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Power System Challenges from the Rapid Expansion of Data Centers

—Current Situation and Efforts in the United States—

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In recent years, the construction of data centers has been progressing rapidly around the world, driven by the growing adoption of generative AI and advances in digitalization. Data centers are facilities that continuously consume large amounts of electricity, and their increasing scale and geographic concentration in specific regions are creating new challenges for power systems that have traditionally been based on relatively gradual growth in electricity demand. In particular, in addition to the increase in electricity demand itself, there are situations in which the development of generation capacity and transmission infrastructure is not keeping pace with the scale and speed of demand growth.

The United States is where these challenges have become particularly evident. Globally, future electricity demand growth is expected to be driven by a wide range of factors, including expanding industrial activity, electrification, and increasing cooling demand. In the United States, however, data centers account for a large share of the increase in electricity demand. Furthermore, because data centers are concentrated in certain regions, large-scale electricity demand is emerging within short periods, exposing constraints in various aspects of the power system, including grid connections, transmission capacity, and generation capacity adequacy.

While the development of generation capacity and transmission infrastructure requires long lead times, data center deployment can proceed at a much faster pace. In addition, data center developers may submit grid connection applications at multiple locations, creating uncertainty regarding when, where, and at what scale data center projects will actually be realized. If infrastructure investment proceeds on the basis of overestimated electricity demand, it may result in unnecessary investment and increased costs for electricity consumers. Conversely, if investment is delayed until electricity demand becomes certain, it may not be possible to supply the required electricity when needed. This creates a difficult challenge of how to undertake advance investment in generation capacity and transmission infrastructure, which require long lead times, while facing uncertainty in future electricity demand.

Furthermore, the impacts of rapid data center expansion may extend to local infrastructure and

residents' daily lives through increased cooling water consumption at data centers. In addition, tightening supply-demand conditions for IT equipment, transformers, and other equipment used in data centers may make the smooth deployment of data centers themselves more difficult.

This paper examines the impacts of growing large-scale electricity demand, particularly from data centers, on power systems and local communities, focusing on the PJM region, operated by the largest regional transmission organization in the United States, where these challenges have become especially pronounced. It then examines the measures being taken in the United States to address grid connections, transmission infrastructure development, generation capacity adequacy, cost allocation, coexistence with local communities, and equipment procurement, and considers the implications for Japan in responding to future growth in large-scale electricity demand.

1. Growth in Electricity Demand and Key Challenges Associated with Data Center Expansion

1.1. Impacts on Electricity Demand and Regional Disparities

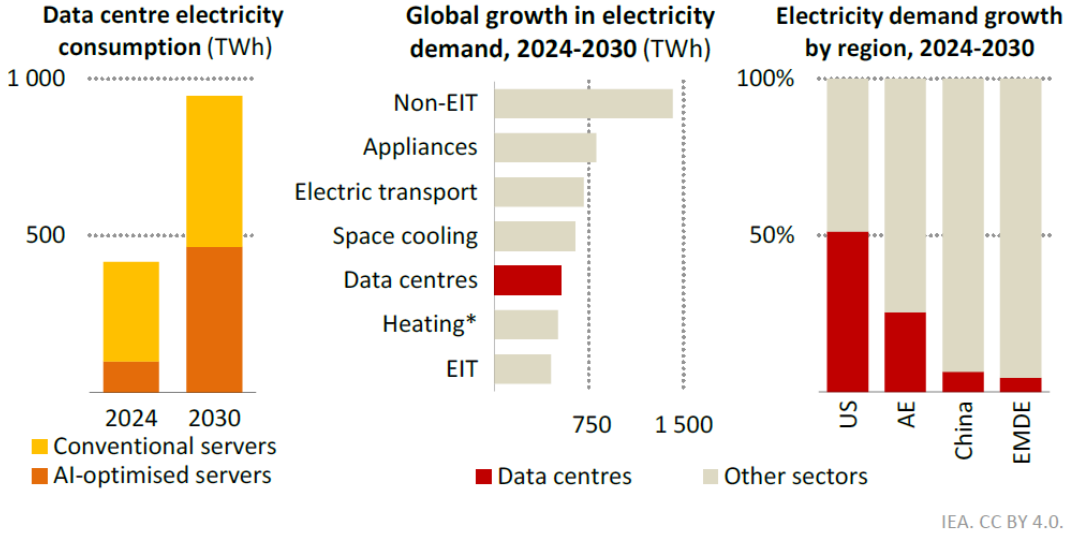
According to the IEA's World Energy Outlook 2025, electricity consumption by data centers is projected to increase from approximately 400 TWh in 2024 to approximately 950 TWh in 2030, driven by the growing adoption of generative AI and other factors. In particular, the largest increase is expected to come from servers optimized for AI, with total electricity consumption by data centers increasing by approximately 550 TWh over the six-year period.

However, looking at the drivers of global electricity demand growth, data centers are not the only major contributing factor. In terms of the increase in electricity demand from 2024 to 2030, the industrial sector excluding energy-intensive industries (Non-EIT) is the largest contributor, followed by appliances, electrification such as electric vehicles (EVs), and cooling, with data centers ranking next.

On the other hand, the situation differs significantly across regions. In the United States, data centers are expected to account for approximately half of the increase in electricity demand through 2030, compared with around one-quarter in advanced economies as a whole and less than 10% in China and emerging and developing economies.

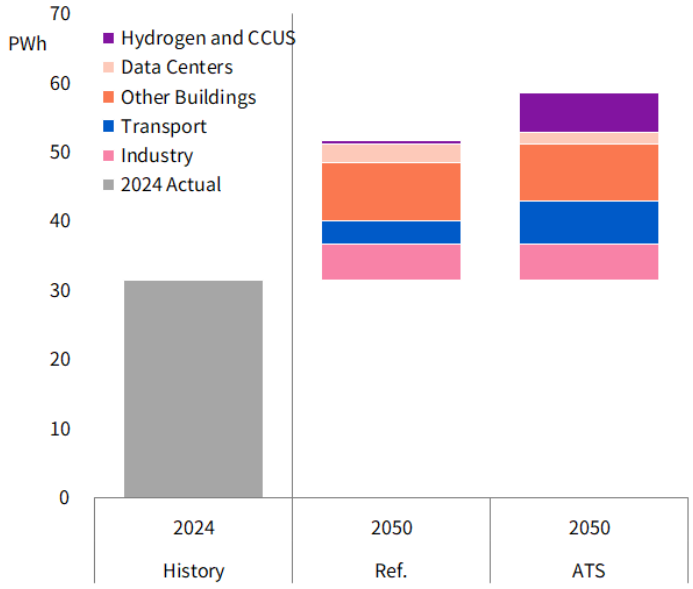
Therefore, although data centers are an important driver of electricity demand growth worldwide, global electricity demand is expected to increase due to a broader range of factors, including expanding industrial activity, electrification, and increasing cooling demand.

Figure 1. Data Center Electricity Consumption and Global and Regional Electricity Demand Growth (2024–2030)



Source: International Energy Agency (IEA). (2025). World Energy Outlook 2025. Retrieved August 30, 2026, from https://iea.blob.core.windows.net/assets/9753df19-0a71-422a-b725-012c555763b3/WorldEnergyOutlook2025.pdf

Figure 2. Drivers of Growth in Global Electricity Generation (2024–2050)



Source: The Institute of Energy Economics, Japan (IEEJ). (2026). IEEJ Outlook 2027. Retrieved November 9, 2026, from https://eneken.ieej.or.jp/data/13616.pdf

The outlook published by the Institute of Energy Economics, Japan (IEEJ) also indicates that global electricity demand is expected to increase significantly in the coming decades. Global electricity generation, which stood at approximately 31 PWh (31 trillion kWh) in 2024, is projected to increase to approximately 52 PWh (52 trillion kWh) in the Reference Scenario and approximately 58 PWh (58 trillion kWh) in the Advanced Technologies Scenario by 2050, representing increases of 64% and 85%, respectively, compared with 2024. This growth is driven by increasing demand in the industrial, residential, and commercial sectors associated with steady economic growth, as well as electrification in the transport sector and the expanded use of hydrogen and carbon capture and storage (CCS). Data centers are also one of the

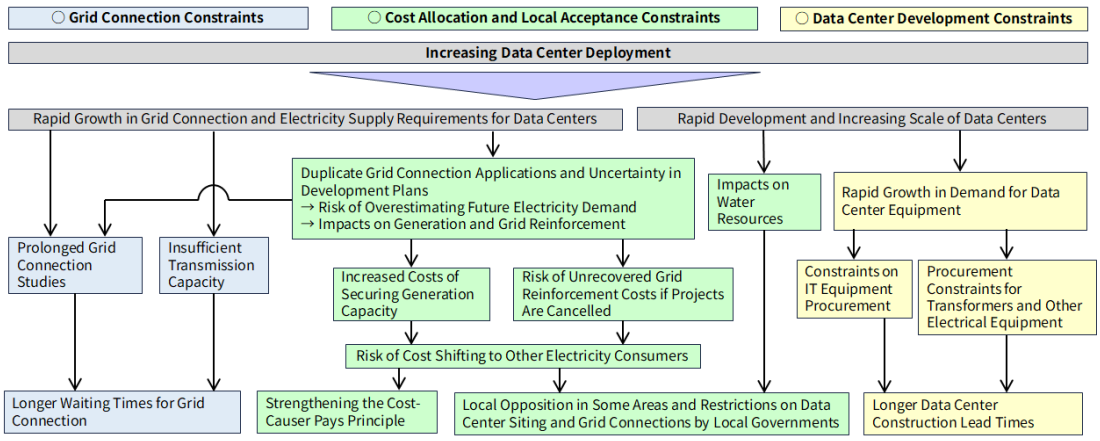
factors contributing to the increase in electricity demand.

Thus, while data centers account for less than 10% of the increase in electricity demand worldwide, they account for approximately half of the increase in the United States, where their impact is particularly significant. Furthermore, because data centers are concentrated in certain regions within the United States and the scale of individual data centers is increasing year by year, securing sufficient generation capacity and transmission infrastructure to accommodate rapid electricity demand growth has become a major challenge in some regions. In particular, the service territory of PJM, the largest regional transmission organization in the United States, includes Virginia, one of the world's largest concentrations of data centers. The growth in large-scale electricity demand, primarily driven by data centers, has created a need for measures addressing various aspects of the power system, including future electricity demand forecasting, grid connections, grid reinforcement, and generation capacity adequacy.

1.2. Key Challenges Associated with Increasing Data Center Deployment

The increase in electricity demand from data centers is creating various challenges for power systems and local communities, particularly in regions where data centers are concentrated. This paper examines these challenges by dividing them into three categories of constraints: (1) grid connections, (2) cost allocation and local community acceptance, and (3) development of demand-side facilities.

Figure 3. Key Challenges Associated with Increasing Data Center Deployment



Source: Prepared by IEEJ

First, the rapid deployment of data centers has led to a sharp increase in demand for connecting large-scale electricity loads to the grid. As a result, the time required for grid connection studies has become longer, and in many cases, existing transmission infrastructure cannot provide sufficient transmission capacity, making grid reinforcement necessary. Consequently, the long lead times required for data centers to actually connect to the grid have become a major challenge.

In addition, as demand for grid connections increases rapidly, duplicate applications for the same project and uncertainty regarding whether planned projects will actually be realized have also become problems. If such projects are excessively incorporated into electricity demand forecasts, the procurement of generation capacity and grid reinforcement based on these forecasts may also become excessive. As a result, the costs required to secure generation capacity through capacity markets and other mechanisms may increase. Furthermore, if data center projects are cancelled, the costs of grid reinforcement undertaken in advance may have to be borne by other electricity consumers. Therefore, how to allocate the costs associated with growing large-scale electricity demand and prevent these costs from being shifted to other electricity consumers has also become an important challenge.

Furthermore, the rapid development and increasing scale of data centers have impacts beyond electricity supply. If the burden on local infrastructure, including water resources used for cooling, increases, it may lead to opposition from local residents and moves to restrict grid connections. In addition, the construction of data centers requires large quantities of IT equipment and electrical equipment, such as transformers. Rapid development is therefore also contributing to tighter supply-demand conditions for such equipment, leading to longer procurement lead times and construction periods.

2. Grid Connection Constraints

2.1. Increasing Grid Connection Applications for Large Loads and Longer Grid Connection Study Periods

As grid connection studies take longer due to the rapid increase in demand for connecting large-scale electricity loads to the grid, it is reasonable for data center developers to examine multiple utilities and candidate locations to determine when grid connections would be available and whether grid reinforcement would be necessary, and then select the location offering the most favorable conditions in order to secure the required electricity as quickly as possible. However, if projects with low feasibility or multiple candidate locations for the same project remain in the grid connection study process, utilities and system operators must assess numerous projects simultaneously, further prolonging the process and reducing its efficiency. Commissioner Rosner of the Federal Energy Regulatory Commission (FERC) has also pointed out that speculative grid connection applications for large loads are congesting the study process, wasting study resources, and distorting electricity demand forecasts.[1]

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[1] Federal Energy Regulatory Commission. (2026a). Commissioner Rosner's remarks on the large load show cause orders, E-7 to E-12: June 18, 2026 open meeting. Retrieved August 30, 2026, from https://www.ferc.gov/news-events/news/commissioner-rosners-remarks-large-load-show-cause-orders-e-7-e-12-june-18-2026
"The Commission's action today also addresses speculative load interconnection requests, which clog up

2.2. Development of Regulatory Frameworks for Large Load Grid Connections in PJM

To address these issues, including speculative and duplicate applications, PJM is developing regulatory frameworks to facilitate grid connections for large loads, such as data centers, while preventing unjustified cost shifting to other grid users and avoiding adverse impacts on grid reliability. Specifically, these efforts are proceeding in two areas: (1) clarification of the existing framework for large loads co-located with generation facilities (co-location facilities), and (2) development of frameworks for grid connections and transmission services for large loads in general.

First, regarding co-location facilities, a key issue was that PJM's existing framework did not sufficiently clarify the terms and conditions for transmission services, cost allocation, and grid reliability when such facilities receive electricity from the grid. FERC initiated a Show Cause Proceeding in February 2025 and, in its Co-Location Order issued in December of the same year, directed PJM to establish the rates, terms, and conditions for transmission services applicable to co-location facilities. In response, PJM submitted Compliance Filings in January and February 2026. In June 2026, FERC accepted certain portions of these filings while requiring additional compliance measures for matters it considered insufficiently addressed.

