

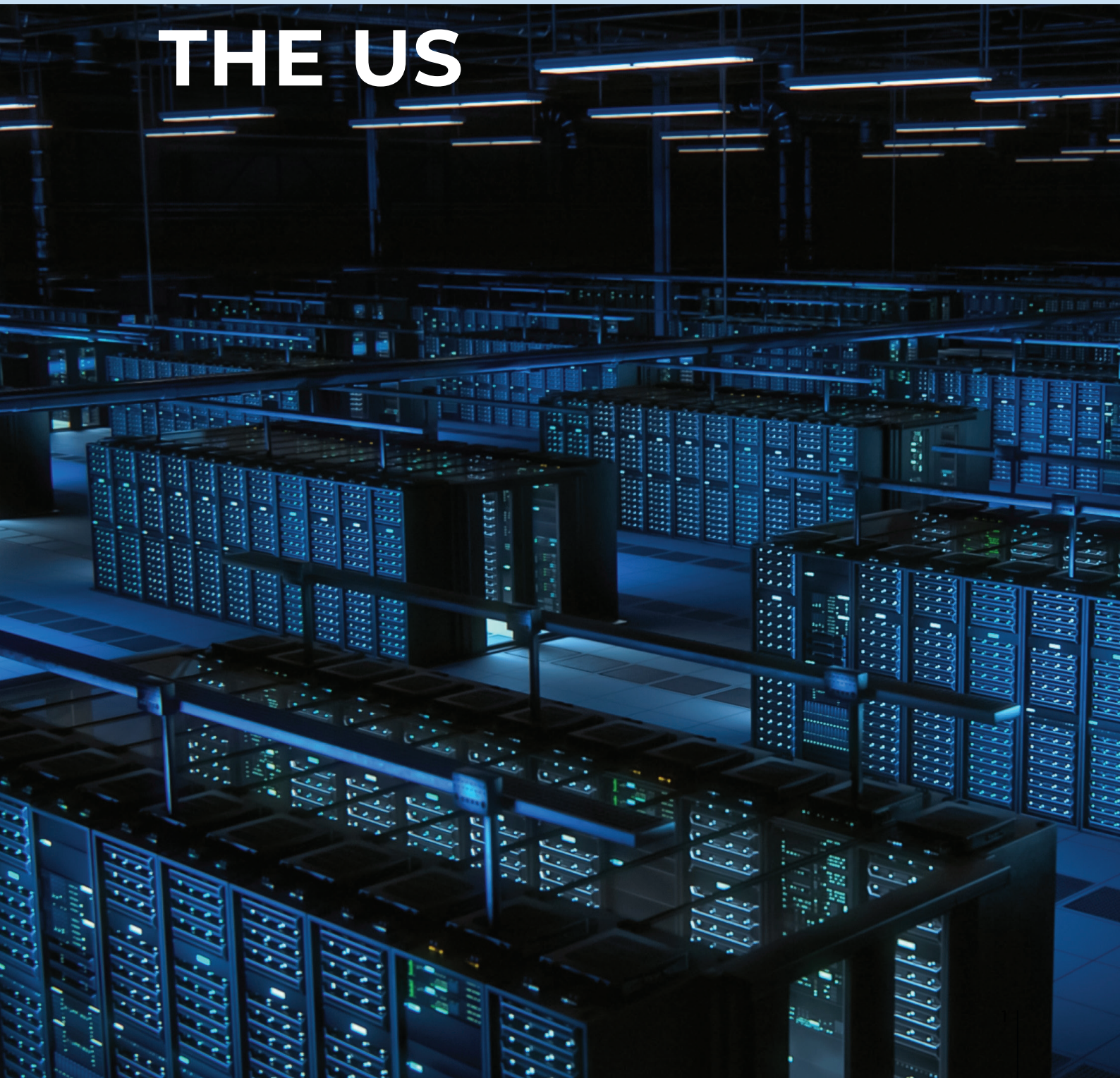
Author

Global **Transmission** Report

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HITACHI

POWERING DATA CENTERS: THE US



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EXECUTIVE SUMMARY

For much of the digital era, data centers operated as background infrastructure, with limited visibility in energy policy. Their rising electricity demand has now placed them at the forefront of energy regulation, with implications for network investment, system operations, and consumer costs. The rapid adoption of artificial intelligence (AI) adds further uncertainty around future load growth and long-term system planning. The business case for building a data center now starts with a basic question: where is reliable electricity available? An AI campus can require hundreds of megawatts, making power availability and grid connection decisive for site selection. Securing power generation, transmission, and grid connections can take several years longer than building the data center itself.

The US is the global leader in data center development, accounting for around 45% of the world's data center electricity consumption in 2024¹. This reflects the concentration of major cloud providers and AI developers in the US, supported by deep capital markets, a strong engineering workforce, and federal policy's focus on domestic AI and semiconductor capabilities.

US data center consumption reached an estimated 192 TWh in 2024, equivalent to almost 4.7% of total US electricity use². The International Energy Agency (IEA) expects data centers to account for close to half of US electricity demand growth through 2030¹. Virginia and Texas remain the two largest markets, though grid-related delays there are pushing developers toward the Midwest and other regions with more available generation, land and transmission capacity.

Unlike some commercial loads, data centers draw continuous power and can scale quickly, carrying reliability risk. On July 22, 2026, a transmission line fault in Ashburn, Virginia, caused about 3.8 GW

of data-center load to drop as facilities switched to backup generators³, resulting in voltage and frequency spikes in the region. Such events illustrate how large the system effects can be when concentrated demand shifts.

Federal and state policy is evolving rapidly in response to the surge in data-center demand, with regulators now focused on balancing speed-to-power with grid reliability, cost accountability, and consumer protection. In June 2026, the Federal Energy Regulatory Commission (FERC) issued tailored show-cause orders to six grid operators, asking them to justify or reform their tariffs for large-load interconnections such as data centers⁴.

The North American Electric Reliability Corporation (NERC) has elevated computational loads, including AI data centers, as a reliability concern through its Level 3 Alert and ongoing standards-development efforts^{5,6}. Meanwhile, the US House of Representatives passed the Ratepayer Protection Act in September 2026, to protect residential customers from data-center connection costs⁷. Together, these actions shift the focus from megawatt availability to the requirements for connecting and operating large, dynamic loads: visibility, operational controls, system studies, and clear cost-allocation mechanisms.

Regional operators are exploring approaches such as flexible or non-firm service, curtailment provisions, enhanced studies, and new reliability safeguards. Many states are developing large-load tariffs and policy frameworks to ensure that infrastructure investments remain equitable for existing customers. Meeting additional data-center demand while connecting large loads reliably will require progress across five areas.

Generation needs to expand. Utility-scale generation must grow, but data center developers

can also explore on-site generation or off-site supply arrangements.

New grid infrastructure needs to be built faster. New lines and major upgrades take 5–10 years⁸, compared with a 1–2 year build timeline for a typical data center⁹. Large power transformers can take 3–5 years to procure¹⁰. Longer planning horizons and more rigorous interconnection queue screening could help utilities prepare infrastructure before new loads arrive.

Existing capacity needs to be used better. Dynamic line rating, advanced conductors, power-flow controls, and digital monitoring can raise transfer capability faster than conventional upgrades, while grid-forming batteries can supply fast frequency and voltage support during disturbances.

