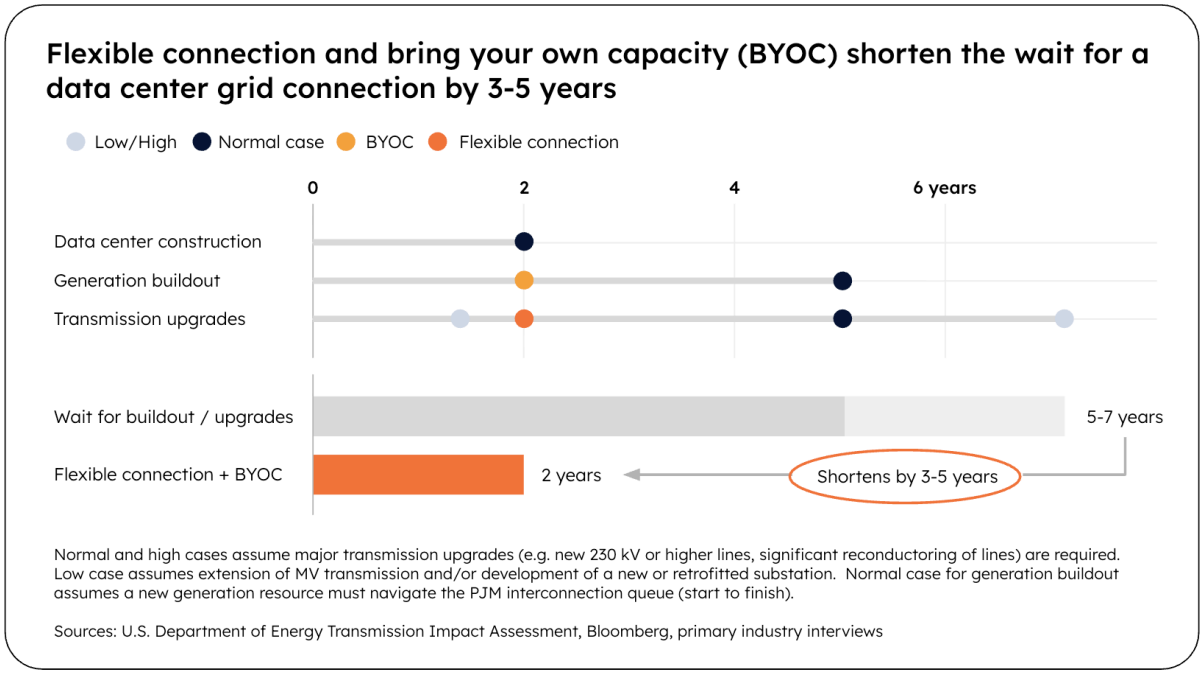
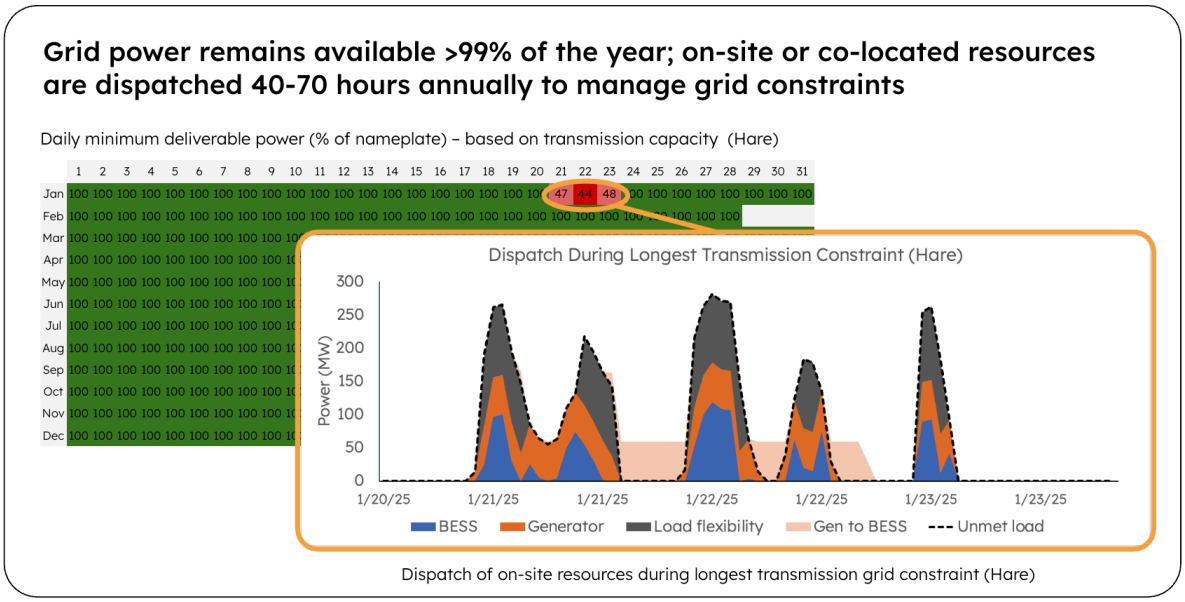


Figure 2: Speed to Power Gains (above) and **Figure 3: Grid Availability (below)**



Key finding #2: Flexible grid connections and BYOC significantly reduce and internalize incremental supply costs

A central question for utilities and regulators is whether new data centers increase costs for other customers. This analysis finds that the same tools that accelerate access to power—flexible grid connections and bring-your-own capacity (BYOC)—also provide a clear pathway to mitigate or avoid those costs. Used together, these mechanisms **mitigate new system buildout** and **shift remaining costs onto the data center**, substantially reducing the risk of cost shifts for other customers.