In contrast, regarding large loads in general, nationwide discussions were initiated following the Advance Notice of Proposed Rulemaking (ANOPR) issued in October 2025. In June 2026, FERC issued a Large Load Show Cause Order to 6 Regional Transmission Organizations and Independent System Operators (RTOs/ISOs), including PJM. In addition to addressing speculative and duplicate applications, the order identified the need to revise the frameworks of each RTO/ISO to ensure that grid connections and transmission services for large loads do not impose unjustified costs or adverse reliability impacts on other grid users. Thus, in PJM, the revision of the existing framework for co-location facilities and the development of a broader framework for large loads are proceeding in parallel while remaining closely related.

Regarding the definition of large loads, the PJM Board approved a policy in January 2026 defining a "Large Load Addition" as an increase in electricity demand of 50 MW or more at a single Point of Interconnection (POI). Meanwhile, FERC has expressed the view that it would be reasonable to define large loads as new industrial or commercial loads with peak demand of 50 MW or more that are connected to transmission systems operating at voltages above 69 kV. Therefore, PJM will need to make further adjustments to establish a more precise definition consistent with FERC's position.

Regarding the verification of project readiness before grid connection and measures to prevent

load interconnection queues, divert resources, and distort forecasts."

speculative reservations of grid capacity, FERC has pointed out the need to clarify in the Tariff mechanisms to discourage speculative or duplicate applications, including application fees and project readiness requirements that become more stringent as the transmission service application and study process progresses. In response, PJM is considering a mechanism under which the financial commitments required of applicants would increase progressively as grid connection studies advance.

FERC has also pointed out the need for a grid connection study framework that jointly considers generation output and electricity demand when assessing grid impacts for large loads electrically proximate to generation facilities (for example, large loads located within 2 substations of a generation facility) or large loads co-located with generation facilities (co-location facilities). In response, PJM has proposed a framework that integrates the study processes for generation interconnection and transmission services for large loads into a single annual process, allowing generation facilities and loads to be evaluated within the same cluster.

Furthermore, FERC has recognized several options, including: (1) requiring the completion of necessary grid upgrades and the installation of protection and metering equipment as conditions for commencing service; (2) allowing generation facilities to terminate their grid interconnection and supply electricity to the associated load in complete electrical isolation from the grid if no entity is designated to receive transmission service on behalf of the co-located load; and (3) making interim transmission services (Interim NITS), subject to load curtailment, available until the necessary grid upgrades are completed.

Where grid reinforcement is required to connect large loads, FERC has also pointed out the need for a mechanism to ensure appropriate cost allocation through a Cost Recovery Agreement concluded among PJM, the transmission owner, and the entity receiving transmission service for the large load, in order to prevent the associated costs from being shifted to other electricity consumers. At the state level, as discussed later, frameworks for recovering costs from specific electricity consumers are being developed by utilities such as AEP Ohio. However, to prevent these costs from being shifted to transmission tariffs, it is also necessary to clarify cost allocation under PJM's Tariff.

In addition, for large loads co-located with generation facilities (co-location facilities), procedures are underway to revise the Tariff so that the costs of Regulation Service and Black Start Service are allocated based on Gross Demand.

Thus, PJM is establishing a threshold for defining large loads and, taking into account FERC's findings and other considerations, is developing regulatory frameworks covering the verification of project readiness before grid connection and prevention of speculative grid capacity reservations, integrated grid connection studies for generation and load, grid protection and other requirements for co-location facilities, allocation of grid reinforcement costs associated with large

loads, and allocation of ancillary service costs based on Gross Demand.

2.3. Development of Regulatory Frameworks for Large Load Grid Connections in Japan

In Japan, against the backdrop of increasing geographically concentrated large loads, such as data centers, measures are being introduced to strengthen the rules governing grid connections for electricity consumers. These measures aim to prevent projects with low feasibility from speculatively reserving grid capacity and to prevent grid reinforcement costs arising from changes in electricity demand plans and other factors from being shifted to other grid users.

First, as measures to verify project readiness before grid connection and prevent speculative reservations of grid capacity, new requirements were introduced in October 2026 for extra-high-voltage electricity consumers (2 MW or more). These include requiring electricity consumers to pay construction cost contributions through their retail electricity suppliers within 3 months after receiving acceptance of their electricity supply applications, and introducing a mechanism to cancel contract applications if deficiencies or changes attributable to the electricity consumer arise. Furthermore, for large electricity consumers with a final contracted demand of 30 MW or more, measures will be introduced in April 2027 to release reserved grid capacity if the commencement of electricity supply is delayed during the staged increase in contracted demand or if contracted demand is reduced.

Rules governing the allocation of grid reinforcement costs arising from changes in electricity demand plans and other factors are also being strengthened. For transmission and substation facilities in the upstream grid, where costs are difficult to attribute directly to individual electricity consumers, a mechanism is being considered under which cost settlement would be calculated by multiplying the total cost of infrastructure works undertaken in connection with the relevant load by the share of that load in the increase in grid capacity, based on a proportional allocation in kW. This would require electricity consumers to bear costs according to the scale of their demand. Furthermore, for large electricity consumers of 30 MW or more, measures requiring certain cost settlements when the commencement of electricity supply associated with the final contracted demand under a standard contract or staged contract is delayed are scheduled to be introduced by April 2027.

Thus, Japan is moving toward combining the verification of project readiness at the grid connection application stage, the release of reserved grid capacity in response to changes in electricity demand plans, and the settlement of grid reinforcement costs attributable to electricity consumers. Through these measures, Japan aims to promote the efficient use of limited grid capacity and prevent the costs of infrastructure development that does not ultimately correspond to actual electricity demand from being shifted to other grid users.

Table 1. Comparison of Grid Connection Measures for Data Centers in Japan and PJM (As of August 2026)

Measure	Japan	PJM	Status in Japan	Status in PJM
Establishing Thresholds for Large Loads	◎	○	In October 2026, requirements were introduced for extra-high-voltage electricity consumers (2 MW or more) to pay construction cost contributions within 3 months after acceptance of their electricity supply applications and to cancel contract applications in the event of deficiencies or changes. For large electricity consumers (30 MW or more), measures to release reserved grid capacity in cases of delayed commencement of electricity supply or reductions in contracted demand, and to require cost settlements in cases of delayed commencement of electricity supply, are scheduled to be introduced in April 2027.	In January 2026, the PJM Board approved a policy defining a "Large Load Addition" as an increase in electricity demand of 50 MW or more at a single Point of Interconnection (POI).[2] However, FERC has expressed the view that it would be reasonable to define large loads as new industrial or commercial loads with peak demand of 50 MW or more that are connected to transmission systems operating at voltages above 69 kV.
Integrated Grid Connection Studies for Generation and Load	—	○	No framework has been established for integrated grid connection studies of generation facilities and large loads.	FERC has pointed out the need for a grid connection study framework that jointly considers generation output and electricity demand when assessing grid impacts for large loads electrically proximate to generation facilities (e.g., large loads located within 2 substations of a generation facility) or large loads co-located with generation facilities. In response, PJM has proposed a framework that integrates the study processes for generation interconnection and transmission services for large loads into a single annual process, allowing generation facilities and loads to be evaluated within the same cluster.[3]
Measures for Large Loads Co-Located with Generation Facilities (Co-Location Facilities)	○	◎	It may be necessary to examine the appropriateness of cost allocation under existing backup supply contracts for self-generation and other arrangements.	FERC has recognized several options, including: (1) requiring the completion of necessary grid upgrades and the installation of protection and metering equipment as conditions for commencing service; (2) allowing generation facilities to terminate their grid interconnection and supply electricity to the associated load in complete electrical isolation from the grid if no entity is designated to receive transmission service on behalf of the co-located load; and (3) making interim transmission services (Interim NITS), subject to load curtailment, available until the necessary grid upgrades are completed.[4]
Verification of Project	◎	○	In October 2026, the following requirements were introduced for extra-	FERC has pointed out the need for mechanisms to discourage speculative or

[2] PJM Interconnection. (2026a). Filing of PJM Interconnection, L.L.C. in compliance with the Commission's December 18, 2025 order on show cause proceeding (Docket No. EL25-49-000, et al.). Retrieved September 20, 2026, from https://www.pjm.com/-/media/DotCom/documents/ferc/filings/2026/20260120-el25-49-000.pdf

[3] PJM Interconnection. (2026b). Show cause for large loads approach. Retrieved September 20, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/workshops/cllsco/2026/20260916/20260916-item-03---show-cause-for-large-loads-approach---presentation.pdf

[4] PJM Interconnection. (2026c). Co-located load and large load show cause orders. Retrieved September 21, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/workshops/cllsco/2026/20260730/20260730-item-02---co-located-load-and-large-load-show-cause-orders---presentation.pdf

Readiness and Prevention of Speculative Grid Capacity Reservations (Before Connection)			high-voltage electricity consumers (2 MW or more): (1) electricity consumers must pay construction cost contributions through their retail electricity suppliers within 3 months after acceptance of their electricity supply applications; and (2) contract applications may be cancelled if deficiencies or changes attributable to the electricity consumer arise.[5] For large electricity consumers of 30 MW or more, measures to release reserved grid capacity in cases of delayed commencement of electricity supply or reductions in contracted demand during the intermediate stages of staged contracts are scheduled to be introduced in April 2027.[6]	duplicate applications in the application and grid connection study processes for large loads, including application fees and project readiness requirements that become more stringent as the study process progresses. PJM is considering a mechanism under which the financial commitments required of developers would increase progressively as grid connection studies advance.[7]
Cost Allocation Based on Cost Causation and Prevention of Cost Shifting for Grid Reinforcement (After Connection)	◎	○	For costs incurred in developing upstream transmission and substation infrastructure, a mechanism is being considered under which electricity consumers would be required to settle costs according to the scale of their demand. Specifically, the amount would be calculated by multiplying the total construction costs by a proportional allocation factor based on kW.[8] For large electricity consumers of 30 MW or more, measures requiring cost settlements in cases of delayed commencement of electricity supply associated with the final contracted demand under standard or staged contracts are scheduled to be introduced in April 2027.[9]	FERC has pointed out the need for a mechanism to ensure appropriate cost allocation through a Cost Recovery Agreement concluded among PJM, the transmission owner, and the entity receiving transmission service for the large load, in order to prevent grid reinforcement costs associated with large loads from being shifted to other electricity consumers. At the state level, frameworks for recovering costs from specific electricity consumers are being developed by utilities such as AEP Ohio. However, to prevent these costs from being shifted to transmission tariffs, it is also necessary to clarify cost allocation under PJM's Tariff.
Allocation of Ancillary Service Costs Based on Gross Demand	—	◎	No PJM-type mechanism has been identified that separately allocates costs equivalent to Regulation Service and Black Start Service to large loads co-located with generation facilities based on Gross Demand. It may be necessary to examine the appropriateness of cost allocation under the existing framework.	For large loads co-located with generation facilities (co-location facilities), PJM is proceeding with Tariff revisions to allocate the costs of Regulation Service and Black Start Service based on Gross Demand.[10]

[5] Agency for Natural Resources and Energy. (2026a). 局地的な大規模需要に対する規律確保について［第 11 回次世代電力系統ワーキンググループ 資料 1］[Ensuring appropriate regulatory requirements for geographically concentrated large-scale electricity demand [Material 1, 11th Meeting of the Working Group on Next-Generation Power Systems]]. Retrieved September 20, 2026, from https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/smart_power_grid_wg/pdf/011_01_00.pdf

[6] Agency for Natural Resources and Energy. (2026b). 局地的な大規模需要に対する規律確保について［第 12 回次世代電力系統ワーキンググループ 資料 3］ [Ensuring appropriate regulatory requirements for geographically concentrated large-scale electricity demand [Material 3, 12th Meeting of the Working Group on Next-Generation Power Systems]]. Retrieved September 20, 2026, from https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/smart_power_grid_wg/pdf/012_03_00.pdf

[7] PJM Interconnection. (2026b).

[8] Agency for Natural Resources and Energy. (2026b).

[9] Agency for Natural Resources and Energy. (2026a).

[10] PJM Interconnection. (2026d). Summary of December 18 co-located load order. Retrieved September 21, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/workshops/cllsco/2026/20260109/20260109-item-02---summary-of-december-18-co-located-load-order---presentation.pdf

Note: A Show Cause Order issued by FERC is an order in which FERC identifies potential problems with existing tariffs, rules, or other provisions and requires the entities concerned either to explain why the existing framework is just and reasonable or to propose changes to remedy the identified problems.
Source: Prepared by The Institute of Energy Economics, Japan (IEEJ).

2.4. Transmission Capacity Constraints

2.4.1. Longer Lead Times for Transmission Infrastructure Development

To accelerate grid connections for large loads, it is necessary not only to improve the efficiency of grid connection studies but also to secure sufficient transmission capacity to actually supply electricity. In recent years, PJM has faced a major challenge as grid infrastructure development has failed to keep pace with electricity demand growth driven by the rapid expansion of data centers. In particular, when data centers ranging from several hundred MW to 1 GW are concentrated in specific regions, large-scale grid reinforcement may be required. However, the development of such transmission infrastructure requires considerably longer lead times than the periods within which data centers seek to receive electricity.

In its 2025 Regional Transmission Expansion Plan (RTEP), PJM stated that reinforcement of backbone transmission lines would be necessary to accommodate future electricity demand growth and other factors, and that such large-scale grid reinforcement would require lead times of more than 7 years.[11] Meanwhile, the timeframes within which data center developers seek to commence electricity supply are considerably shorter than the lead times required for grid reinforcement. At a meeting of the U.S. Department of Energy's (DOE) Industrial Technology Innovation Advisory Committee (ITIAC), an example was presented in which a large data center developer requested that a utility provide 1 GW of electricity within 18 months.[12] This does not mean that all data centers are constructed within approximately 18 months, but it suggests a significant gap between the timeframes within which data center developers require electricity and the lead times necessary for large-scale grid reinforcement. Given that PJM has indicated that reinforcement of backbone transmission lines requires long lead times exceeding 7 years, it is not easy for the grid to accommodate the timeframes requested by data center developers.