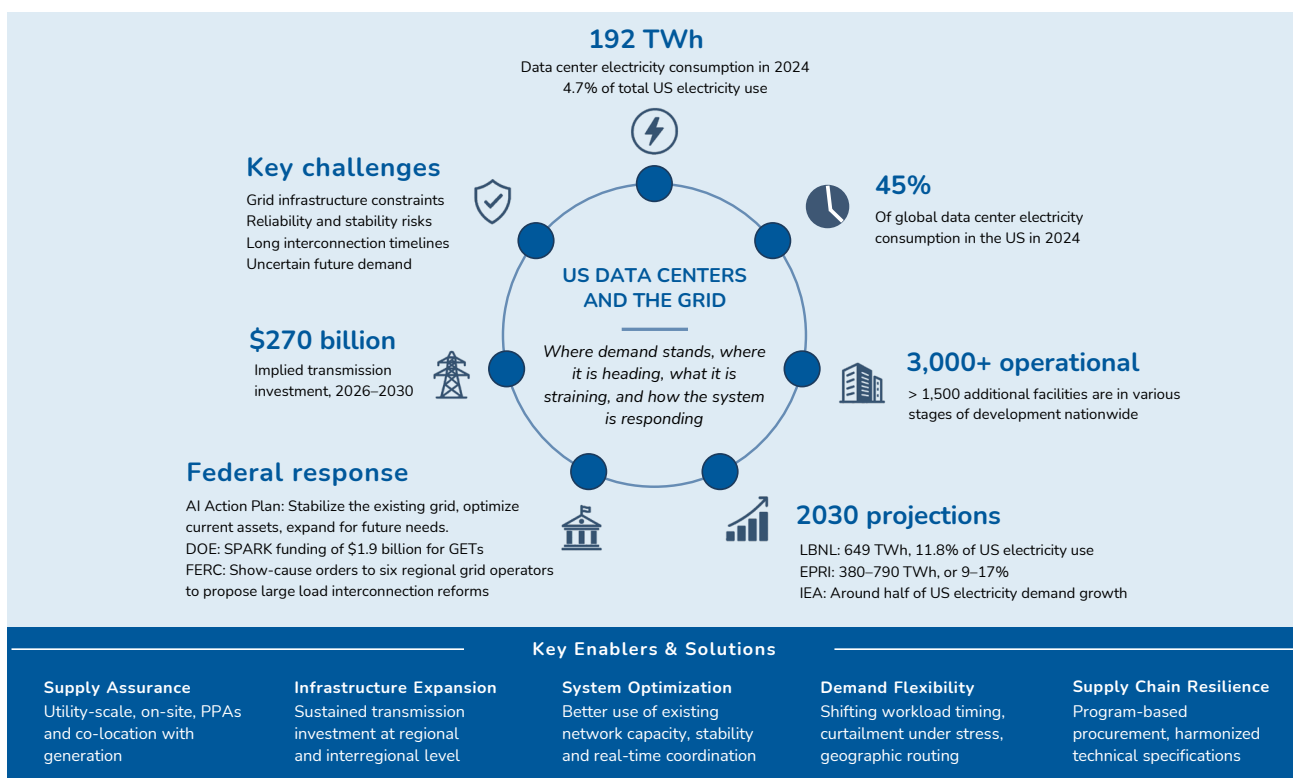
Demand itself needs to be part of the solution. Some computing workloads can be scheduled for

off-peak hours or shifted between facilities, and selected loads can be curtailed briefly in exchange for faster interconnection or lower costs. Load flexibility combined with batteries maximizes the utilization of available energy and allows the load to be increased in size while maintaining the same level of generation capacity. Greater load flexibility can help data centers secure connections faster.

Supply chains need to be strengthened. Lead times for transformers, switchgear, and other critical equipment have stretched to years. Program-based procurement and greater harmonization in technical specifications can help manufacturers ramp up production and address these constraints.

These efforts require close coordination between utilities, regulators, technology providers, and data center developers to keep pace with new demand without compromising reliability or driving up costs for consumers. ■

Figure 1: Powering Data Centers in the US



Notes: LBNL: Lawrence Berkeley National Laboratory; EPRI: Electric Power Research Institute; IEA: International Energy Agency; GETs: Grid-Enhancing Technologies; DOE: Department of Energy; SPARK: Speed to Power through Accelerated Reconductoring and Key Advanced Transmission Technology Upgrades; PPA: Power Purchase Agreement

INTRODUCTION

Data centers are becoming one of the largest sources of new electricity demand in the US, driven largely by the rapid expansion of artificial intelligence (AI). The US is the world's largest data center market and is likely to remain the leader in coming years. Many companies driving growth in cloud computing and AI are based in the US. The country also benefits from well-developed capital markets, a deep engineering workforce, and established digital infrastructure. These factors make the US a preferred location for data center investment.

The US also has a strategic and economic interest in maintaining its position in AI and advanced computing, which is being adopted across business, research, healthcare, manufacturing and national security. Federal policy has focused strongly on domestic AI capabilities, semiconductor manufacturing, and supporting energy and infrastructure, producing a growing pipeline of data center projects.

Reliable access to electricity is essential to this growth. Without sufficient electricity and a viable grid connection, a data center cannot begin operations, regardless of demand for its services. The main challenge is that data centers can be built faster than the power infrastructure needed to support them. AI facilities can require hundreds of megawatts and may be built within a few years, while new generation, transmission and distribution infrastructure can take several years to plan, permit, finance and construct. Data centers also compete for grid capacity, equipment and investment with other demand sources, including electric vehicles (EVs) and new manufacturing facilities.

Data centers also have operating characteristics that differ from other commercial loads. They generally require continuous power with high peaks and limited tolerance for outages. Their electricity use can change quickly as servers are

installed and facilities expanded. AI workloads add another consideration: training and inference can produce sharp ramps in electricity use. These characteristics challenge power systems planned around slower, more predictable demand, and affect the infrastructure needed to serve new facilities. Existing transmission capacity can limit where data centers connect without upgrades or additional generation. Utilities face long lead times for transformers, cables, and switchgear. Thus, a project's location and timing can directly affect connection costs and time to power.

Connecting new large loads also involves a complex regulatory process, often requiring projects to work with federal agencies, regional grid operators, state utility commissions, utilities and local authorities. Requirements vary by jurisdiction and affect how projects are studied, connected, permitted and charged for infrastructure. Grid operators are adapting their interconnection processes as requests from large electricity users increase.

This report examines the growth of data center electricity demand in the US and its implications for the power grid. It reviews federal and state policies affecting large-load connections, including tariffs, cost allocation, permitting, reliability and co-located generation. It evaluates key options for meeting demand: utility-scale generation and storage, on-site generation, power purchase agreements, co-located generation, transmission investment, network upgrades, digital monitoring and control, and demand flexibility.

The main objective of this report is to assess how the US power system can accommodate continued data center development while maintaining reliable service and limiting costs for other customers. ■

DATA CENTER DEMAND AND LOCATION

US electricity demand, after years of near-zero growth, is rising rapidly. Data centers are a major source of this increase, with AI driving higher electricity use. New data center capacity is moving beyond established markets, as developers seek sites with sufficient power, land, grid capacity, and faster permitting. This is changing the scale and location of new electricity loads across the US power system.

Data center electricity consumption reached an estimated 192 TWh in 2024, equivalent to 4.7% of US electricity use². Consumption increased by 14% between 2023 and 2024, driven mainly by the expansion of AI-accelerated servers². The

US accounted for around 45% of global data center electricity consumption in 2024¹. This growth is outpacing other major sources of new electricity demand, including EV charging, building electrification and manufacturing reshoring.

Projections show data center electricity consumption rising sharply by 2030. Lawrence Berkeley National Laboratory (LBNL) projects that data center electricity consumption could reach 649 TWh by 2030, equivalent to 11.8% of projected US electricity use, with a range of 521–843 TWh². Electric Power Research Institute (EPRI) estimates 380–790 TWh by 2030, equivalent to 9–17% of

Figure 2: US Data Center Demand

2024: Where Demand Stands	2030: Where it is Headed
Total Consumption 192 TWh Electricity consumed by US data centers	LBNL 649 TWh 11.8% of US electricity use
Share of Total US 4.7% Of all electricity consumed nationwide	EPRI 380–790 TWh Equivalent to 9–17% of US electricity use
Share of Global 45% Of global consumption in the US	IEA 50% Of US electricity demand growth by 2030 could come from data centers
AI uncertainty and speculative interconnection queues for data centers are producing a wide range of growth estimates.	

Notes: LBNL: Lawrence Berkeley National Laboratory; EPRI: Electric Power Research Institute; IEA: International Energy Agency

US electricity demand¹¹. The International Energy Agency (IEA) estimates that data centers could account for nearly half of US electricity demand growth through 2030¹. The range in estimation reflects uncertainty over AI deployment, computing architectures, and efficiency improvements. Even the lower estimates imply an increase comparable to the current electricity consumption of several large US states combined¹².

AI workloads are sharply increasing facility power requirements. Traditional cloud server racks draw around 3–5 kW, but racks of modern high-density AI chips can require up to 120 kW, and are expected to reach as much as 1 MW by 2027¹³. This is pushing up facility scale. Conventional data centers typically need 20–40 MW, while hyperscale AI campuses can require 100 MW or more¹⁴, and higher densities are also raising cooling and power-delivery requirements. The AI power profile is also less predictable than conventional loads. Training can cause large swings in demand as graphics processing units (GPUs) switch between compute-intensive tasks. Inference demand depends on real-time user activity, which makes it harder to forecast. Together, these patterns create sharper, less predictable power demand than the gradual load growth that grid planning has traditionally assumed.