- **Each gigawatt of new data center demand adds $764 million in system supply costs**[6] under a traditional firm-only interconnection—driven by 2.17 GW of required nameplate generation additions across natural gas, storage, solar, and wind
- **Flexible grid connections** with 20% conditional firm avoid **273 MW of new build**, primarily battery storage and natural gas, eliminating **$78 million** in incremental system costs per GW
- **BYOC** internalizes **$326 million** in capacity costs per GW, with the data center procuring accredited resources directly and offering them into the market to increase supply
- Data center **payments for the energy portion** of their bill cover an additional **$329 million** per GW of new demand

Across these components, a **data center contributes ~$733 million per GW** toward the costs associated with its incremental load, reducing the net system cost increase by **nearly 100%.** Flexible grid connections reduce the amount of new capacity the system must build, while BYOC ensures the data center, not other customers, pays for the capacity required to serve its firm load.

Flexible data centers also **increase utilization** of transmission and generation assets, spreading fixed costs more broadly and creating **new opportunities to ease rate pressure for all customers**.

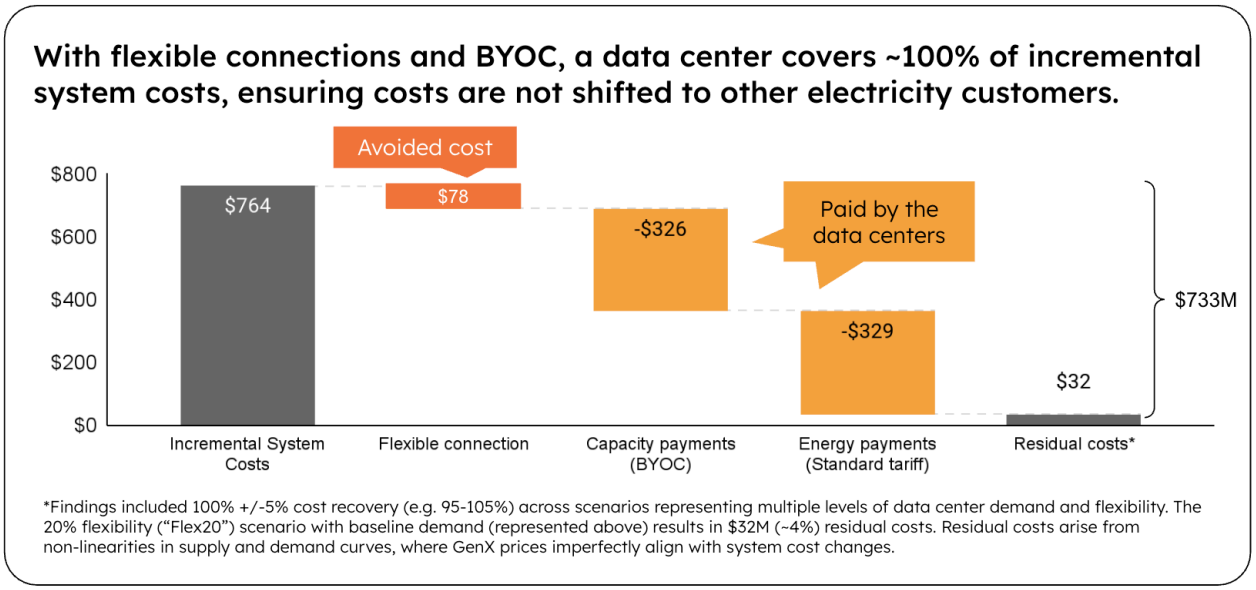


Figure 4: Incremental Cost Coverage by Flexible Connection and BYOC

[6] Incremental system supply costs estimated by the capacity expansion modeling (via GenX)

The implications

Flexible connections and BYOC offer a faster, more affordable path for integrating large data centers:

- **Speed**: three to five years faster access to full power for the data centers
- **Affordability**: data centers directly cover incremental costs while increasing grid utilization, enabling utilities to spread fixed costs over more electricity sales
- **Reliability**: data centers gain reliable grid supply for >99% of the year, while utilities gain additional demand side resources to alleviate system stress

The foundations for rapid progress are already in place. Utilities have the data needed to evaluate flexible grid connections, and the planning tools required to do this work are readily available. Early demonstrations show this approach can work. What's needed now is for utilities, regulators, and data center developers to build on that foundation by adopting advanced planning tools, defining clear service agreements, and launching near-term, large-scale demonstrations that make flexible grid connections and BYOC available to data centers that are willing to operate flexibly.

While the grid will still require major transmission and generation investments to meet long-term AI-driven demand, flexibility offers **the fastest, most practical path forward today**. It allows data centers to connect faster, protects reliability, and gives planners the time and breathing room needed to build the infrastructure of the future—a strategy that strengthens the grid instead of waiting on it.

Read the full report

The complete report, including the technical appendix, is available for download at no cost by visiting www.camus.energy/flexible-data-center-report.

Download the full report