2.4.2. Effective Utilization of Existing Infrastructure and Planned Grid Reinforcement

[11] PJM Interconnection. (2026e). 2025 RTEP Window 1 reliability analysis report. Retrieved August 30, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/committees/teac/2026/20260106/20260106-2025-rtep-window-1-reliability-analysis-report.pdf
"requiring 7 or more years to develop, i.e., 500 kV and above developments"
[12] U.S. Department of Energy. (2024a). Industrial Technology Innovation Advisory Committee fourth meeting – Day 1 text version. Retrieved August 30, 2026, from https://www.energy.gov/cmei/ito/industrial-technology-innovation-advisory-committee-fourth-meeting-day-1-text-version-0
"the Googles or the Amazons, et cetera, will come to a utility, and they'll say, I need 1 gigawatt of energy in 18 months."

To address these challenges, PJM is not only pursuing large-scale grid reinforcement but also promoting more effective utilization of existing transmission infrastructure and strengthening grid planning in anticipation of future electricity demand growth. In addition, measures to flexibly adjust electricity demand on the part of large electricity consumers, such as data centers, are being considered.

One of the measures pursued from a relatively early stage has been to maximize the utilization of existing transmission infrastructure. Dynamic Line Rating (DLR), which dynamically evaluates the actual transmission capacity of power lines according to weather conditions and other factors, has been introduced within the PJM region. At PPL Electric Utilities, a transmission and distribution utility, DLR data from transmission lines have been transmitted to PJM since October 2022 and are being used in PJM's reliability assessments and market operations.[13] PJM is also evaluating and promoting the use of Grid-Enhancing Technologies (GETs), including Advanced Power Flow Controllers (APFCs), which control electricity flows, Topology Control & Optimization, which alleviates congestion by modifying grid configurations, and advanced conductors, as technologies to enhance the capability of existing transmission networks.[14] Since constructing new transmission lines or undertaking large-scale reinforcement requires long periods, maximizing the available transmission capacity of existing infrastructure through these technologies may provide measures that can be implemented within relatively short timeframes.

However, in regions experiencing particularly large increases in data center demand, more effective utilization of existing transmission infrastructure alone may be insufficient. PJM therefore incorporates anticipated large-scale electricity demand growth into its demand forecasts and grid analysis assumptions, and examines the transmission infrastructure required to accommodate this growth from a regional perspective, while also taking into account planned local grid reinforcement projects. For example, in its 2025 RTEP, PJM incorporated substantial increases in data center demand expected in the AEP, PPL, Dominion, and other areas into its 2030 and 2032 grid models and examined large-scale grid reinforcement, including backbone transmission lines at 500 kV and 765 kV. This approach goes beyond addressing the local grid reinforcement needs associated with individual data center locations.[15] Instead, it considers multiple increases in electricity demand, the construction and retirement of generation facilities, and other factors across the entire region, while taking local grid reinforcement into account, to

[13] PJM Interconnection. (2022). Dynamic line rating activated by PPL Electric Utilities. Retrieved August 30, 2026, from https://insidelines.pjm.com/dynamic-line-rating-activated-by-ppl-electric-utilities/

[14] PJM Interconnection. (2025a). PJM launches new Grid Optimization Solutions webpage. Retrieved August 30, 2026, from https://insidelines.pjm.com/pjm-launches-new-grid-optimization-solutions-webpage/

[15] PJM Interconnection. (2026e).
"PJM developed multiple scenarios using five-year (2030) and seven-year (2032) base case suite"
"Substantial data center load additions in the AEP, PPL and Dominion zones"

develop the transmission infrastructure, including higher-voltage networks, that will be required in the future in a more comprehensive manner.

2.4.3. Development of Regulatory Frameworks to Address Transmission Capacity Constraints in PJM

From the perspective of effectively utilizing existing transmission infrastructure, FERC has pointed out the need to evaluate alternative transmission technologies, such as DLR, that can expand the transmission capacity of existing power lines within relatively short periods as options when considering transmission services for large loads.

Regarding measures to ensure stable power system operations associated with large loads, FERC has also pointed out the need for PJM to establish mechanisms that allow large loads to be remotely disconnected and to introduce ramp-rate requirements (requirements governing the rate of increase or decrease in electricity demand) and ride-through requirements (requirements to maintain operation during temporary voltage or frequency disturbances and other events) for large loads in order to maintain grid reliability.

Furthermore, regarding early grid connections for large loads (Connect-and-Manage), FERC has pointed out the need for a mechanism to provide transmission services to Flexible Large Loads subject to conditions such as limiting the amount of electricity received from the grid to a specified level. In response, PJM is considering several options as interim measures until grid reinforcement is completed, including "fully matched," in which on-site generation capacity comparable to the large load is installed; "partially matched," in which on-site generation capacity is installed to meet part of the large load; and "storage matched," in which energy storage facilities, such as batteries, are installed.[16]

Thus, in response to large loads, PJM is developing and considering regulatory frameworks based on FERC's findings, including the evaluation of alternative transmission technologies to effectively utilize existing transmission infrastructure, stable grid operations through remote disconnection of large loads and ramp-rate and ride-through requirements, regional grid reinforcement through the RTEP, and early grid connections for large loads subject to limitations on electricity received from the grid.

2.4.4. Development of Regulatory Frameworks to Address Transmission Capacity Constraints in Japan

[16] Exelon. (2026). Develop process to provide large load customers flexibility to connect to the transmission grid in the PJM region: Problem/opportunity statement [PJM Markets and Reliability Committee meeting material]. March 25, 2026. https://www.pjm.com/-/media/DotCom/committees-groups/committees/mrc/2026/20260325/20260325-item-02---2-exelon-large-load-flexibility-problem-statement.pdf

In contrast, Japan is pursuing a combination of measures to accommodate increasing large-scale electricity demand from data centers and other facilities, including policies to guide the location of electricity demand, proactive grid development in anticipation of future demand, early grid connections for large loads, and financing support for transmission infrastructure investment.

First, regarding policies to guide data center locations, Japan is promoting the publication of Welcome Zone Maps, which identify areas where early grid connections can be expected without requiring relatively large-scale grid reinforcement. Going forward, plans have been presented to increase the number of available sites shown on these maps and to provide more detailed geographic grid information. Furthermore, under the GX Strategic Regions initiative, Japan has indicated a policy direction to promote Watt-Bit Collaboration, which involves integrated development of electricity and communications infrastructure, and to establish clusters of data centers.

Regarding grid development, Japan has introduced a proactive, or "push-type," approach to grid development under which necessary grid reinforcement is undertaken in advance and in a planned manner based on the Master Plan, taking into account future generation locations and electricity demand growth. Furthermore, in anticipation of large-scale electricity demand growth associated with data center development and the expansion of renewable energy deployment, Japan has indicated a policy direction to proactively and systematically develop backbone transmission networks at the two highest voltage levels, even before grid connections for individual electricity consumers or generation facilities have been finalized.

In addition, regarding grid connections for large loads, Japan has indicated a policy direction to consider measures that would allow early grid connections under certain conditions before the completion of grid reinforcement, rather than relying solely on the conventional approach of connecting loads after the necessary grid reinforcement has been completed.

Furthermore, because such proactive grid development requires substantial funding, a mechanism has been introduced under which the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO), raises funds through the Fiscal Loan Fund and other sources and provides long-term loans to General Transmission and Distribution Utilities and other entities for the development of cross-regional interconnection networks and other transmission infrastructure.

On the other hand, when grid infrastructure is developed proactively before individual electricity consumers have been identified, cost allocation associated with uncertainty in future electricity demand plans becomes a challenge. Where grid reinforcement is undertaken in response to grid connection applications from individual large electricity consumers, it is possible to require those consumers to bear certain costs through construction cost contributions and cost settlements when their electricity demand plans are changed. In contrast, where grid infrastructure

is developed in advance in areas where local governments and other entities anticipate future concentrations of data centers, before individual electricity consumers have been identified, it is difficult to require such financial commitments from specific consumers. Therefore, it is also necessary to consider who should bear the costs of grid infrastructure investment if the anticipated electricity demand does not materialize, and how the associated risks should be shared.

Thus, rather than reinforcing the grid only after receiving connection applications from individual large electricity consumers, Japan is moving toward guiding data centers and other large loads to locations that are desirable from a grid perspective, proactively developing grid infrastructure in anticipation of future electricity demand growth, and combining early grid connections utilizing existing transmission infrastructure with financing support for grid investment. Through these measures, Japan aims to achieve both the rapid accommodation of large loads and efficient grid development. Going forward, while promoting such proactive grid development, it will also be important to clarify cost allocation and risk-sharing arrangements in cases where anticipated electricity demand does not materialize as expected.

Table 2. Comparison of Measures to Address Transmission Capacity Constraints in Japan and PJM (As of August 2026)

Measure	Japan	PJM	Status in Japan	Status in PJM
Effective Utilization of Existing Transmission Infrastructure (DLR, etc.)	△	○	Demonstration projects and studies on the application of technologies such as Dynamic Line Rating (DLR) to improve the utilization of existing transmission infrastructure are underway. However, these technologies have not yet become widely established as a standard means of expanding transmission capacity nationwide.	FERC has pointed out the need to evaluate alternative transmission technologies that can expand the capacity of existing transmission lines within relatively short periods as options when considering transmission services for large loads.
Measures to Ensure Stable Power System Operations for Large Loads	△	○	Measures to ensure stable power system operations for large loads have not yet been established. (Note: In May 2026, the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO), invited proposals for a commissioned study on overseas grid codes for large-load facilities, including data centers.)	FERC has pointed out the need for PJM to establish mechanisms for remotely disconnecting large loads and to introduce ramp-rate requirements (requirements governing the rate of increase or decrease in electricity demand) and ride-through requirements (requirements to maintain operation during temporary voltage or frequency disturbances and other events) for large loads in order to maintain grid reliability.
Policies to Guide Data Center Locations	◎	—	Japan is promoting the publication of Welcome Zone Maps and plans to increase the number of available sites shown on these maps and provide more detailed geographic grid information. Furthermore, under the GX Strategic Regions initiative, Japan is moving toward establishing data center clusters aimed at realizing Watt-Bit Collaboration.	No common PJM-wide framework has been identified for guiding the location of large loads.
Proactive Grid Development in Anticipation of Future Demand	◎	◎	Japan has introduced a proactive, or "push-type," approach to grid development based on the Master Plan, under which necessary grid reinforcement is undertaken in advance and in a planned manner, taking into account future generation locations and electricity demand growth. Furthermore, in anticipation of increasing electricity demand associated	PJM incorporates anticipated large-scale electricity demand growth, including from data centers, into its demand forecasts and grid analyses in advance. Taking local grid reinforcement into account, PJM considers multiple increases in electricity demand, the construction and retirement of generation facilities, and other factors across the entire

			with data center development and the further expansion of renewable energy deployment, Japan is moving toward proactively and systematically developing grid infrastructure before connections for individual electricity consumers or generation facilities have been finalized, targeting backbone transmission networks at the two highest voltage levels.[17]	region, and systematically examines the grid reinforcement required in the future, including higher-voltage transmission networks, through its Regional Transmission Expansion Plan (RTEP).
Early Grid Connections for Large Loads (Connect-and-Manage)	○	○	Japan is moving toward considering measures that would allow early grid connections for large loads under certain conditions.[18]	FERC has pointed out the need for a mechanism to provide transmission services to Flexible Large Loads subject to conditions such as limiting the amount of electricity received from the grid to a specified level. PJM is considering several options for temporary flexibility, including "fully matched," "partially matched," and "storage matched."[19]

Source: Prepared by The Institute of Energy Economics, Japan (IEEJ).

3. Constraints Related to Cost Allocation and Local Community Acceptance

3.1. Duplicate Applications and Uncertainty Regarding Project Feasibility

3.1.1. Discrepancies Between Grid Connection Applications and Actual Electricity Demand

In recent years, PJM has experienced an increase in grid connection applications against the backdrop of growing large-scale electricity demand, primarily driven by data centers. A key issue is the extent to which the electricity demand indicated in these applications will actually materialize. In particular, data center developers may submit grid connection applications to multiple utilities and system operators for several candidate locations. Therefore, the electricity demand identified through grid connection applications does not necessarily correspond to the electricity demand that will ultimately materialize.

For data center developers, there is a certain rationale for examining the feasibility of grid connections at multiple candidate locations during the early stages of development. Some data centers currently being planned have capacities reaching several hundred MW, and the timing of grid connection availability may differ significantly depending on the location. Rather than

[17] Agency for Natural Resources and Energy. (2026c). 改正電気事業法に基づくファイナンス支援の実施に向けて［第 3 回電力システム改革等に関するワーキンググループ 資料 3］ [Toward the implementation of financial support under the amended Electricity Business Act [Material 3, 3rd Meeting of the Working Group on Electricity System Reform and Related Issues]]. Retrieved September 20, 2026, from https://www.meti.go.jp/shingikai/enecho/denryoku_gas/jisedai_kiban/electric_power_wg/pdf/003_03_00.pdf

[18] Agency for Natural Resources and Energy. (2025). 局地的な大規模需要について［第 4 回次世代電力系統ワーキンググループ 資料 3］ [Geographically concentrated large-scale electricity demand [Material 3, 4th Meeting of the Working Group on Next-Generation Power Systems]]. Retrieved September 20, 2026, from https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/smart_power_grid_wg/pdf/004_03_00.pdf

[19] PJM Interconnection. (2026f). Informational report on stakeholder processes addressing resource adequacy for new large loads (Docket No. EL26-67-000). Federal Energy Regulatory Commission. Retrieved September 21, 2026, from https://elibrary.ferc.gov/eLibrary/filedownload?fileid=E75D6C98-4842-C027-91C8-9F89CFB00000

conducting a grid connection study for one candidate location and then searching for another location after discovering that grid connection would require a long lead time, it is more reasonable for data center developers to submit grid connection applications for multiple candidate locations to several utilities and system operators in advance, compare the timing and costs of grid connections, and then determine the location. FERC Commissioner Rosner has also pointed out that, under the current framework, data center developers have an incentive to approach multiple utilities with potential projects and compare their options in order to identify locations where they can connect to the grid more quickly and at lower cost.[20]

On the other hand, if numerous such applications are submitted, the scale of large-load demand identified by utilities and system operators may substantially exceed the electricity demand of data centers and other facilities that are actually constructed. As discussed earlier, allowing multiple candidate locations to remain in the grid connection study process can prolong studies for other projects (a grid connection study issue). Furthermore, if such projects are incorporated into future electricity demand forecasts, they may lead to overestimation of future electricity demand or make it more difficult to determine the regions where demand will ultimately materialize (an electricity demand forecasting issue).