The US has more than 3,000 operational data centers, and over 1,500 in various stages of development¹⁵. Virginia and Texas are the two principal markets. Virginia hosts almost 35% of known global hyperscale data center capacity¹⁶. Northern Virginia, including Loudoun, Fairfax and Prince William counties, forms the world's largest contiguous data center cluster, with over 5 GW capacity¹. Dominion Energy reported that data centers accounted for approximately 28% of its electricity sales in 2025¹⁷. Texas is the second largest market, supported by

its competitive wholesale electricity market, access to renewable generation and land availability¹⁵. California, Illinois, Georgia and Arizona also have significant data center capacity¹⁵.

Limited grid capacity constrains further development in some markets, while new locations offer greater power, land and transmission capacity. The Midwest is emerging as a major hub for new development, with Ohio, Iowa and Indiana recording significant project pipelines, as well as activity in Michigan, Minnesota, Wisconsin, Nebraska and North Dakota. New Mexico, Louisiana, Mississippi, Nevada and Pennsylvania are also seeing rapidly expanding project pipelines, with further projects in Colorado and Missouri.

These fast-paced developments have also prompted closer scrutiny by governments and the public. Some states have already introduced or are considering temporary moratoriums on new data center approvals. As of August 2026, legislation for data center moratoriums is either active, advancing, or under discussion in more than 40 states across the US¹⁸. While recognizing the role data centers play in driving economic growth, the states want a better read on grid capacity and ratepayer impacts before approving more projects.

The scale, concentration and uncertainty of data center demand are creating new challenges for electricity system planning and regulation, prompting measures across state and federal levels to speed power delivery, while adapting infrastructure, market structures, and regulations to ensure grid reliability, cost accountability, and consumer protection. The next chapter examines the policy and regulatory frameworks governing these issues, including the rules for market participation, grid access and the allocation of infrastructure costs. ■

POLICY AND REGULATORY MOMENTUM

Federal and state policymakers have responded quickly to align the regulatory environment with AI-driven demand, as electricity infrastructure is now viewed as a matter of national competitiveness in AI. The White House, the Department of Energy (DOE), and the Federal Energy Regulatory Commission (FERC) have acted through executive orders, funding programs and new rulemaking authorities. These actions signal a transition from focusing solely on megawatt availability to establishing the operational, regulatory, and economic framework needed to integrate large, dynamic loads reliably, transparently, and at scale.

At the state level, public utility commissions and legislatures have advanced reforms to streamline permitting for new transmission and generation capacity. Several states have enacted or proposed large-load tariffs and co-location frameworks. These reforms recognize that AI infrastructure growth may outpace existing utility regulatory structures.

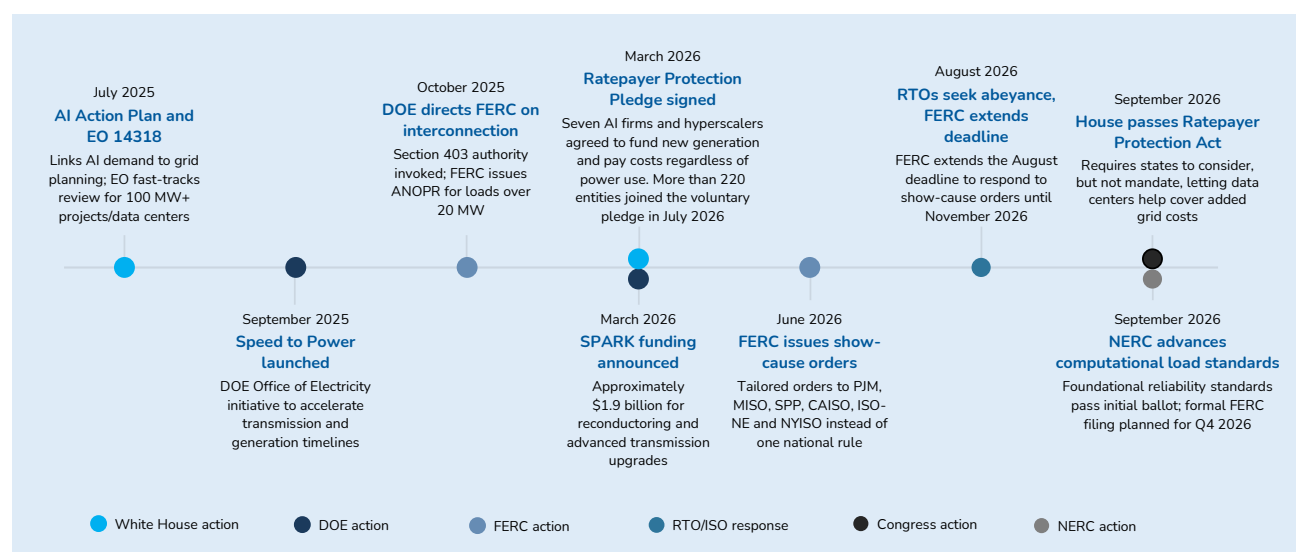
3.1 Federal Initiatives

3.1.1 AI Action Plan: Advancing Grid Development and Federal Permitting

The July 2025 release of Winning the Race: America's AI Action Plan was the first federal strategy to link AI electricity demand directly to power system planning¹⁹. The Plan's grid chapter sets three priorities: stabilize the existing grid, optimize current assets, and expand for future needs. Stability measures focus on keeping critical generation online and building backup capacity for peak demand. Optimization focuses on greater use of advanced transmission technologies (ATTs), reconductoring and demand-side measures. Expansion prioritizes faster interconnection for dispatchable generation, including nuclear and enhanced geothermal.

The Plan also calls for faster federal permitting, including new Categorical Exclusions under the National Environmental Policy Act (NEPA) for

Figure 3: Federal Action Shaping Data Center Development



lower-impact projects and identification of federal land for data centers. Executive Order 14318, issued alongside the Plan, defines "Qualifying Data Center Projects" as facilities needing more than 100 MW of new AI-related load²⁰. These projects get streamlined environmental review and priority siting on federal land.

3.1.2 Speed to Power Program: Enhancing Existing Grid Capacity

In September 2025, the DOE's Office of Electricity launched the Speed to Power initiative to accelerate transmission and generation project timelines²¹. The initiative reflects a growing recognition that the pace of grid infrastructure delivery, rather than the availability of technology or capital, is now the main constraint on connecting new data-center load to the power system. In March 2026, the DOE announced approximately \$1.9 billion in funding opportunities under the Speed to Power through Accelerated Reconductoring and Key Advanced Transmission Technology Upgrades (SPARK) program²². SPARK is essentially the third round of the Grid Resilience and Innovation Partnerships (GRIP) program.

SPARK funds upgrades to existing transmission corridors using advanced conductors and

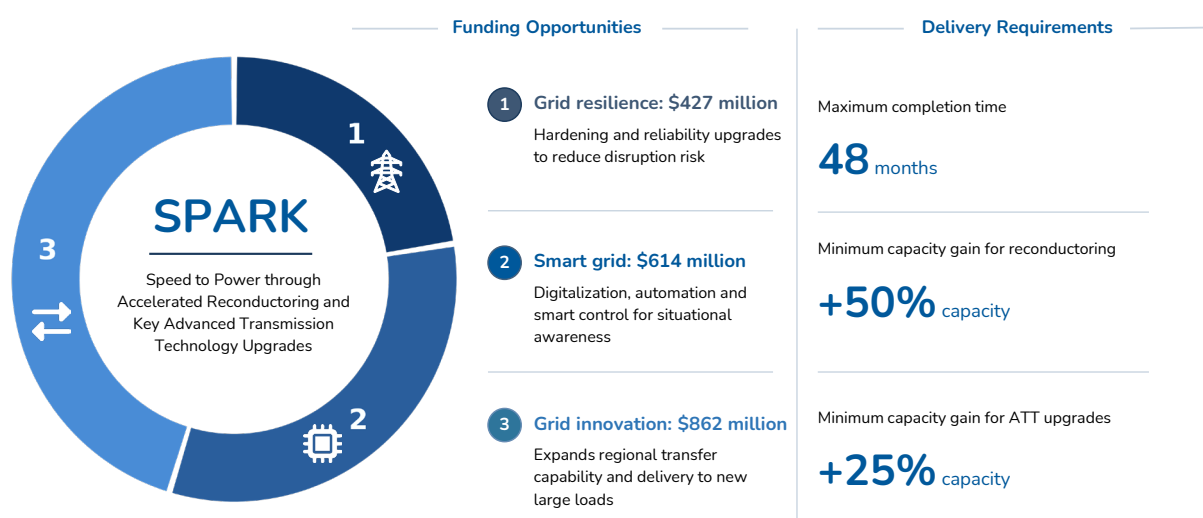
technologies, without requiring new rights-of-way.