A useful example for understanding this situation is the new tariff introduced by AEP Ohio for data centers in Ohio, within the PJM region.[21] At AEP Ohio, electricity demand requested by data center developers had exceeded 30 GW. Against this backdrop, the Public Utilities Commission of Ohio (PUCO) approved a new tariff in July 2025 that requires data center developers to assume certain financial and legal obligations. Under this tariff, data center developers wishing to proceed with formal technical studies must request such studies from AEP Ohio and bear the associated costs. Following the tariff's effective date and a 45-day application period, the electricity demand for which formal technical studies had been requested by September 2025 amounted to approximately 13 GW. This was less than half of the more than 30 GW indicated before the introduction of the tariff.

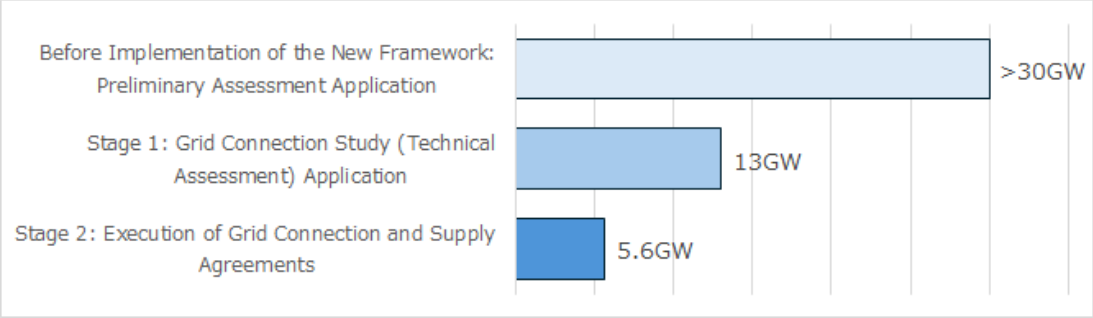
AEP Ohio subsequently conducted technical studies for these projects and, beginning in November 2025, presented data center developers with the dates when electricity supply could become available and the required financial security and other conditions. After reviewing these conditions, data center developers were required to decide within 60 days whether to enter into legally binding contracts involving financial obligations. As a result, by February 2026, the electricity demand covered by executed contracts had declined to approximately 5.6 GW.

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[20] Federal Energy Regulatory Commission. (2026a).
"Under current rules, data centers can (and are incentivized to) 'shop around' their prospective projects with different utilities to identify the fastest and cheapest location to connect."

[21] AEP Ohio. (2026). AEP Ohio updates PUCO on data center load: Figures show tariff is working. Retrieved August 30, 2026, from https://www.aepohio.com/company/news/view?releaseID=10753

Figure 4. Screening of Data Center Electricity Demand Requests in AEP Ohio's Service Territory



Source: Prepared by IEEJ based on AEP Ohio. (2026). AEP Ohio updates PUCO on data center load: Figures show tariff is working. Retrieved August 29, 2026, from https://www.aepohio.com/company/news/view?releaseID=10753

3.1.2. Impacts of Duplicate Applications on Electricity Demand Forecasts

Duplicate grid connection applications may not only affect grid connection studies but also make future electricity demand appear larger than it actually is. For example, consider a developer planning to construct only one 500 MW data center but submitting separate 500 MW grid connection applications for three candidate locations in Virginia, Ohio, and Pennsylvania. If all these applications are treated as separate loads, the total electricity demand would appear to be 1,500 MW, even though the actual additional demand would be only 500 MW. FERC Commissioner Rosner has also pointed out that incorporating projects that will not materialize into electricity demand forecasts may inflate projected demand growth, leading to double counting, inaccurate market signals, and unnecessarily high prices for electricity consumers.[22]

If duplicate applications cause electricity demand forecasts to exceed actual demand, two main problems may arise. The first is the possibility that the generation capacity required in the future will be overestimated in the capacity market, resulting in the procurement of more generation capacity than necessary (impacts on generation capacity procurement). The second concerns transmission planning. If grid reinforcement needs are assessed even at locations where electricity demand will not actually materialize, efficient transmission investment becomes more difficult (impacts on grid reinforcement). Since both problems may ultimately lead to increased costs for electricity consumers, it is important to assess not only the feasibility of large-load projects, such as data centers, but also as accurately as possible where and to what extent electricity demand will actually materialize.

PJM has also emphasized the importance of obtaining accurate information on new large loads,

[22] Federal Energy Regulatory Commission. (2026a).
"Worse yet, it can inflate expected load growth by modeling projects that do not materialize, leading to double counting, inaccurate market signals, and unnecessarily high prices for consumers."

including data centers, and avoiding double counting in electricity demand forecasts.[23] Accordingly, PJM is revising the submission and review process for "Large Load Adjustments," through which new large-scale electricity demand, including from data centers, is incorporated into future electricity demand forecasts. Specifically, as part of the annual submission of Large Load Adjustments, Transmission Owners (TOs) are required to seek confirmation from the relevant electricity consumers regarding large-load grid connection applications for which an Electric Service Obligation (ESO) or Construction Commitment (CC) has not yet been established. The confirmation concerns whether other grid connection applications for the same large load have been submitted within or outside the PJM region. If multiple grid connection applications are identified for the same load and only some of the proposed sites are expected to reach commercial operation, the Transmission Owner must report to PJM the number of duplicate sites and the associated electricity demand (MW).[24]

3.2. Increasing Costs of Securing Generation Capacity

3.2.1. Growth in Data Center Demand and Rising Capacity Market Prices

Upward revisions to electricity demand forecasts associated with the expansion of data centers are affecting not only grid reinforcement but also the procurement of generation capacity required in the future. Meanwhile, as existing power plants, particularly coal-fired power plants, continue to retire, the construction of new generation capacity has not kept pace with electricity demand growth. As a result, while the amount of generation capacity required is increasing, securing that capacity is becoming more difficult, and the associated procurement costs are also rising. These challenges are particularly evident in PJM.

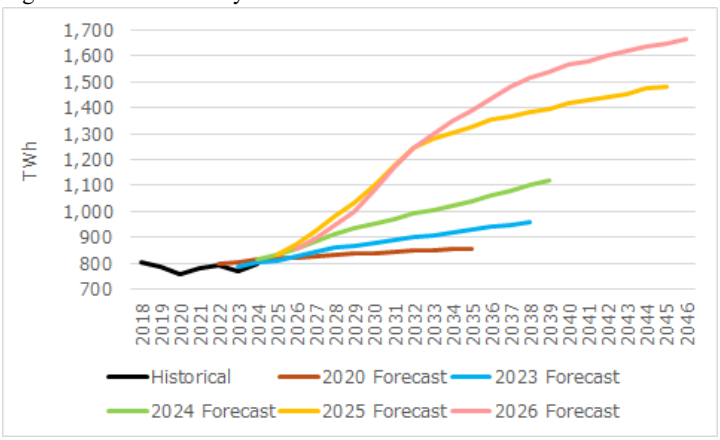
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[23] PJM Interconnection. (2026g). 2025 year in review: Planning prepares for burgeoning electricity demand. Retrieved August 30, 2026, from https://insidelines.pjm.com/2025-year-in-review-planning-prepares-for-burgeoning-electricity-demand/
"It is critical for PJM to get the most accurate information about data centers and other new large loads in order to avoid double-counting in its forecasts, which are used both for procuring enough resources in the capacity market and for planning transmission for the regional grid."

[24] PJM Interconnection. (2026a).
"As part of the large load adjustment annual submissions to PJM, TOs shall inquire with their subject customers, and indicate to PJM accordingly, whether any load interconnection requests they've received (that do not have either an Electric Service Obligation [ESO] or Construction Commitment [CC]) are duplicative with other such requests made to interconnect large load either within or outside of the PJM region such that only a subset of such requests are expected to achieve actual commercial operation. If so, the submitters are required to provide the number of sites and amount of megawatts that are duplicative that are included in their submission."

According to PJM's 2025 Long-Term Load Forecast, summer peak electricity demand was projected to increase by approximately 32 GW between 2024 and 2030, of which approximately 30 GW was expected to come from data centers.[25] Unlike conventional electricity demand growth, a single data center project may require several hundred MW to GW-scale electricity demand, and the grid connection of multiple large-scale projects within relatively short periods has led to rapid upward revisions in electricity demand forecasts.

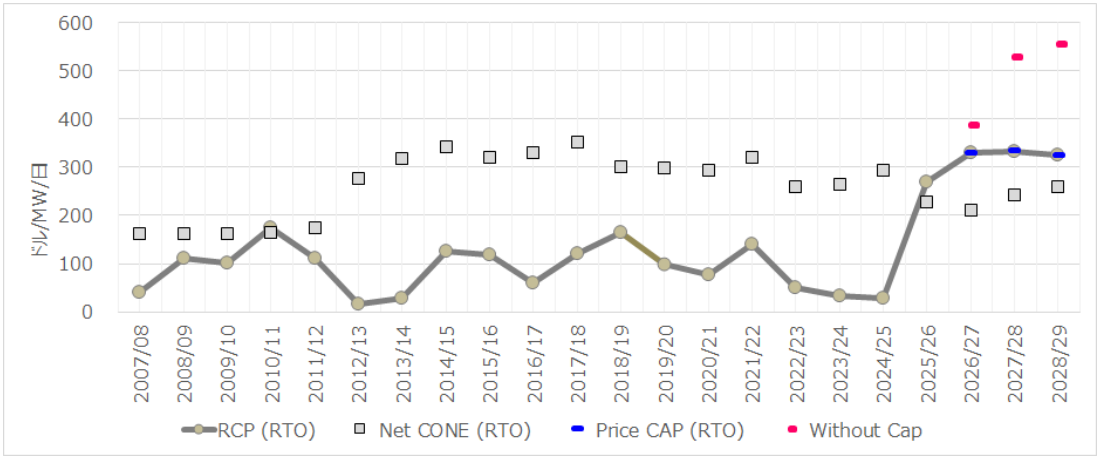
Figure 5. PJM Electricity Demand Forecast



Source: Prepared by IEEJ based on PJM materials.

This increase in electricity demand has had a significant impact on PJM's capacity market (Reliability Pricing Model: RPM). The PJM-wide capacity clearing price rose approximately ninefold, from $28.92/MW-day (approximately ¥1,600/kW-year) in 2024/25 to $269.92/MW-day (approximately ¥14,800/kW-year) in 2025/26, and reached $329.17/MW-day (approximately ¥18,000/kW-year) in 2026/27. Furthermore, in 2027/28, the price reached the cap of $333.44/MW-day (approximately ¥18,300/kW-year), while the amount of generation capacity

Figure 6. Trends in PJM Capacity Market (RPM) Clearing Prices



Source: Prepared by IEEJ based on PJM materials.

[25] PJM Interconnection. (2025b). PJM Board fast-tracks effort to reliably serve large loads. PJM Inside Lines. Retrieved September 8, 2026, from https://insidelines.pjm.com/pjm-board-fast-tracks-effort-to-reliably-serve-large-loads/
"The letter notes that PJM's 2025 Long-Term Load Forecast predicts a peak load growth of 32 GW from 2024 to 2030, with about 30 GW of that coming from data centers."

procured fell approximately 6.6 GW short of the capacity required for reliability, marking the first time since the establishment of PJM's capacity market that the required generation capacity could not be secured. In the following 2028/29 delivery year, the price again reached the cap of $325/MW-day (approximately ¥17,800/kW-year), but generation capacity remained approximately 6.8 GW below the required level, marking the second consecutive year in which PJM failed to secure the required generation capacity. These increases in capacity prices reflect not only growing electricity demand but also the fact that the development of new generation capacity has not kept pace with demand growth, among other factors.

In PJM, the generation capacity required is calculated based on a standard level of annual peak demand, known as the 50/50 peak load forecast, under which the probabilities of actual demand exceeding or falling below the forecast are each 50%.[26] However, actual electricity demand may exceed forecasts due to extreme heat, severe cold, or other factors, while generation facilities may also experience unplanned outages caused by equipment failures and other events. PJM therefore probabilistically accounts for demand fluctuations, unplanned generation outages, and other uncertainties to determine the reserve capacity required to keep the risk of generation capacity shortages below a specified level. Specifically, PJM calculates the amount of reserve capacity that must be secured in addition to peak demand to satisfy the reliability criterion of a Loss of Load Expectation (LOLE) of "one day in ten years," and establishes this as the Installed Reserve Margin (IRM).[27] In the 2027/28 capacity market, while the required IRM was approximately 20%, the reserve margin based on the generation capacity actually procured remained in the 14% range, indicating that PJM had failed to secure the level of generation capacity required for reliability.[28]

3.2.2. Retirement of Existing Generation Facilities and Measures to Maintain Generation Capacity

One factor behind PJM's inability to secure sufficient generation capacity through its capacity market is the continued retirement of existing generation facilities, particularly coal-fired power

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[26] PJM Interconnection. (2026h). Manual 19: Load forecasting & analysis (Revision 39). Retrieved September 18, 2026, from https://www.pjm.com/-/media/DotCom/documents/manuals/m19.pdf
“From this distribution, the median result is used as the base (50/50) forecast”

[27] PJM Interconnection. (2024). Manual 14B: PJM Region Transmission Planning Process (Revision 56). Retrieved September 18, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/committees/mrc/2024/20240627/20240627-consent-agenda-c---3-er24-99-manual-14b-revisions---clean.pdf
To ensure the adequacy of the generating capacity of the entire PJM footprint, the acceptable loss of load expectation (LOLE) is based on load exceeding available capacity, on average, not more than one occurrence in ten years (1/10).

[28] PJM Interconnection. (2025c). PJM auction procures 134,479 MW of generation resources. Retrieved August 30, 2026, from https://insidelines.pjm.com/pjm-auction-procures-134479-mw-of-generation-resources/

plants, within the PJM region. While repair and maintenance costs have increased for aging facilities, the combination of historically low capacity market revenues, costs associated with compliance with environmental regulations, and state decarbonization policies has reduced the economic viability of making additional investments to continue operations.[29] According to PJM, retirement notices were submitted for 30 generation facilities totaling more than 6.5 GW in 2025 alone.[30] PJM has pointed out that retirements of generation facilities needed to maintain reliability, driven by aging infrastructure and environmental policies, are exceeding the additions of new inverter-based resources, such as solar and wind power.[31] If existing generation facilities continue to retire while electricity demand increases, the amount of additional generation capacity that must be secured will become even greater.

In response to the reduction in generation capacity caused by the retirement of existing thermal power plants, the Trump administration has shifted toward policies aimed at preventing the retirement of existing generation facilities, against the backdrop of rapidly increasing electricity demand and concerns over supply reliability.[32] In particular, regarding coal-fired power plants, the Department of Energy (DOE) announced in February 2026 that it would provide a total of $175 million in support for 6 projects aimed at modernizing existing generation facilities and extending their operating lives.[33] Furthermore, in June 2026, the administration announced a policy to provide up to $425 million in support for 13 coal-fired power plants under the Defense Production Act (DPA), with the aim of maintaining more than 14 GW of coal-fired generation capacity.[34]

Meanwhile, the Trump administration has also implemented a policy of requiring generation

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[29] PJM Interconnection. (2023). Energy transition in PJM: Resource retirements, replacements & risks. Retrieved August 30, 2026, from https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx

[30] PJM Interconnection. (2026i). PJM report highlights 2025 planning efforts. Retrieved August 30, 2026, from https://insidelines.pjm.com/pjm-report-highlights-2025-planning-efforts/
"PJM received 30 deactivation notifications totaling over 6.5 GW in 2025."

[31] PJM Interconnection. (2026h).
"Accelerated retirements of generators that provide necessary attributes needed to maintain reliability are outpacing the addition of new, mainly inverter-based resources. The retirements are being driven by unit age and environmental public policy."

[32] The White House. (2025). Reinvigorating America's beautiful clean coal industry and amending Executive Order 14241. Retrieved August 30, 2026, from https://www.whitehouse.gov/presidential-actions/2025/04/reinvigorating-americas-beautiful-clean-coal-industry-and-amending-executive-order-14241/

[33] U.S. Department of Energy. (2026a). Energy Department announces $175 million to modernize coal plants, keeping affordable reliable power online for Americans. Retrieved August 30, 2026, from https://www.energy.gov/articles/energy-department-announces-175-million-modernize-coal-plants-keeping-affordable-reliable

[34] U.S. Department of Energy. (2026b). Fact sheet: The Energy Department is unleashing beautiful, clean coal. Retrieved September 7, 2026, from https://www.energy.gov/articles/fact-sheet-energy-department-unleashing-beautiful-clean-coal

facilities scheduled for retirement or shutdown to continue operating when deemed necessary for supply reliability, through emergency orders issued under Section 202(c) of the Federal Power Act.[35] Within the PJM region, orders have been issued requiring Eddystone Units 3 and 4 in Pennsylvania and Wagner Unit 4 in Maryland to remain available for operation.[36] Thus, in the short term, measures are being taken to maintain generation capacity by preventing the retirement of existing generation facilities.

3.2.3. Challenges and Regulatory Reforms Concerning Grid Connections for New Generation Facilities

One reason why new generation facilities have not been able to smoothly replace retiring generation facilities in PJM is the rapid increase in grid connection applications, primarily for renewable energy generation and battery storage, which has made it impossible to process the large number of projects under the conventional "first-come, first-served" approach involving individual project reviews. In July 2023, PJM entered a transition period toward a new grid connection process based on a "first-ready, first-served" approach that places greater emphasis on project readiness, and has been processing the existing backlog of applications through Transition Cycles. As of July 2023, the total capacity of projects under review exceeded 260 GW, more than 95% of which consisted of renewable energy generation, battery storage, or hybrid projects combining both.[37] Under the Transition Cycles, 18 GW of Fast Track projects had already reached the contract execution stage,[38] approximately 14.4 GW of projects in Transition Cycle 1 had reached the final agreement stage,[39] and the capacity of projects in Transition Cycle 2 had been narrowed to 29.7 GW at the Phase II stage as of June 2026.[40]

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[35] U.S. Department of Energy. (2026c). Constellation Energy Corp. and PJM Interconnection, L.L.C. regarding Eddystone Unit 3 and Unit 4: Order No. 202-26-40. Retrieved August 30, 2026, from https://www.energy.gov/documents/doe-order-no-202-26-40

[36] U.S. Department of Energy. (2026d). Federal Power Act Section 202(c): PJM Interconnection L.L.C. (PJM) Order No. 202-26-25. Retrieved August 30, 2026, from https://www.energy.gov/ceser/federal-power-act-section-202c-pjm-interconnection-llc-pjm-order-no-202-26-25

[37] PJM Interconnection. (2023). Transition to new interconnection process begins July 10. Retrieved September 19, 2026, from https://insidelines.pjm.com/transition-to-new-interconnection-process-begins-july-10/

[38] PJM Interconnection. (2025d). PJM chooses 51 generation resource projects to address near-term electricity demand growth [News release]. Retrieved September 27, 2026, from https://www.pjm.com/-/media/DotCom/about-pjm/newsroom/2025-releases/20250502-pjm-chooses-51-generation-resource-projects-to-address-near-term-electricity-demand-growth.pdf

[39] PJM Interconnection. (2026j). Original Generation Interconnection Agreement, Service Agreement No. 7799; Project Identifier No. AF1-128; and Notice of Cancellation of Service Agreement Nos. 6993 and 6994 [FERC Docket No. ER26-1082-000]. Retrieved September 27, 2026, from https://www.pjm.com/pjmfiles/pub/planning/project-queues/csa/af1_128_csa.pdf

[40] PJM Interconnection. (2026k). Transition Cycle 2, Phase II System Impact Study: Executive summary. Retrieved September 27, 2026, from https://www.pjm.com/pjmfiles/pub/planning/project-queues/Cluster-Reports/TC2/TC2_PH2_Executive_Summary.htm

While the Transition Cycles were being processed, reviews of new applications under the regular cycle were effectively suspended. Processing resumed with Cycle No. 1, the first cycle under the new grid connection process, for which the application window closed in April 2026. As a result, new generation projects were required to wait for extended periods before entering the grid connection study process, contributing to delays in adding generation capacity.

Under the "first-ready, first-served" approach, developers seeking grid connections for new generation facilities are required to provide Readiness Deposits to demonstrate project readiness,[41] secure Site Control, and meet other requirements. Multiple projects are reviewed together in cycles, allowing projects that are sufficiently prepared to proceed through the review process while encouraging projects that are not ready to withdraw. The first cycle, which closed in April 2026, included 811 projects representing approximately 220 GW of proposed generation capacity.[42]

3.2.4. Introduction of Reliability Backstop Procurement (RBP) to Secure New Generation Capacity

Due to concerns that the conventional capacity market (Reliability Pricing Model: RPM) alone cannot secure sufficient generation capacity, PJM plans to implement Reliability Backstop Procurement (RBP). PJM already had a mechanism under which RBP would be triggered if generation capacity shortages occurred in three consecutive capacity auctions.[43] However, in the 2027/28 capacity market, PJM failed to secure the required generation capacity across its entire region for the first time since the introduction of its capacity market, and a further shortage of approximately 6.8 GW occurred in the subsequent 2028/29 capacity market. Consequently, the

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[41] PJM Interconnection. (2026l). Manual 14H: New Service Requests Cycle Process (Revision 07). Retrieved September 19, 2026, from https://www.pjm.com/-/media/DotCom/documents/manuals/m14h.pdf
In PJM, Readiness Deposits are required in up to three stages. RD1 requires a deposit of $4,000/MW at the time of application. At Decision Point I, RD2 is calculated by subtracting RD1 from the greater of 10% of the allocated grid reinforcement costs determined in Phase I or RD1. At Decision Point II, RD3 is calculated by subtracting the cumulative amount of RD1 and RD2 from the greater of 20% of the allocated grid reinforcement costs determined in Phase II or the cumulative amount of RD1 and RD2. RD2 and RD3 may be zero but cannot be negative. After completion of Phase III, developers proceeding to final contract negotiations are required to provide Security based on the grid reinforcement costs allocated to their projects in the Phase III System Impact Study. Readiness Deposits are managed separately from Security, and some or all of the deposits may be forfeited depending on the timing of project withdrawal and other circumstances.

[42] PJM Interconnection. (2026m). Over 800 new generation projects seek to connect under PJM's reformed process. Retrieved August 30, 2026, from https://www.pjm.com/-/media/DotCom/about-pjm/newsroom/2026-releases/20260429-over-800-new-generation-projects-seek-to-connect-under-pjms-reformed-process.pdf

[43] PJM Interconnection. (2025e). Large load additions: Pre-CIFP education. Retrieved August 30, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/cifp-lla/2025/20250902/20250902-item-03---large-load-additions-pre-cifp-education---pjm-presentation.pdf

need to establish an additional generation capacity procurement mechanism ahead of the conventional trigger conditions became more pressing, and PJM submitted a detailed RBP proposal to FERC in July 2026.[44]

RBP is designed as a one-time procurement mechanism to address generation capacity shortages in the capacity market.[45] Its basic procurement target is the 6.8 GW shortfall identified in the 2028/29 capacity auction. However, rather than procuring the entire 6.8 GW through RBP, any generation capacity newly secured through bilateral contracts between generation companies and electricity retailers or other arrangements would be deducted from the procurement target to avoid double procurement of generation capacity.

A key feature of RBP is that it provides long-term revenue certainty for new generation facilities. Conventional capacity auctions are conducted annually, and capacity prices vary from year to year, making it difficult for new generation projects requiring substantial initial investment to predict future investment recovery. In contrast, PJM's RBP proposal allows contracts of up to 15 years for new generation capacity. For price determination, a pay-as-bid approach is adopted, under which payments are determined based on each project's bid price rather than applying a uniform clearing price to all successful bidders. Furthermore, PJM's procurement price cap is set at a MW-weighted average of $555/MW-day (approximately ¥30,400/kW-year),[46][47] exceeding the price cap of $325/MW-day (approximately ¥17,800/kW-year) in the 2028/29 capacity auction. The objective is to encourage investment in new generation facilities not only by allowing higher capacity prices but also by securing revenues over an extended period.

However, the introduction of RBP will not necessarily eliminate the 6.8 GW generation capacity shortfall. According to Reuters, in addition to the approximately 220 GW of projects undergoing grid connection reviews in PJM, constraints related to supply chains, permitting, workforce availability, and other factors are extending the lead times required for planned projects to reach actual development.[48]

Moreover, the RBP price level may not be sufficient to ensure the economic viability of all new

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[44] PJM Interconnection. (2026n). PJM reliability backstop proposal outlines steps to secure new supply and maintain reliability. Retrieved August 30, 2026, from https://insidelines.pjm.com/pjm-reliability-backstop-proposal-outlines-steps-to-secure-new-supply-and-maintain-reliability/

[45] PJM Interconnection. (2026o). Reliability backstop design working paper. Retrieved August 30, 2026, from https://www.pjm.com/-/media/DotCom/committees-groups/workshops/rbpw/2026/20260218/20260218-item-03---pjm-reliability-backstop-design-working-paper.pdf

[46] This is considered to have been established in light of the fact that, without the price cap, the capacity price in the 2028/29 capacity auction would have reached $554.72/MW-day.

[47] PJM Interconnection. (2026o).

[48] Rochas, A. F. (2026a). PJM capacity market woes spur activity in bilateral power deals. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/business/energy/pjm-capacity-market-woes-spur-activity-bilateral-power-deals--reeii-2026-08-26/

thermal power projects. According to Reuters, Aurora Energy Research, a UK-based energy market research firm, considers that a price of $555/MW-day (approximately ¥30,400/kW-year) could support investment in new thermal power plants and battery storage. On the other hand, generation company AlphaGen has pointed out that some new projects may require capacity revenues of approximately $1,285–1,665/MW-day (approximately ¥70,400–91,200/kW-year) to achieve economic viability.[49]

3.2.5. Gas Turbine Supply Constraints

Furthermore, even if issues related to investment profitability and grid connections are resolved, physical constraints such as equipment procurement and construction periods will remain for the development of new generation facilities. In particular, one factor constraining the construction of new gas-fired power plants is the increasing difficulty of procuring gas turbines and related equipment. Against the backdrop of rapidly growing electricity demand from data centers and other factors, plans for new gas-fired power plants have increased sharply in the United States, with gas turbine orders expanding from 7 GW in 2020 to 44 GW in 2025. As a result, the supply of large gas turbines has become constrained, and lead times have extended to more than five years.[50] Therefore, even if rising capacity prices strengthen investment incentives for new generation facilities, it will take several years before actual generation capacity increases.

According to an analysis by Thunder Said Energy, a UK-based energy research firm, average annual additions to global gas-fired generation capacity are expected to increase from approximately 50 GW during 2015–2024 to approximately 90 GW during 2025–2035.[51] Regarding gas turbine supply capacity, Thunder Said Energy estimates current global manufacturing capacity at approximately 70 GW per year, based on an analysis aggregating the capacities of major gas turbine manufacturing facilities worldwide, and projects that this capacity will expand to approximately 100 GW per year by 2030.[52]

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[49] Rochas, A. F. (2026a).

[50] Rochas, A. F. (2026b). Power developers adapt gas turbine strategies to mitigate tight supply. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/business/energy/power-developers-adapt-gas-turbine-strategies-mitigate-tight-supply--reeii-2026-03-02/

[51] Thunder Said Energy. (2026a). Global gas generation capacity by region and over time? Retrieved September 2, 2026, from https://thundersaidenergy.com/downloads/global-gas-turbines-by-region-and-over-time/

"Global gas generation capacity additions averaged 50 GW pa over the decade from 2015-2024, of which the US was 20%, Europe was 10%, Asia was 50%, LatAm was 10% and Africa was 10%. Yet global gas turbine additions could double to 90 GW pa in 2025-35."

[52] Thunder Said Energy. (2026b). Gas turbine manufacturing by company by facility? Retrieved September 2, 2026, from https://thundersaidenergy.com/downloads/gas-turbines-and-chp-technology-leaders/

"25 gas turbine manufacturing facilities are captured in this data-file, owned by major OEMs, such as GE Vernova, Siemens Energy and Mitsubishi Heavy, covering 8M m2, employing 40,000 people, with capacity to produce 70GW pa of turbines."

Since the delivery of large gas turbines currently requires more than five years, a substantial lead time is necessary before equipment ordered today can contribute to the commencement of commercial operation at power plants. However, if manufacturing capacity expands toward 2030, the existing backlog of orders may gradually be cleared, potentially easing gas turbine procurement constraints over the medium to long term.