3.1.3 Large Load Interconnection: Standardizing Procedures

In October 2025, DOE used its rarely invoked Section 403 authority to direct FERC to set standard interconnection procedures for loads above 20 MW²³. FERC responded with an Advance Notice of Proposed Rulemaking (ANOPR), proposing standard application procedures, joint load and generation studies, expedited review for loads accepting curtailment, and a cost-causer-pays rule for network upgrades²⁴.

On June 18, 2026, FERC issued tailored show-cause orders to the six Regional Transmission Organizations (RTOs)/Independent System Operators (ISOs) under its jurisdiction: PJM Interconnection, the Midcontinent Independent System Operator (MISO), Southwest Power Pool (SPP), the California Independent System Operator (CAISO), ISO New England (ISO-NE) and the New York Independent System Operator (NYISO)⁴. The orders require each regional grid operator and its transmission owners either to demonstrate that their existing tariffs remain just and reasonable or to propose reforms in five key areas: transmission-service application and study processes; cost transparency; study procedures

Figure 4: DOE's SPARK Funding Opportunity

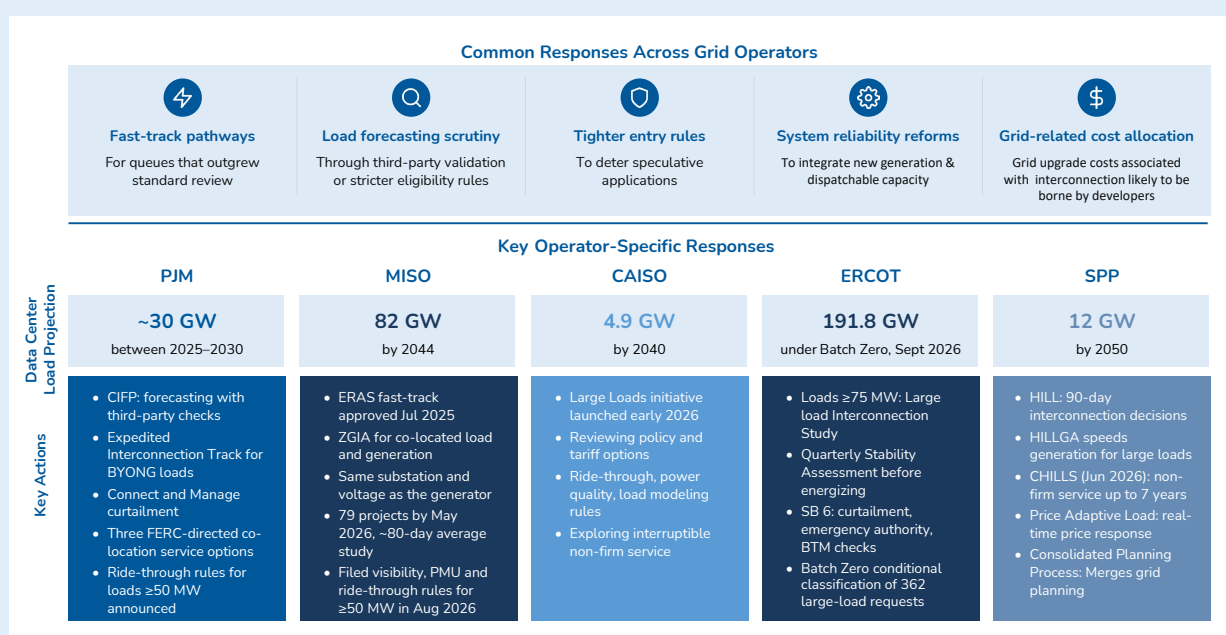


Awards are expected between October 2026 and January 2027, with completion required by January 2031.

RTO/ISO Initiatives

Federal and state rules set the framework, while RTOs and ISOs are responsible for studying and connecting new loads, including data centers. Regional grid operators are building fast-track pathways to manage queues that have outgrown standard review. Load forecasting now gets more scrutiny, often through third-party validation and stricter eligibility rules. Entry requirements have tightened to limit speculative applications. Operators have initiated measures to maintain system reliability, including reforms to support the integration of new generation and dispatchable capacity. Finally, operators and regulators are developing new approaches to allocate the transmission-upgrade costs associated with large-load interconnections.

Figure 5: Selected RTO/ISO Responses to Large Load Interconnection



Note: BTM: behind-the-meter; BYONG: Bring Your Own New Generation; CHILLS: Conditional High Impact Large Load Service; CIFP: Critical Issue Fast Path; ERAS: Expedited Resource Addition Study; HILL: High Impact Large Load; HILLGA: HILL with Generator Assessment; SB 6: Texas Senate Bill 6; ZGIA: Zero Injection Generator Interconnection Agreement

ERCOT's 191.8 GW reflects 362 large-load interconnection requests that received conditional classifications under the September 2026 Batch Zero process. It is not a data-center demand forecast, and it does not guarantee transmission capacity or energization approval.

Source: Compiled from the RTO/ISO documented files.

for co-location arrangements in which a large load connects directly to a nearby generation facility; co-location and behind-the-meter (BTM) generation rules; and new transmission services for flexible large loads. FERC has granted these regional grid operators time until November 2026 to respond⁴. MISO filed its own large-load reliability framework with FERC in August 2026 in response to the June

2026 show-cause orders. The proposal includes visibility, use of phasor measurement units (PMUs), ramp-rate, and ride-through requirements for loads above 50 MW, with a separate “computational load” category for facilities drawing at least 25 MW for IT equipment²⁵. MISO said it plans further proposals on transmission products and cost-shift protections before its November 16, 2026, deadline²⁵.

For these proceedings, FERC defines a large load as a new commercial or industrial customer at a single site, with peak demand of at least 50 MW, connecting to the transmission grid at a voltage of at least 69 kV and not forming part of a co-location arrangement²⁶. However, the orders allow each RTO/ISO to propose an alternative definition if it can demonstrate that the approach is just and reasonable.

3.1.4 Ratepayer Protection Pledge: Charging Data Centers for Infrastructure Costs

Alongside federal permitting and interconnection reforms, seven leading AI companies and hyperscalers signed the voluntary Ratepayer Protection Pledge in March 2026²⁷, committing to fund new power generation and grid infrastructure, pay agreed power and infrastructure costs, support local workforce development, and coordinate with grid operators during periods of system stress. By July 2026, more than 220 additional utilities, developers, cooperatives, public power providers and state governors had joined²⁸.

Because the pledge is voluntary rather than binding, its effect depends on the contracts and rate arrangements each signatory negotiates with utilities and state regulators, which vary by jurisdiction. This was illustrated in September 2026, when Microsoft, a pledge signatory, appealed a Virginia State Corporation Commission order requiring data center operators to prepay transmission infrastructure costs²⁹. Microsoft supported the principle that data center operators should cover the costs they cause but challenged the prepayment mechanism itself.

In September 2026, the US House of Representatives passed the Ratepayer Protection Act, the first bill aimed directly at the costs of data center growth for electricity consumers⁷. The bill would require state utility regulators to consider whether large electricity users, including data centers, should cover the additional infrastructure costs of serving them. The bill would encourage, but not require, states to adopt a rule requiring data center developers to cover the

cost of the transmission or generation upgrades needed to serve them³⁰.

3.2 State Initiatives

State and local governments are redefining the conditions for developing data centers. Historically, policy focused on attracting investment through tax incentives, streamlined permitting, and competitive electricity rates. As data center capacity expanded, policymakers shifted their attention toward infrastructure cost allocation, introducing specialized tariffs, interconnection requirements, and mechanisms to protect existing customers from the costs of serving large new loads. Today, many jurisdictions have entered a third phase that balances economic development against grid reliability, resource availability, community impacts, and ratepayer protection.