Thus, in PJM, while the rapid increase in electricity demand, primarily driven by data centers, is increasing the amount of generation capacity required, the retirement of existing generation facilities and delays in constructing new facilities are making it increasingly difficult to secure sufficient generation capacity, resulting in substantial increases in capacity prices. However, even if higher capacity prices strengthen investment incentives for new generation facilities, considerable time is required before new generation capacity can actually commence operation. Therefore, in the short term, it is important to limit reductions in generation capacity by maintaining existing facilities and taking other measures. Over the medium to long term, it is important to encourage investment in new generation facilities through reforms to grid connection procedures, the provision of long-term revenue certainty for new generation facilities through RBP, and the securing of new generation capacity by large electricity consumers under the Bring Your Own New Generation (BYONG) approach. Furthermore, in addition to these regulatory measures, expanding the manufacturing capacity of power generation equipment, including gas turbines, will be important to enable the actual construction of new generation facilities.

3.3. Risk of Unrecovered Grid Reinforcement Costs Following Project Withdrawal

3.3.1. Differences in Time Horizons Between Transmission Investment and Large Loads

How to recover the costs of grid reinforcement undertaken to accommodate large loads, such as data centers, has also become an issue. In the United States, increasing attention is being paid to the risk that utilities may be unable to fully recover the costs of grid reinforcement investments made in advance from the relevant electricity consumers if large-load projects are canceled or downsized. Against this backdrop, an increasing number of states are introducing or considering special tariffs for data centers and other large electricity consumers.

The development of transmission infrastructure requires substantial investment and long lead times from planning to commercial operation. At present, delivery times for large power transformers and other equipment have become longer, while grid planning, land acquisition, environmental reviews, permitting, and other procedures also require considerable time. If new backbone transmission lines or major reinforcements are required, it may take approximately 5–

"Global gas turbine manufacturing capacity by region, from 2019 to 2030. Capacity is set to increase to around 100 GW per year by 2030" (identified in metadata embedded in the HTML source of the webpage (accessed September 2, 2026).

15 years before they become operational, whereas data centers can be constructed in approximately 1–3 years.[53]

Transmission infrastructure is designed to remain in service for several decades, and its construction costs are recovered over extended periods through transmission tariffs. In contrast, electricity demand from data centers may increase more slowly than initially anticipated, remain below projected levels, shift to other regions, or fail to materialize altogether.[54] Consequently, if a large data center withdraws or scales down its operations without bearing sufficient costs corresponding to the construction of transmission infrastructure, the utility may be left with unrecovered investment costs. In such cases, costs that can no longer be recovered from the data center may be incorporated into transmission tariffs and shifted to other electricity consumers. The introduction of long-term contracts, minimum charges, financial security requirements, exit fees, and other measures for large electricity consumers, including data centers, is intended to ensure that the parties responsible bear the unrecovered costs associated with early withdrawal or similar events, thereby preventing these costs from being shifted to other electricity consumers.

3.3.2. Examples of Unrecovered Costs Resulting from Reductions in Large-Load Demand

Such risks are not limited to data centers. There have been previous cases in which electricity demand underlying grid reinforcement investments declined after the reinforcement had been undertaken to accommodate large loads. In July 2017, Taiwan's Hon Hai Precision Industry (Foxconn) announced plans to invest $10 billion in Wisconsin to construct a manufacturing facility for liquid crystal display (LCD) panels used in large televisions and other products.[55] In October of the same year, Mount Pleasant, Wisconsin, was selected as the construction site.[56]

To supply electricity to the planned facility, transmission company American Transmission Company (ATC) launched the Mount Pleasant Tech Interconnection Project. To accommodate the facility's projected electricity demand of 200 MW and an additional 30 MW of demand growth in the surrounding area, ATC planned to construct a new 345/138 kV substation, add circuits and increase the capacity of 345 kV transmission lines, and install four 138 kV underground circuits

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[53] International Energy Agency. (2026). Grids. In Electricity 2026. Retrieved August 30, 2026, from https://www.iea.org/reports/electricity-2026/grids

[54] Cohen, J., Beyer, D., & Shwisberg, L. (2026). Planning for uncertain data center demand. RMI. Retrieved February 1, 2026, from https://rmi.org/resources/planning-for-uncertain-data-center-demand/
"These assets may be underutilized if the load they are intended to serve arrives late, develops at a smaller scale than expected, relocates, or never materializes"

[55] Foxconn Technology Group. (2017). Foxconn announces launch of intelligent manufacturing ecosystem in U.S. during White House event. Retrieved August 30, 2026, from https://www.prnewswire.com/news-releases/foxconn-announces-launch-of-intelligent-manufacturing-ecosystem-in-us-during-white-house-event-300494861.html

[56] Wisconsin Department of Natural Resources. (n.d.). Wisconsin Foxconn Technology Group development project. Retrieved August 30, 2026, from https://dnr.wisconsin.gov/Business/Foxconn.html

connecting to a customer-owned substation.[57] The project cost was estimated at approximately $117 million. ATC applied for a Certificate of Public Convenience and Necessity (CPCN) in January 2018, and the Public Service Commission of Wisconsin (PSCW) approved the application in July of the same year.[58]

However, while transmission and substation facilities were being developed to supply electricity to Foxconn, with operations scheduled to commence in December 2019, it became apparent in January 2019 that Foxconn was considering scaling back or shelving its LCD panel manufacturing plans and shifting toward a facility focused primarily on research and development and other activities.[59] In this situation, concerns were raised that the costs of grid reinforcement and related investments could be borne by approximately five million electricity consumers across multiple states within ATC's service territory through transmission service charges over approximately 40 years.[60] Subsequently, the transmission infrastructure developed for Foxconn was repurposed to supply electricity to Microsoft's data center constructed in the same area.[61] This case illustrates the risk that, when grid reinforcement is undertaken in anticipation of a specific large load, changes or reductions in the underlying business plan may result in the reinforced infrastructure being underutilized. Such risks may also arise in the future for data centers, which have exceptionally large electricity demand requirements per facility.

3.3.3. Increasing Investment Recovery Risks Due to the Growing Scale of Data Centers

One reason why these risks are becoming a greater concern for data centers is the rapid increase in electricity demand per facility. Epoch AI, a U.S.-based nonprofit research organization, maintains publicly available databases covering AI models, semiconductors, data centers, and related subjects. An examination of the world's major data centers included in its database indicates that the scale of these facilities is increasing rapidly.

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[57] American Transmission Co. (2018). 2018 summary report: 10-year transmission system assessment. Retrieved August 30, 2026, from https://www.atc10yearplan.com/2018/files/2021/09/2018_TYA-Final-web.pdf

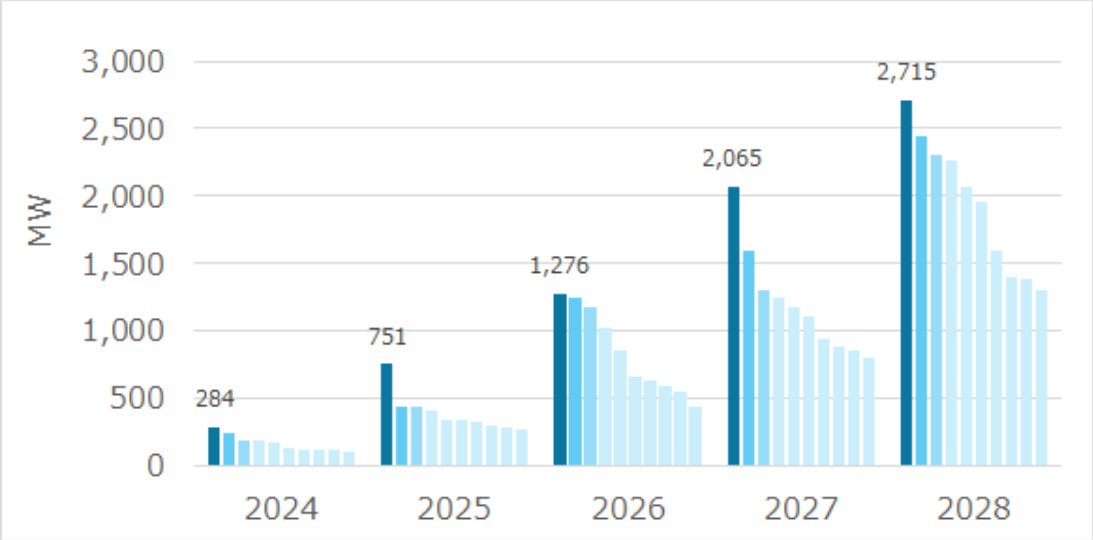
[58] American Transmission Co. (2018).

[59] Macy Yu, J., & Plume, K. (2019, January 30). Exclusive: Foxconn reconsidering plans to make LCD panels at Wisconsin plant. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/article/business/exclusive-foxconn-reconsidering-plans-to-make-lcd-panels-at-wisconsin-plant-idUSKCN1PO0EA/

[60] The Associated Press. (2018). Wisconsin PSC approves Foxconn transmission lines. Wisconsin Public Radio. Retrieved August 30, 2026, from https://www.wpr.org/news/wisconsin-psc-approves-foxconn-transmission-lines

[61] Schulz, J. (2023). We Energies plans $100M project to support new Microsoft data center. A law passed for Foxconn may exempt it from regulation. Wisconsin Public Radio. Retrieved August 30, 2026, from https://www.wpr.org/politics/we-energies-plans-100m-project-support-new-microsoft-data-center-law-passed-foxconn-may-exempt-it

Figure 7. Total Power Demand of Major AI Data Centers Worldwide (Top 10 Facilities at Year-End)



Note: The figure shows the 10 facilities with the highest total power demand at the end of each year. Power demand includes IT equipment and supporting infrastructure, such as cooling systems. Figures from 2026 onward include estimates for facilities under construction. The data cover major AI data centers tracked by Epoch AI, rather than all data centers worldwide. Most facilities are located in the United States.
Source: Prepared by IEEJ based on Epoch AI. (2026). AI data centers: AI data center timelines [Data set]. Retrieved August 17, 2026, from https://epoch.ai/data/ai-data-centers

At the end of 2024, even the largest data center had a capacity of slightly less than 300 MW, but this is expected to exceed 1,000 MW in 2026 and reach approximately 2,700 MW in 2028. The minimum capacity required to rank among the ten largest facilities in each year is also projected to increase from approximately 100 MW to 1,300 MW, indicating that the scale of facilities is increasing not only among a few exceptionally large data centers but across the entire group of leading facilities. Many of the largest facilities are associated with major U.S. technology companies, including Google, Microsoft, Meta, and Amazon, as well as OpenAI and xAI.

It should be noted that the figures for 2026 onward include estimates for facilities under construction. Furthermore, the data cover major facilities identified by Epoch AI and do not constitute comprehensive statistics on all data centers worldwide. Nevertheless, they confirm that the electricity demand requirements of major data centers are increasing substantially within a short period. When large-scale grid reinforcement is undertaken to accommodate data centers with electricity demand ranging from several hundred MW to several GW, the investment costs remaining if such projects are canceled or downsized may also become substantial. In addition, the number of facilities itself is increasing, and there is a growing tendency for data centers to concentrate in specific regions where conditions related to telecommunications networks, land

availability, electricity supply, and other factors are favorable. Consequently, the cancellation of even a single project could have a significant impact on regional transmission planning.

3.4. Strengthening the Cost-Causation Principles

3.4.1. Addressing Unrecovered Costs Through Tariffs for Large Loads

As discussed earlier, if projects are canceled or downsized, or actual electricity demand falls below initial expectations after transmission infrastructure has been developed to accommodate large loads such as data centers, part of the infrastructure investment costs may be shifted to other electricity consumers. Accordingly, there is a growing trend in the United States toward requiring large electricity consumers to enter into long-term contracts and provide minimum payments, financial security, exit fees, and other financial commitments.

A representative example is AEP Ohio's "Data Center Tariff," approved by the Public Utilities Commission of Ohio (PUCO) in July 2025.[62] Under this tariff, data center developers are required to pay specified minimum charges, including transmission-related charges, throughout the contract period, even if their data centers do not actually commence operation or consume less electricity than initially planned. This reflects the cost-causation principle, under which the risk of unrecovered utility infrastructure investment costs is borne by the data center developers whose projects necessitated the infrastructure development, rather than by other electricity consumers.

3.4.2. Long-Term Contracts and Cost Recovery Measures at AEP Ohio

AEP Ohio's tariff applies to new data centers and expansions of existing facilities with monthly maximum demand exceeding 25 MW. The contract term consists of a ramp-up period of up to 4 years, during which electricity demand increases toward the planned capacity, followed by an additional 8 years. If the full four-year ramp-up period is used, the total contract term is 12 years. Contracted capacity during the ramp-up period is also increased progressively, reaching 50% in the first year, 65% in the second year, 80% in the third year, and at least 90% in the fourth year.

The tariff also establishes a mechanism requiring new loads associated with new data centers or expansions of existing facilities to pay demand charges based on a specified minimum level, even if actual electricity demand falls below planned levels. During the ramp-up period, monthly billing demand must be at least 85% of the contracted capacity established for each year. After the ramp-up period, the minimum monthly billing demand is the greater of 85% of the highest monthly billing demand during the preceding 11 months or a predetermined minimum billing demand based on contracted capacity. Furthermore, customers remain obligated to pay minimum charges even if they curtail or reduce demand, suspend service, or terminate service during the

[62] AEP Ohio. (n.d.). Data center tariff. Retrieved August 16, 2026, from https://www.aepohio.com/company/about/rates/data-center-tariff/

initial contract term.

In addition, financial security is required depending on the creditworthiness of the data center developer to ensure that contractual payment obligations are fulfilled. Unless the developer satisfies both of the following conditions—having credit ratings of at least A− from S&P and A3 from Moody's, and holding cash and cash equivalents on its audited balance sheet exceeding ten times the required security amount—it must provide a guarantee or other financial security equivalent to 50% of the total minimum charges payable over the contract term.

Cost allocation provisions also apply when a project is canceled or delayed before electricity supply commences. If a customer cancels its grid connection project or delays the project by more than 12 months beyond the targeted electricity service commencement date for reasons attributable to the customer, it is required to reimburse AEP Ohio for the full cost of infrastructure developed for that project.

Certain restrictions also apply to contract termination after the commencement of service. Once 5 years have elapsed following the end of the demand ramp-up period, the customer may terminate the contract by paying an exit fee equivalent to 36 months of minimum charges. For example, if the ramp-up period lasts 3 years, the customer becomes eligible to terminate the contract under this mechanism only after 8 years have elapsed from the beginning of the contract. Therefore, the customer cannot terminate the contract at any time during the contract term simply by paying an exit fee equivalent to 36 months of minimum charges.