This evolution is visible in several states. Texas was among the first to establish a comprehensive large-load framework through Senate Bill 6, addressing transmission cost allocation, reliability protections, and load-management requirements. More recently, however, the state's focus expanded beyond infrastructure planning when the Governor directed the Electric Reliability Council of Texas (ERCOT) and the Public Utility Commission of Texas (PUCT) to review pending data center interconnection requests, including project viability, water use, on-site generation, and operational flexibility³¹. The message is clear: securing power is no longer sufficient. Projects must also demonstrate that they can be integrated responsibly and support broader system objectives. On September 3, 2026, ERCOT issued conditional Batch Zero classifications covering 362 large-load projects, totaling 191.8 GW of capacity. Of these, 204 projects (66.4 GW) qualified as base load and 158 (125.4 GW) as studied load³². Final classifications will depend on ERCOT's eligibility audit and a separate community impact review³².

Similar shifts are occurring elsewhere. Virginia³³ and Pennsylvania³⁴ are increasingly focused on grid capacity, cost allocation, energy affordability, and

the long-term implications of rapid load growth. In September 2026, the Virginia Governor signed Executive Order 22, introducing a Data Center Accountability Framework. The framework removes by-right approval for data centers using more than 25 MW, requires stronger upfront financial commitments from developers to discourage speculative projects, and directs utilities to allocate a fairer share of transmission and generation costs to data centers and other large loads³⁵. It also sets standards to prevent sudden demand swings from destabilizing the grid and limits BTM natural gas generation³⁵. New York has gone further, temporarily pausing approval of new data center projects while it develops a broader oversight framework³⁶. These actions reflect growing concern that large-load development should align with reliability, affordability, and public-policy objectives rather than being evaluated solely on its economic benefits.

At the local level, the conversation has evolved even more dramatically. Counties and municipalities in Indiana³⁷, Georgia³⁸, Ohio³⁹, California⁴⁰, and other high-growth markets have introduced

zoning restrictions, permitting reviews, setback requirements, noise limitations, and temporary moratoriums in response to concerns about land use, water consumption, transmission infrastructure, environmental impacts, and quality of life. In many regions, local governments have become the primary approval gatekeepers and require developers to show both economic value and compatibility with community priorities and infrastructure constraints.

As a result, the approval test for new data centers is changing. Regulators, utilities, and local communities now expect projects to act as "responsible grid participants" and community partners. Operational flexibility, shown through phased energization, curtailment capability, demand response, energy storage, dedicated generation, telemetry, or advanced control systems, now matters as much as power demand itself. In many markets, success no longer depends on delivering sufficient power. It depends on integrating a project in a way that enhances grid reliability, protects ratepayers, aligns with community priorities, and supports long-term system resilience. ■

GRID-RELATED CHALLENGES

4

The US grid faces growing pressure from aging infrastructure, limited transmission expansion, and rapid load growth from data centers and electrification. Grid planning and interconnection processes were designed for gradual, predictable, geographically distributed load growth. They now need to accommodate large, volatile, concentrated loads that can develop faster than new generation and transmission, contributing to interconnection backlogs, congestion, and planning delays.

As recent North American Electric Reliability Corporation (NERC) and FERC actions make clear, megawatt availability alone is no longer enough. Power must also be delivered, controlled, protected, and integrated reliably. For large AI and data center campuses, grid readiness depends on capacity, system strength, visibility, flexibility, and accountability. Without these conditions, data center growth can lead to interconnection backlogs, congestion, voltage and frequency instability, planning delays, and closer scrutiny of infrastructure costs.

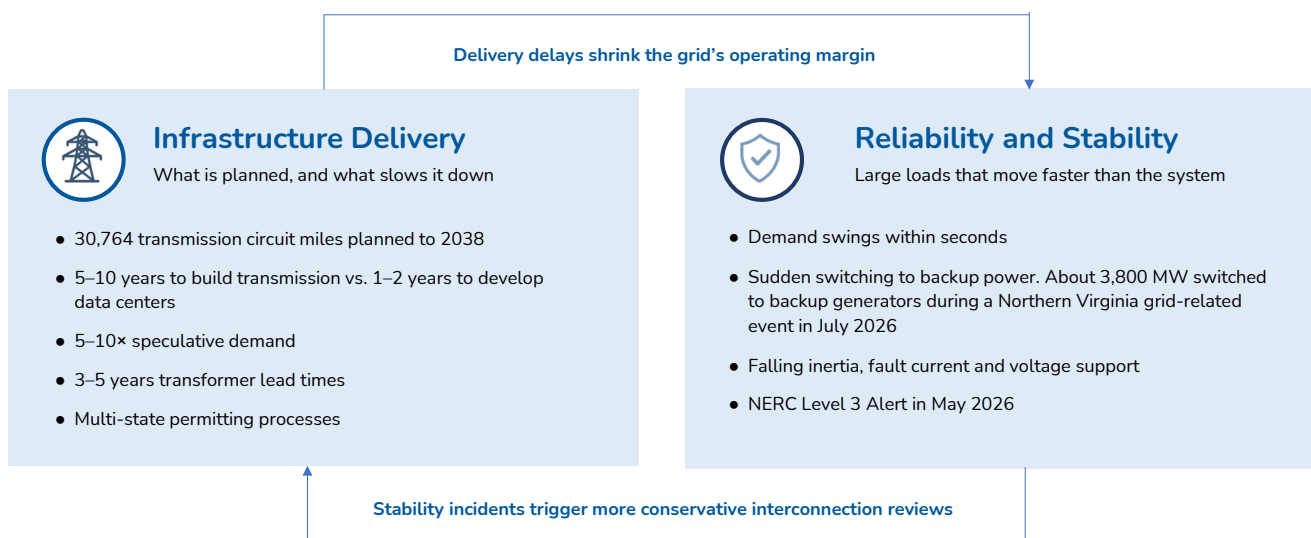
4.1 Infrastructure Delivery

NERC data show about 30,764 circuit miles of transmission planned through 2038, including 21,709 circuit miles of new lines and 9,055 circuit miles of upgrades at 100 kV and above⁴¹. A large part of the existing network is already operating near its limit, making expansion a precondition for some new connections. However, infrastructure expansion faces many challenges as described below.

Delivery timelines: Transmission projects typically take 5–10 years from planning to energization, while data-center demand can materialize within one to two years. This mismatch is particularly significant in established data center hubs, where individual projects can exceed existing network loads.

Demand uncertainty: Interconnection queues also contain projects that may never be built. Grid analysts estimate speculative requests run 5–10 times higher than the data centers ultimately built, as developers submit duplicate requests across states to hedge

Figure 6: Grid-Related Challenges



uncertainty⁴². Many utilities and state legislators now require deposits, proof of project maturity, or disclosure of duplicate requests, but uncertainty continues to complicate investment. Variation in data center types and volumes also complicates forecasting models.

Grid equipment supply constraints: Equipment shortages can delay projects even after interconnection approval. Large power transformer lead times have reached 3–5 years¹⁰, while demand from data centers, renewable generation, and grid replacement competes for the same supply chain.

Permitting and planning: Transmission projects face state siting processes, environmental review, and local approvals. A single interregional project may require approvals across several states, each with its own process and timeline, extending the period between identifying a need and completing the project. FERC Order No. 1920, issued in May 2024, requires longer-term regional transmission planning, but implementation is still underway⁴³.

4.2 Reliability and Stability Risks

Large data centers introduce a different grid risk because their electricity demand can change rapidly, leading to stability challenges from voltage or frequency deviations. They require uninterrupted power with limited scheduling flexibility. Idaho National Laboratory's (INL) large-load taxonomy distinguishes between “slow” loads, which have relatively stable and predictable demand, and “fast” loads, which can experience sudden and significant changes in power use⁴⁴. A slow load rarely changes by 50 MW or more within 60 minutes, with such events occurring fewer than 12 times a year or only during grid instability, while a fast load experiences these changes as part of normal operations⁴⁴. The 50 MW threshold reflects the potential grid impact of rapid load changes, which can require a prompt response from generators and other grid resources⁴⁴.

Data-center demand can ramp up sharply during model training and fall once training concludes. In addition, AI training workloads can exhibit

rapid fluctuations while operating, as large GPU clusters cycle through different computational and communication tasks. These dynamics can produce significant short-duration variations in power demand, creating operational challenges for grid operators. Facilities can also disconnect rapidly and switch to on-site backup power following a voltage or frequency disturbance. If several facilities respond simultaneously, the resulting loss of load can reach hundreds or thousands of megawatts.

On July 22, 2026, nearly 3.8 GW of Northern Virginia data-center load unexpectedly transferred from the PJM grid to on-site generation after a 230 kV line was automatically removed following a mechanical failure³. The resulting loss of load caused frequency and voltage to rise. A similar incident in 2024 disconnected about 1.5 GW of data-center load in Northern Virginia³. Concentration in major hubs increases the potential scale of such events. Following the July 2026 event, PJM proposed ride-through rules in September 2026 requiring large computational loads (data centers connected at 100 kV or higher and with at least 50 MW) to remain connected during specified disturbances rather than switching to backup power⁴⁵. Facilities would need to restore at least 90% of load within two seconds after conditions normalize⁴⁵.

The risk increases as the generation mix changes. Retirements of large conventional generators reduce the inertia, fault current, and voltage support. Wind and solar output increase the need for flexible resources and accurate forecasting. NERC issued a Level 3 Alert in May 2026 requiring additional data collection, stability studies, commissioning procedures, and fault recording for areas with concentrated computational load⁵. In July 2026, FERC directed NERC to develop mandatory reliability standards for computational loads, including AI data centers and crypto mining⁶. NERC's foundational Computational Loads Reliability Standards passed initial ballot on September 19, 2026, drawing on findings from incident reviews, and input from industry and data center stakeholders, with a formal filing to FERC planned before the end of 2026⁴⁶. ■

KEY ENABLERS AND SOLUTIONS

The US data center sector is growing at a pace that requires coordinated action across generation investment, network technology, system operations, and market design. Several solutions are already being deployed across the country, while others are emerging for wider use by data center developers and grid operators.

This chapter examines the key enablers for meeting the electricity needs of data centers while maintaining grid reliability and affordability.

5.1 Supply Assurance

Meeting projected data-center demand will require increased investment in new generation, renewable capacity, and energy storage. Supply can be secured through four main routes: utility-scale generation and storage; hybrid architectures like BTM generation, microgrids, and on-site storage; Power Purchase Agreements (PPAs); and co-located generation. These options differ in lead times, costs, interconnection requirements, and risk allocation, and most large operators now pursue more than one simultaneously.

Grid-scale generation and storage: Natural gas supplies about 41% of today's data center electricity, followed by renewables (primarily solar and wind) at about 24%, and nuclear at 20% and coal at 15%¹. Gas is expected to remain the largest source of dispatchable power through 2030. Recent utility integrated resource plans call for 84 GW of new gas capacity through 2035, 32 GW more than planned at the end of 2023¹, with some projects being developed in response to data-center demand.

Renewable additions are also expanding, although recent changes to federal tax credit policy have altered the investment outlook⁴⁷. The Energy Information Administration's (EIA) planned capacity data shows 43.4 GW of utility-scale solar, 11.8 GW of wind and 24 GW of battery storage additions in 2026⁴⁸. Battery storage supports both grid supply and large-load integration by providing capacity during peak periods and responding quickly to demand changes. Nuclear offers a longer-term source of firm, low-carbon generation, but most new nuclear projects, including proposed small modular reactors (SMRs), are unlikely to add any significant capacity before 2030¹.

Figure 7: Key Routes to Securing Supply

 Utility-scale generation & storage	 On-site and hybrid generation	 Power purchase agreements	 Co-located generation
- Gas about 41% of today's data center consumption mix; renewables 24%, nuclear 20%, coal 15% - Gas the largest source of dispatchable power through 2030. 84 GW of new gas planned through 2035 — 32 GW more than at end-2023 - New nuclear, including SMRs, unlikely before 2030	- Power available before full interconnection - Microgrids combine generation, storage and controllable loads - Energy parks emerging in Ohio, Montana, Texas and Utah - Option to use more renewable energy	- Contract for off-site generation over a defined period - Largely used for renewables, now also nuclear - Secures price and supply, not transmission access - Example: Amazon–Talen deal with up to 1,920 MW at Susquehanna	- Load connected directly to nearby generation - Reduces network upgrades, but not the need for transmission - FERC Section 206 proceedings opened for all six RTOs/ISOs on June 18, 2026 - Framework remains region-specific

On-site and hybrid generation: On-site generation can provide power before full grid interconnection is available and can reduce dependence on transmission capacity. Gas remains the fastest deployable firm capacity for BTM generation use, even as average delivery lead times for heavy-duty gas turbines have increased to 5–7 years, and can potentially conflict with clean energy commitments for several data center developers⁴⁹.

Data centers can also use microgrids that combine generation, storage, and controllable loads. These systems can operate with limited grid support and later integrate more fully with the grid. Their economics depend on fuel costs, emissions requirements, reliability needs, and the cost of grid connection.

Power purchase agreements: PPAs allow operators to contract for off-site electricity over a defined period, widely used for renewable procurement and increasingly for nuclear generation.

The Amazon and Talen Energy agreement at the Susquehanna nuclear plant illustrates this model. In June 2025, the companies agreed to a PPA for up to 1,920 MW of carbon-free electricity for Amazon operations⁵⁰. The arrangement moved from a co-located structure toward a front-of-the-meter model, with power supplied to the PJM grid and delivered to Amazon through the retail and transmission system.

PPAs can provide long-term price and supply commitments, but they do not by themselves remove transmission or interconnection constraints. Physical delivery still depends on the relevant grid and market arrangements.

Co-location with generation: Co-location connects a large load directly to a nearby generation facility, subject to applicable grid and market rules. It can reduce the transmission capacity and network upgrades needed to serve the load but does not necessarily eliminate the need for transmission or other grid services. Treatment depends on the connection's nature, how the load uses the transmission system, and how costs are allocated.

As noted in Chapter 3, FERC is revising the regulatory framework for large loads and co-located generation, issuing show-cause orders to all six RTOs and ISOs under its jurisdiction in June 2026⁴. Because the framework remains region-specific, developers should assess both the physical and electrical configuration of a proposed arrangement and the applicable transmission, market, reliability and cost-allocation rules before relying on it.

5.2 Infrastructure Expansion

Meeting the infrastructure requirements identified in Chapter 4 will require sustained investment in transmission expansion at both regional and interregional levels. According to the Edison Electric Institute (EEI), investor-owned utilities are expected to invest approximately \$1.36 trillion between 2026 and 2030⁵¹. If transmission maintains its historical share of around 20% of total capital expenditure, this translates to about \$270 billion in transmission investment over the period⁵¹.

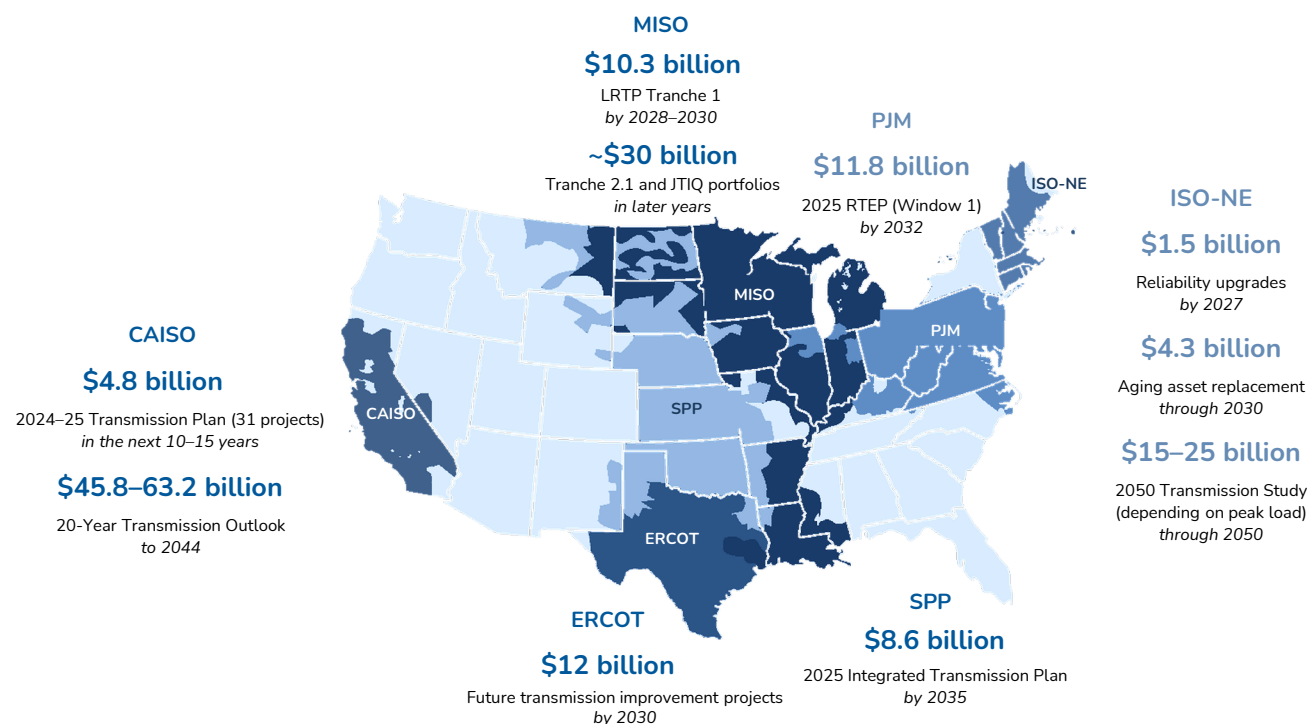
Every major regional grid operator has its own expansion plan underway as shown in Figure 8.