PUCO has also identified preventing the costs of infrastructure developed for data centers from being shifted to other electricity consumers when that infrastructure is underutilized as one of the objectives of the tariff.[63] However, the tariff has faced opposition from the data center industry. According to Reuters, Microsoft, Google, Meta, Amazon, and other companies argued that AEP Ohio's proposed minimum charges, which would impose additional financial obligations on specific industries such as data centers, should not be limited by industry classification but should instead apply to all large electricity consumers with demand exceeding 50 MW at a single location.[64]

Such financial commitments serve not only to recover infrastructure investment costs but also to assess the likelihood that projects seeking grid connections will actually materialize. As discussed earlier, of the more than 30 GW of electricity demand indicated before the introduction of AEP Ohio's tariff, projects totaling 13 GW proceeded to request formal load studies and pay

[63] Public Utilities Commission of Ohio. (2025). PUCO orders AEP Ohio to create data center specific tariff. Retrieved August 16, 2026, from https://puco.ohio.gov/news/puco-orders-aep-ohio-to-create-data-center-specific-tariff

[64] Kearney, L. (2024). Big Tech proposes power-rate terms in Ohio data-center fight. Reuters. Retrieved August 16, 2026, from https://www.reuters.com/technology/big-tech-proposes-power-rate-terms-ohio-data-center-fight-2024-10-10/

the associated study costs. Subsequently, the total was narrowed to 5.6 GW for projects whose developers entered into binding contracts and provided the required financial security.[65]

3.4.3. Expansion of Large-Load Tariffs to Other States

The trend toward imposing such obligations on large electricity consumers is spreading beyond Ohio. According to FERC Commissioner Rosner, as of March 2026, 20 states had approved at least one tariff for large electricity consumers, while proposed tariffs were under review in another 9 states.[66] In June of the same year, Commissioner Rosner also stated that tariffs for large electricity consumers had been introduced in more than half of all U.S. states.[67]

In Virginia, the State Corporation Commission (SCC) approved Dominion Energy Virginia's new GS-5 tariff classification in November 2025.[68] The tariff applies to large electricity consumers with contracted or metered demand of at least 25 MW at a single site and an actual or projected load factor of at least 75%, regardless of industry. Therefore, facilities other than data centers may also be subject to the tariff.

Eligible customers that begin receiving electricity service and enter into electricity supply contracts on or after January 1, 2027, are required to enter into 14-year contracts. Even if metered demand falls below contracted demand, charges are calculated using minimum billing demand levels equivalent to 85% of contracted demand for transmission and distribution charges and 60% for generation charges. The objective is to reduce the risk that the costs of electricity infrastructure developed to accommodate large-load facilities, including data centers, will be shifted to other electricity consumers.

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[65] AEP Ohio. (2026). AEP Ohio updates PUCO on data center load: Figures show tariff is working. Retrieved August 16, 2026, from https://www.aepohio.com/company/news/view?releaseID=10753

[66] Federal Energy Regulatory Commission. (2026b). E-3: Commissioner Rosner's dissent in withdrawal of notice of inquiry and termination of rulemaking proceeding. Retrieved September 8, 2026, from https://www.ferc.gov/news-events/news/e-3-commissioner-rosners-dissent-withdrawal-notice-inquiry-and-termination

"As of March 2026, 20 states had approved at least one large load tariff, and another nine states had pending large load tariffs."

[67] Federal Energy Regulatory Commission. (2026a).

"State regulators in more than half of the country have enacted large load tariffs."

[68] Virginia State Corporation Commission. (2025). Final order: Application of Virginia Electric and Power Company for a 2025 biennial review of the rates, terms and conditions for the provision of generation, distribution and transmission services pursuant to § 56-585.1 A of the Code of Virginia (Case No. PUR-2025-00058). Retrieved August 16, 2026, from https://www.scc.virginia.gov/docketsearch/DOCS/89g601%21.PDF

Table 3. Comparison of Large-Load Tariffs of AEP Ohio and Dominion Energy Virginia

Item	Ohio: AEP Ohio Schedule DCT	Virginia: Dominion Energy Virginia Schedule GS-5
Regulatory Authority	Public Utilities Commission of Ohio (PUCO)	Virginia State Corporation Commission (SCC)
Effective Date	23-Jul-25	1-Jan-27
Tariff Classification	Tariff for data centers	Tariff for large electricity consumers with high load factors
Eligible Industries	Data centers	No industry restrictions
Demand Threshold	More than 25 MW	25 MW or more
Load Factor Requirement	None	Actual or projected load factor of at least 75%
Contract Term	Demand ramp-up period plus 8 years	14 years, including the demand ramp-up period
Minimum Contract Term	8 years if no ramp-up period is required	14 years
Maximum Demand Ramp-Up Period	4 years	4 years
Minimum Contracted Capacity During Ramp-Up	Year 1: at least 50%; Year 2: at least 65%; Year 3: at least 80%; Year 4: at least 90%	Annual increase of at least 20%
Minimum Charge Calculation	During ramp-up: Monthly billing demand must be at least 85% of the contracted capacity established for each year. After ramp-up: The greater of (i) 85% of the highest monthly billing demand during the preceding 11 months or (ii) the minimum demand based on contracted capacity.	Transmission and distribution: 85% of contracted demand. Generation: 60% of contracted demand.
Base Financial Security Requirement	50% of the total minimum charges over the entire contract term, unless specified creditworthiness and cash requirements are met	$1.5 million per MW of contracted demand
Reduction or Exemption from Financial Security Requirements	Exempt from providing financial security if requirements are met, including credit ratings of at least A? from S&P and A3 from Moody's, and cash and cash equivalents exceeding ten times the required security amount	Financial security requirement may be reduced by up to 70%, depending on the customer's creditworthiness
Annual Reduction in Financial Security	Reduced annually by an amount equivalent to 1 year's minimum charges	One-fourteenth of the financial security amount is released annually
Cancellation or Delay Before Service Commencement	If the project is canceled before service commencement or delayed by more than 12 months beyond the scheduled service commencement date, the customer must reimburse AEP Ohio for the full cost of infrastructure developed for the project	No provision specified in the GS-5 order
Project Cancellation During Contract Term	Obligation to pay minimum charges generally continues	Exit fee equivalent to the unpaid minimum charges for the remaining contract term
Early Contract Termination	Permitted after 5 years have elapsed following the end of the ramp-up period, subject to payment of 36 months of minimum charges	Payment of minimum charges for the remaining contract term

Source: Prepared by IEEJ based on AEP Ohio. (n.d.). Data center tariff. Retrieved August 16, 2026, from

https://www.aepohio.com/company/about/rates/data-center-tariff/; and Virginia State Corporation Commission. (2025). Final order: Application of Virginia Electric and Power Company for a 2025 biennial review of the rates, terms and conditions for the provision of generation, distribution and transmission services pursuant to § 56-585.1 A of the Code of Virginia (Case No. PUR-2025-00058). Retrieved August 16, 2026, from https://www.scc.virginia.gov/docketsearch/DOCS/89g601%21.PDF

Thus, special tariffs for large electricity consumers are primarily intended to reduce the risk of unrecovered infrastructure investment costs arising when data centers do not commence operation as planned or when electricity demand does not increase to the contracted level. By combining long-term contracts, minimum charges, financial security requirements, exit fees, and other measures, these tariffs enable utilities to recover certain costs from the parties responsible even if projects are canceled or downsized. They also require developers seeking grid connections to make financial commitments at an early stage, thereby helping to assess the likelihood that their projects will actually materialize.

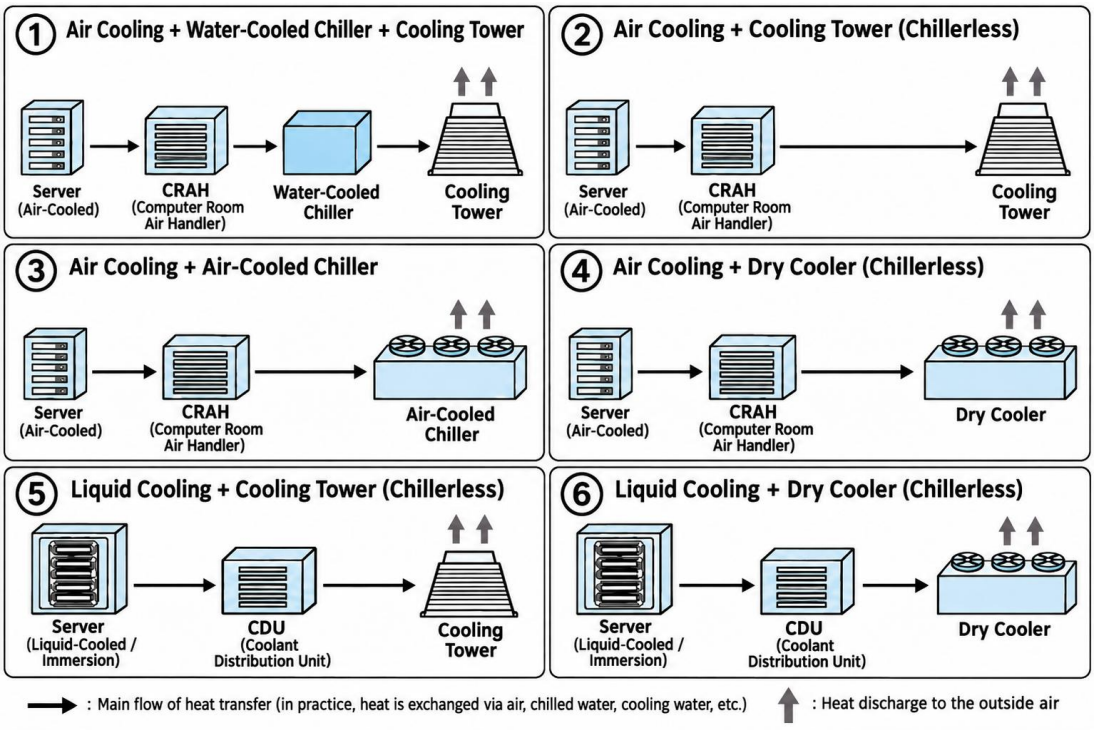
3.5. Impacts on Water Resources

3.5.1. Trade-offs Between Electricity and Water Consumption in Cooling Systems

Data centers must continuously remove large amounts of heat generated by servers and maintain server room temperatures within a specified range. Cooling equipment is therefore essential for ensuring the stable operation of servers. Furthermore, the configuration of cooling systems significantly affects not only the electricity consumption of the entire facility but also its water consumption.

Data center cooling can be divided into two processes: removing and transporting heat from IT equipment, and ultimately releasing the recovered heat into the external environment. Cooling methods on the IT equipment side include air cooling, which uses air to cool equipment, and liquid cooling, which uses liquids to directly remove heat from equipment. Air cooling includes conventional systems that circulate and cool air within server rooms using Computer Room Air Handlers (CRAHs) and other equipment, as well as Rear Door Heat Exchangers (RDHx), which capture waste heat at the rear of server racks. Liquid cooling, on the other hand, includes Direct Liquid Cooling (DLC), which circulates coolant through cold plates attached to heat-generating components such as Central Processing Units (CPUs) and Graphics Processing Units (GPUs) used for AI computing to directly remove heat, and Immersion Cooling, in which servers themselves are immersed in a dielectric cooling liquid. Heat rejection methods on the facility side include

Figure 8. Schematic Illustration of Major Cooling and Heat Rejection Systems in Data Centers



Note 1: This figure schematically illustrates the configurations of the respective cooling systems and the paths of heat transfer. Actual installations may include additional equipment such as pumps, heat exchangers, and piping.
Note 2: A Computer Room Air Handler (CRAH) is an air-conditioning unit that draws in warm air from a server room, cools it, and supplies the cooled air back to the servers. A Coolant Distribution Unit (CDU) circulates the coolant used in direct liquid cooling and transfers heat from the server side to the facility-side cooling water system or other heat rejection systems. A water-cooled chiller is a refrigeration unit that produces chilled water and supplies it to CRAHs, which cool the air in the server room. The heat absorbed by the chiller is typically transferred through a cooling water circuit to a cooling tower, where it is released to the outdoor air. A cooling tower is a facility that cools heated water primarily through evaporation, thereby rejecting heat to the outdoor air. A dry cooler is an air-cooled heat rejection device that uses fans to circulate outdoor air and release heat from the coolant without evaporating water.
Source: Prepared by The Institute of Energy Economics, Japan (IEEJ).

systems that evaporate water in cooling towers and use the latent heat of vaporization to release heat into the atmosphere, as well as systems that use dry coolers to release heat into the atmosphere through heat exchange with outdoor air.

Table 4. Characteristics of Major Cooling and Heat Rejection Systems in Data Centers

IT Equipment-Side Cooling Method	Facility-Side Cooling and Heat Rejection System	Ability to Operate Under High Outdoor Air Temperatures	IT-Side Equipment Cost	Facility-Side Equipment Cost	Water Consumption	Electricity Consumption
Air Cooling	Water-Cooled Chiller + Cooling Tower	○	Low	High	High	Medium
Air Cooling	Cooling Tower (Chillerless)	△	Low	Medium	High	Low
Air Cooling	Air-Cooled Chiller	○	Low	Medium	Very Low	High
Air Cooling	Dry Cooler (Chillerless)	△~×	Low	Low~Medium	Very Low	Low~Medium
Liquid Cooling / Immersion Cooling	Cooling Tower (Chillerless)	○	Medium~High	Low~Medium	High	Low
Liquid Cooling / Immersion Cooling	Dry Cooler (Chillerless)	△~○	Medium~High	Low~Medium	Very Low	Low

Note: This table summarizes the relative characteristics of representative equipment configurations. The assessments do not indicate absolute performance levels or costs. “Equipment Cost” refers to a relative assessment of cooling equipment costs. Actual equipment costs, water consumption, electricity consumption for cooling, and the ability to operate under high outdoor air temperatures vary depending on meteorological conditions such as outdoor air temperature and humidity, allowable temperatures of IT equipment and coolants, facility size, equipment redundancy, cooling system configuration, and other factors.
Source: Prepared by The Institute of Energy Economics, Japan (IEEJ).