Realizing this scale of spending depends on further enablers.

Long-term, coordinated planning: A 20-year or longer planning horizon, using multiple scenarios and a broader set of benefits, could better inform investment decisions. FERC's Order No. 1920 requires transmission providers to conduct long-term regional planning over at least 20 years, using at least three distinct scenarios, and to evaluate investments based on specified economic and reliability benefits⁴³.

Planning could also more explicitly assess emerging system-performance needs, including inertia, voltage stability, and the impacts of inverter-based resources. While these issues may already factor into existing studies, addressing them explicitly in long-term planning could improve visibility into emerging grid constraints and guide future investment.

Figure 8: Key Regional Transmission Investment Plans



Notes: JTIQ: Joint Targeted Interconnection Queue; L RTP: Long-Range Transmission Plan; RTEP: Regional Transmission Expansion Plan.

Source: Individual RTO/ISO transmission plans, DOE National Transmission Needs Study (Draft, July 2026)

Anticipatory investment: Planning in response to confirmed connection requests has led to long interconnection queues across major markets. A proactive rather than reactive approach can give the grid equipment manufacturing supply chain greater demand visibility and support earlier procurement and manufacturing decisions.

Permitting reforms: Permitting can add several years to major transmission projects, often extending to 10–15 years for new interstate infrastructure. DOE’s Coordinated Interagency Transmission Authorizations and Permits (CITAP) program provides a coordinated federal review process for qualifying interstate projects⁵², and FERC Order No. 1977 requires project applicants to develop public and Tribal engagement plans⁵³. Streamlined permitting procedures, early and transparent community engagement with clear local benefits, and better coordination across government layers can help accelerate timelines.

Interconnection process reforms: Interconnection queues have traditionally followed a first-come, first-

served approach, allowing projects to hold positions while contributing to growing backlogs and delays. FERC Order No. 2023 replaced this with a “first-ready, first-served” cluster study process for generation, supported by higher financial readiness and site-control requirements and withdrawal penalties to discourage speculative projects⁵⁴. FERC’s ongoing large-load interconnection rulemaking seeks more standardized procedures and readiness requirements. Faster adoption of these reforms could reduce queue congestion and shorten connection times.

5.3 System Optimization: Network Capacity, Stability, and Digitalization

Advanced grid technologies, digitalization and AI can help the US electricity system meet growing data-center demand by making better use of existing network capacity, supporting grid stability as generation and large loads change, and improving real-time coordination. These measures can help address near-term network capacity and reliability needs while new generation and transmission

capacity is developed and brought online. Incentivizing utilities to prioritize non-wire solutions along with capital-intensive investments can help accelerate grid optimization.

5.3.1 Enhancing Existing Network Capacity

Grid-enhancing technologies (GETs) can increase the capacity and efficiency of the existing grid infrastructure. They can often be deployed faster than new transmission lines, particularly where new rights-of-way or permitting are constraints. DOE's 2026 SPARK funding opportunity explicitly supports reconductoring and GETs that increase transfer capability and improve grid flexibility. Despite a recent wave of legislation across several states requiring consideration of GETs, the deployment remains uneven and largely state-driven. An overview of technologies to enhance the capacity of the existing transmission network is provided below:

- Dynamic line rating (DLR) uses real-time measurements of weather and conductor conditions to determine the safe operating capacity of a transmission line. This can increase transfer capability when actual operating conditions allow higher flows than static ratings. Several utilities, such as National Grid⁵⁵, PPL Electric Utilities⁵⁶, and Great River Energy⁵⁷, have deployed DLR technology.
- Advanced Power Flow Controller (APFC) devices use power electronic controls to improve voltage regulation and power flow management. APFCs can actively control power flows to redistribute loading across transmission paths and alleviate congestion.
- Transmission Topology Optimization (TTO) uses software to identify beneficial network configurations to redirect power flows around congested elements. MISO has established a formal congestion-cost reconfiguration process through which market participants can propose topology-based solutions. PJM, meanwhile, has topology-control capabilities in operational use.

- Reconductoring replaces existing conductors with higher-capacity, low-sag alternatives while retaining existing towers and rights-of-way.

5.3.2 Maintaining Real-Time System Stability

The changing generation mix and rapid growth of large data-center loads increase the need for fast voltage and frequency control. Many new generation and storage assets, as well as data-center loads, connect to the grid through power electronics. This changes system behavior during disturbances and can reduce some of the stabilizing services traditionally provided by synchronous generators.

Batteries can provide fast frequency and voltage support, but battery storage alone may not provide all the grid services required as data-center loads scale. A broader set of technologies is needed. Grid-forming inverters can establish voltage and frequency references and provide fast response to system disturbances. Grid-forming battery energy storage systems (BESS) pilots in ERCOT⁵⁸ and CAISO⁵⁹ are demonstrating that battery systems can provide fast frequency response, voltage support, and black-start capability, functions previously reserved for large thermal units. Flexible Alternating Current Transmission Systems (FACTS) devices, including static synchronous compensators (STATCOMs) and static VAR compensators (SVCs), can provide rapid reactive power support and help manage local voltage constraints. In high-voltage transmission lines, series compensators can be deployed to compensate for inductive reactance, thereby increasing power transfer capability, enhancing transient stability, and optimizing active power flow. Emerging solutions such as eSTATCOMs combine grid-stability capabilities with integrated energy storage, enabling voltage support, frequency response, and active power balancing that can help accommodate large, fast-changing data-center loads while improving overall system resilience.

High-voltage direct current (HVDC) could play a larger part in infrastructure expansion, especially where substantial volumes of electricity need to

move between regions or over long distances. It also has a role in maintaining stability. Controlled power transfers can help manage inter-area power flows and limit disturbance propagation, complementing its role in capacity expansion.

5.3.3 Improving Network Visibility and Control

Digitalization and AI can provide the intelligence layer that enables advanced grid technologies to operate more effectively. By connecting physical network assets through sensors, advanced monitoring systems, digital substations and secure communications, operators can gain real-time visibility of network conditions, including power flows, voltage performance, congestion and asset health.

- PMUs provide synchronized measurements at rates of 30–120 samples per second, compared with one sample every 2–4 seconds for conventional monitoring, enabling operators to monitor voltage angles, frequency deviations and power flows with much greater temporal resolution⁶⁰. This capability is particularly relevant as large, concentrated loads introduce rapid and localized changes in demand. In the US, Wide Area Monitoring Systems (WAMS) are evolving beyond situational awareness toward real-time stability assessment. ERCOT and EPRI have demonstrated a proof of concept that uses existing PMU infrastructure to estimate system strength and inertia in real time⁶¹.
- Advanced Energy Management Systems (AEMS) integrate synchrophasor data with weather forecasting, load prediction, dispatch schedules, and market information to provide operators with a more comprehensive view of system conditions. AI and automation can further support operators by identifying emerging constraints and evaluating corrective actions. Interconnection automation is an emerging application: FERC has highlighted demonstrations in which automated software reproduced a manual study that had taken nearly two years in around 10 days, illustrating the potential to substantially reduce

study times⁶². MISO is also implementing a platform that uses advanced analytics, machine learning and AI to improve planning and interconnection studies⁶³.

- At the distribution level, Advanced Distribution Management Systems (ADMS) improve outage management, fault restoration and distribution-system visibility. Distributed Energy Resource Management Systems (DERMS) coordinate distributed resources to provide services such as voltage support and peak-demand management. Utilities including Southern California Edison (SCE), Pacific Gas and Electric (PG&E), Duke Energy and Xcel Energy are deploying these platforms to improve DER integration, increase hosting capacity and, in some cases, defer conventional grid upgrades. Digital substations can further improve monitoring and control by replacing conventional analog equipment with digital sensors and International Electrotechnical Commission (IEC) 61850 communications.

5.4 Demand Flexibility and Load Shifting

Demand-side flexibility could be one of the most cost-effective ways to integrate large data center loads. It works through three channels:

- **Timing:** shifting flexible workloads like AI training to off-peak periods.
- **Curtailment:** pausing non-urgent computing during system stress for compensation.
- **Geographic shifting:** routing compute to regions with more available capacity or lower prices.

With supporting regulatory frameworks and market structures, data centers can become participants in grid stability, offering demand response and operational reserve services. Large technology companies are already signing such agreements. By March 2026, Google had integrated 1 GW of demand response capacity into long-term utility contracts across Indiana, Tennessee, Arkansas, Minnesota and Michigan⁶⁴. These agreements let utilities request temporary reductions or shifts in

electricity use during peak demand. Carbon Direct's ERCOT modeling found that flexible data center demand could eliminate forced load shedding even at 40 GW of data-center load, avoiding an estimated \$5.5 billion in annual consumer welfare losses while requiring curtailment for less than 1% of the year⁶⁵.

Automated load management complements these strategies. EPRI's DCFlex initiative, with more than 60 participating companies, is testing whether data centers can act as flexible grid assets by modulating power consumption in response to grid signals without disrupting computing¹¹. IEA modeling suggests that if US data centers operate flexibly for just 1% of operating hours, the existing grid could accommodate up to 70 GW of additional capacity, enough to cover all colocation, service provider and hyperscale additions¹.

Time-of-use and other dynamic pricing provide similar incentives to shift flexible workloads to lower-demand periods. PJM, ERCOT and CAISO all let large consumers offer load reductions for compensation or respond to real-time prices. In Texas, ERCOT's energy-only design exposes consumers to sharp wholesale price spikes during system stress, incentivizing data centers to shift energy-intensive work, such as AI training, to lower-price overnight periods. In PJM, data centers can already offer load reductions as capacity and be paid for committing to reduce demand during peak events.

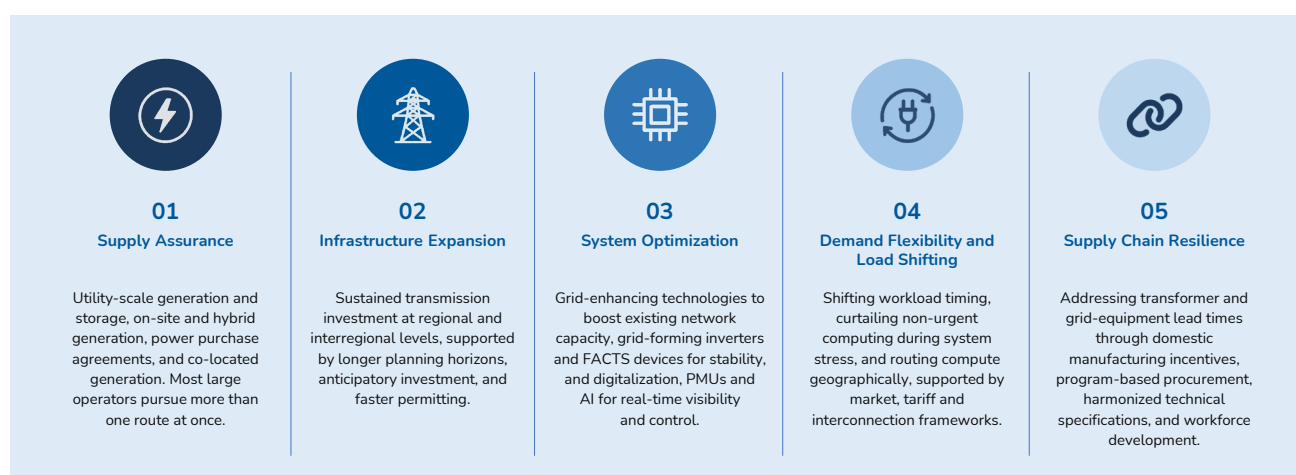
Regulators are now open to treating large data centers as flexible or dispatchable loads rather than passive consumers, which could expand their role in capacity and ancillary service markets, including frequency regulation and ramping support. FERC's June 2026 show-cause orders to RTOs/ISOs also emphasized flexible transmission service for large loads willing to limit withdrawals, which could raise the value of demonstrated load flexibility in future interconnection and transmission arrangements⁴.

5.5 Supply Chain Resilience

Delivering the generation, transmission and distribution investment described above depends on the availability of grid equipment and materials. US grid supply chains were built around steady replacement needs and gradual network expansion and are now under pressure from the scale and pace of new demand.

Demand-supply gap and lead times: Lead times for large power transformers now average 3–5 years¹⁰. Demand for switchgear, substations and other equipment has also risen, contributing to shortages across most categories. The industry has responded with new investment, but new or expanded facilities can still take up to five years to come online for greenfield projects and up to three years for brownfield expansions⁶⁶.

Figure 9: Key Enablers and Solutions to Power Data Centers



Incentives for domestic manufacturing: Policymakers now treat grid equipment manufacturing as a national security matter, driving policies to expand domestic production and reduce reliance on foreign suppliers. In April 2026, a Presidential Determination under Defense Production Act Section 303 addressed US grid equipment and supply chains⁶⁷, and bipartisan legislation has also been introduced to boost domestic transformer production⁶⁸. Fully onshoring vertically integrated supply chains is not economically viable, so imported components will remain part of US supply chains. Strategic reserves of critical components could also improve resilience.

Shifting from project-based to program-based procurement: Moving from project-by-project procurement to multi-project, program-based approaches could speed up grid development,

reduce administrative work and make it easier to replicate designs. Framework agreements give suppliers multi-year visibility across projects, helping them invest in added manufacturing capacity, while capacity reservation contracts can secure production slots through advance financial commitments during periods of high demand.

Harmonizing technical specifications: Manufacturers often face different design requirements across individual projects, which adds to design and production time. Wider use of standard specifications, supported by testing and certification, could improve safety and interoperability. Standardized designs would also make it easier to replicate projects, apply lessons from earlier projects and reduce design, manufacturing and construction time, while supporting pooled procurement. ■

CONCLUSION

US data center electricity demand is likely to remain high through the end of the decade, although the scale and timing of many new projects remain uncertain. Much of this uncertainty comes from the pace of AI workload growth, the energy intensity of next-generation computing architectures, and how far efficiency gains in hardware and data center design can offset underlying demand growth. This makes load forecasts and the treatment of interconnection requests important for generation and transmission planning. Utilities and grid operators need better information on which projects are financially committed, where they will connect and when their full electricity requirements will be needed. The share of the announced project pipeline that converts into realized, operating load remains the largest source of uncertainty in current US grid planning.

Over the next several years, data center development, generation investment and transmission planning will need to be considered more closely together. Where credible large-load growth is identified, grid investment can begin before individual facilities reach final connection. Where demand remains uncertain, staged investment and flexible connection arrangements can reduce the risk of unused capacity.

Natural gas can provide firm capacity in the near term, while renewables, storage and nuclear can provide additional supply over a longer period. On-site generation, co-located resources and PPAs can provide further options for individual facilities. However, these arrangements do not remove the need for transmission and distribution capacity where data centers depend on the wider grid.

Transmission investment will remain necessary in areas where existing networks cannot accommodate new demand. Existing infrastructure can provide additional capacity through reconductoring, dynamic

line rating, advanced power-flow controls and network optimization. These measures can be implemented faster than some new transmission projects and can provide additional capacity while larger projects are being planned and built.

Cost allocation will remain an important regulatory challenge. States will need to determine which infrastructure costs should be paid directly by data centers and which should be recovered from other customers. Data center developers could take more responsibility for network upgrades required by their connections. Emerging regulatory reforms are also likely to place greater emphasis on load transparency and forecasting, requiring large electricity users to provide more robust information on expected demand profiles, operational characteristics, and development timelines. This would improve planning and reduce the risk of building infrastructure for projects that do not proceed.

Large data centers can also provide demand flexibility. AI training and other non-urgent workloads can be moved to periods of lower electricity demand or reduced during system emergencies. This could reduce peak capacity requirements and, in suitable locations, allow some connections before all permanent network upgrades are complete.

The requirements for connecting new data center demand reliably and affordably are clear. Interconnection processes need to be faster and more disciplined. Generation and transmission investment needs to keep pace with new demand. Existing grid capacity should be used more efficiently. Infrastructure costs should be clearly allocated. Large loads should provide greater flexibility where possible. These measures should now be applied without delay so that new data-center demand can be served without compromising grid reliability or increasing costs for other electricity consumers. ■

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info@globaltransmission.info