Depending on the required cooling temperature and outdoor air conditions, chillers may also be used to lower the temperature of the coolant. In conventional air-cooled data centers, cooling systems combining chillers and cooling towers are widely used. In contrast, where IT equipment can be cooled using relatively high-temperature coolant, as in certain liquid cooling systems, it may be possible to reject heat through cooling towers or dry coolers without operating chillers, depending on outdoor air conditions. When dry coolers are used, if the outdoor air temperature is high and heat exchange with outdoor air alone cannot achieve the required cooling temperature, mechanical cooling using chillers or other equipment may be employed in combination. In such cases, the electricity consumption required for cooling increases compared with operation using dry coolers alone. Conversely, when the outdoor air temperature is sufficiently low, the low temperature of outdoor air can be utilized to reduce or suspend chiller operation, thereby reducing electricity consumption for cooling.

Thus, data centers can employ various combinations of IT equipment-side cooling methods and facility-side heat rejection systems, and the amounts of electricity and water required for cooling vary considerably depending on the combination adopted. An analysis by Lawrence Berkeley National Laboratory (LBNL) also evaluates Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE) for various cooling systems, demonstrating that both indicators vary

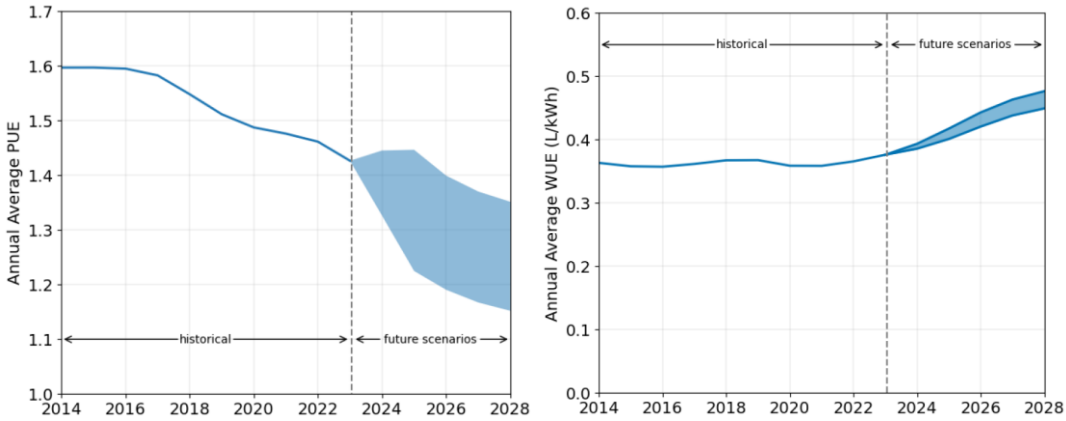
depending on cooling system configurations, meteorological conditions, and other factors.[69] PUE is calculated by dividing the total electricity consumption of a data center facility by the electricity consumption of its IT equipment, including servers. Its theoretical minimum value is 1.0, and the closer the value is to 1.0, the less electricity is consumed by cooling equipment and other non-IT equipment, indicating higher overall energy efficiency of the facility. WUE, on the other hand, is an indicator of the amount of water used by a data center facility per unit of electricity consumed by its IT equipment. For example, a WUE of 1.0 L/kWh means that the data center facility uses 1 liter of water for every 1 kWh of electricity consumed by its IT equipment. Therefore, a lower WUE indicates higher water use efficiency.

The relationship between PUE and WUE indicates that improvements in electricity use efficiency do not necessarily lead to improvements in water use efficiency in data center cooling. For example, evaporative heat rejection using cooling towers can efficiently release heat into the atmosphere through water evaporation, making it relatively easy to reduce the electricity consumption required for cooling, while increasing water consumption. In contrast, dry heat rejection using dry coolers can substantially reduce water consumption, but electricity consumption may increase under high outdoor air temperatures due to the additional use of mechanical cooling or other measures. Thus, depending on the cooling system and site conditions, a trade-off may arise between improvements in PUE and WUE.

However, electricity and water consumption vary considerably depending on the combination of IT equipment-side cooling methods and facility-side heat rejection systems, as well as the meteorological conditions of the region where the data center is located. In particular, direct liquid cooling can remove heat using coolant at higher temperatures than air cooling, thereby expanding the range of conditions under which heat can be rejected using outdoor air. Consequently, combining direct liquid cooling with dry heat rejection systems, such as dry coolers, may reduce the electricity required for cooling while limiting water consumption, thereby improving both PUE and WUE. Therefore, when evaluating the environmental impacts of data center cooling, it is important to assess not only PUE but also WUE, and to select appropriate cooling systems based on regional meteorological conditions and the availability of water resources.

[69] Shehabi, A., Smith, S. J., Hubbard, A., Newkirk, A., Lei, N., Siddik, M. A. B., Holecek, B., Koomey, J., Masanet, E., & Sartor, D. (2024). 2024 United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory. Retrieved August 15, 2026, from https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report_1.pdf

Figure 9. Trends and Projections of PUE and WUE in the United States (Left: PUE; Right: WUE)



Source: hehabi, A., Smith, S. J., Hubbard, A., Newkirk, A., Lei, N., Siddik, M. A. B., Holecek, B., Koomey, J., Masanet, E., & Sartor, D. (2024). 2024 United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory. Retrieved August 15, 2026, from https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report_1.pdf

3.5.2. Impacts of the Increasing Scale and Concentration of Data Centers on Water Resources and Regulatory Responses

As data centers become larger and increasingly concentrated in certain areas, their water consumption has grown to levels that could affect regional water supplies. According to estimates by Lawrence Berkeley National Laboratory (LBNL), total annual water consumption by data centers reached 21.2 billion liters in 2014 (equivalent to approximately 17 Tokyo Domes), of which 64% was attributable to enterprise data centers owned and operated by individual companies. By 2023, annual water consumption had increased to 66 billion liters, with hyperscale and colocation data centers together accounting for 84% of the total. By 2028, the share attributable to enterprise data centers is projected to decline to 2%, while water consumption by hyperscale data centers is expected to reach 60–124 billion liters (equivalent to approximately 48–100 Tokyo Domes).[70] As water demand shifts from relatively small enterprise data centers to large hyperscale and other facilities, the possibility of water consumption becoming concentrated in specific regions is also increasing.

[70] Shehabi, A., Smith, S. J., Hubbard, A., Newkirk, A., Lei, N., Siddik, M. A. B., Holecek, B., Koomey, J., Masanet, E., & Sartor, D. (2024). 2024 United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory. Retrieved August 15, 2026, from https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report_1.pdf
"In 2014, data centers consumed 21.2 billion liters of water, with 64% in internal data centers. By 2023, hyperscale and colocation account for 84% of the 66-billion-liter total, while internal data centers fell to just 12%, driven by water efficiency improvements. These trends are expected to continue through 2028, with internal data centers falling to just 2% of the total. Hyperscale data centers in 2028 are expected to consume between 60 and 124 billion liters."

Data centers are not the only facilities that require large amounts of cooling water. In general, thermal and nuclear power plants handle substantially larger volumes of cooling water than data centers. Because power plants are expected to use large quantities of water, they are often constructed near coastlines, major rivers, or lakes. In contrast, data center site selection places greater emphasis on factors such as access to a stable supply of low-cost electricity, land availability, and proximity to demand centers. Consequently, data centers are often located inland or near urban areas,[71] where they use potable water supplied by water utilities or reclaimed water.[72] In regions where multiple data centers are concentrated, their impacts on local water resources can become even more significant.

In the United States, some states have introduced requirements to assess large-scale water demand during the permitting process, while others require reporting of water supplied to data centers. In Minnesota, a regulatory framework took effect in 2025 requiring water-use permit reviews for data centers involving new or additional water consumption exceeding 100 million gallons (approximately 378.5 million liters) annually. These reviews consider water conservation measures, water reuse, the use of reclaimed water, and the installation of closed-loop systems (cooling systems that circulate coolant through piping to reduce water consumption through evaporation), as well as potential competition with other water users in the region.[73] In Virginia, a reporting framework has been established requiring water utilities and other suppliers to report separately to the state the volumes of potable water and reclaimed water supplied to data centers.[74]

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[71] Joint Legislative Audit and Review Commission. (2024). Data centers in Virginia (Report No. 598). Retrieved August 30, 2026, from https://jlarc.virginia.gov/pdfs/reports/Rpt598.pdf
"Multiple factors have contributed to Northern Virginia's market prominence, including a strong fiber network, supply of reliable cheap energy, available land, proximity to major national customers, and the creation of a state data center tax incentive."

[72] Joint Legislative Audit and Review Commission. (2024).
"Data centers were typically one of these water utilities' larger customers, but a data center was the single largest customer for only two utilities."

[73] State of Minnesota. (2025). Minnesota Statutes § 103G.271: Appropriation and use of waters. Retrieved August 30, 2026, from https://www.revisor.mn.gov/statutes/cite/103G.271
"(2) technologies or measures that promote water conservation, the efficient use of water, and watershed health, are reasonably considered, including but not limited to using water efficient fixtures and practices, recycling water before discharging, partnering with local water utilities to use discharged water from the data center, using reclaimed water, installing closed-loop systems, and supporting water restoration and replenishment in local watersheds; and"

[74] Commonwealth of Virginia. (2026). Code of Virginia § 62.1-44.38: Plans and programs; registration of certain data by water users; advisory committees; committee membership for federal, state, and local agencies; water supply planning assistance. Retrieved August 30, 2026, from https://law.lis.virginia.gov/vacode/title62.1/chapter3.2/section62.1-44.38/
"Any water user required to register water withdrawal and use data pursuant to this subsection that provides water to another person offsite shall include in its report, submitted on its regular reporting schedule, the total volume of potable water and, reported separately, the total volume of reclaimed water provided during each month for each of the following categories: (i) a data center, as that term is defined in subdivision A 43 of § 58.1-3506, with an air permit issued by the Department and (ii) to the extent

3.5.3. Reducing Water Consumption Through Advances in Cooling Technologies

Meanwhile, data center operators are also developing cooling technologies to reduce water consumption. According to Amazon Web Services (AWS), the latest AI servers incorporate large numbers of Graphics Processing Units (GPUs) for AI computing, which are densely arranged to enable high-speed data exchange, thereby increasing power density per rack. As a result, conventional air cooling systems may not always provide sufficient or efficient cooling. To address this challenge, AWS developed an In-Row Heat Exchanger (IRHX), which captures heat generated by high-density AI equipment directly at the rack before it spreads into the surrounding environment.[75] By capturing heat at the rack, close to its source, AWS reduces the frequency with which water-consuming evaporative cooling equipment needs to operate. AWS estimates that expanding the deployment of AI racks equipped with IRHX technology could reduce water consumption by approximately 9% compared with air-cooled data centers using evaporative cooling systems.

In 2025, AWS also expanded the deployment of smart meters to monitor water consumption in data centers in real time and detect and repair water leaks. Through these and other initiatives, AWS reduced cooling water consumption worldwide by 938 million liters in 2025, while the average WUE of its data centers reached 0.12 L/kWh. This represents an improvement of 20% compared with 2024 and 52% compared with 2021.

In August 2024, Microsoft introduced a new data center design capable of supporting AI workloads without consuming water for cooling. The design employs direct-to-chip liquid cooling, which delivers coolant directly to semiconductor chips, together with a closed-loop cooling system that continuously recirculates the coolant. By eliminating the need for continuous water consumption for cooling, Microsoft estimates that the design can reduce water use by more than 125 million liters annually per facility.[76] Microsoft continues to innovate and advance its cooling technologies, including through the deployment of this new data center design. As a result, the average WUE of data centers owned and operated by Microsoft declined to 0.27 L/kWh in 2025.[77]

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available without utility billing system modifications, (a) domestic purposes, (b) commercial and industrial purposes, separately or combined as available, and (c) all other non-categorized purposes."

[75] Amazon Web Services. (2026). Sustainability report 2025: AWS summary. Retrieved August 30, 2026, from https://sustainability.aboutamazon.com/2025-aws-summary.pdf

[76] Solomon, S. (2024). Sustainable by design: Next-generation datacenters consume zero water for cooling. Microsoft. Retrieved August 30, 2026, from https://www.microsoft.com/en-us/microsoft-cloud/blog/2024/12/09/sustainable-by-design-next-generation-datacenters-consume-zero-water-for-cooling/

[77] Priest, J., & Solomon, S. (2026). Inside Microsoft's two-decade push to cut water intensity while scaling for growth. Microsoft. Retrieved August 30, 2026, from https://blogs.microsoft.com/blog/2026/06/24/inside-microsofts-two-decade-push-to-cut-water-intensity-while-scaling-for-growth/

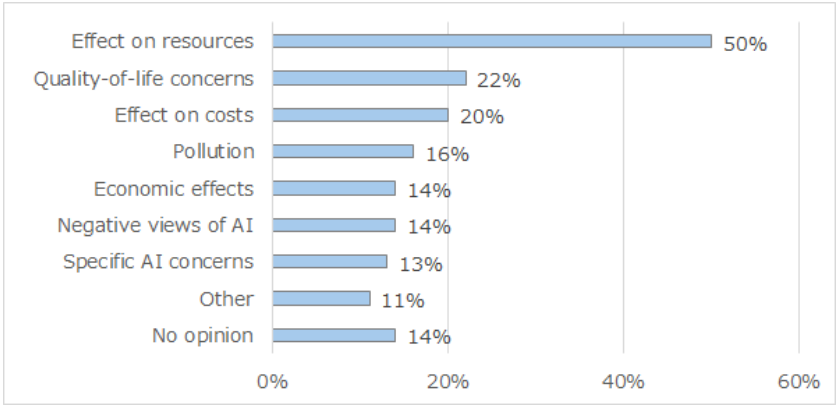
Thus, the rapid development and increasing scale of data centers may affect not only electricity grids but also water resources and water supply infrastructure in the regions where they are located. At the same time, improvements in cooling technologies can substantially reduce water consumption. However, cooling systems that consume little or no water are not necessarily the most energy-efficient options in all regions. When selecting cooling systems, it is therefore necessary to consider both electricity and water consumption, rather than pursuing improvements in either PUE or WUE alone, while taking into account regional climate conditions, water resource availability, and electricity supply conditions.

3.6. Local Community Opposition in Certain Regions

As discussed above, the rapid growth and increasing scale of data centers may give rise to various challenges in the regions where they are located, including the allocation of costs associated with electricity supply and impacts on local infrastructure, particularly water resources. Against the backdrop of concerns over these issues, opposition among local residents to data center construction has been growing in the United States.

According to a survey conducted in March 2026 by Gallup, a major U.S. polling organization, 71% of respondents opposed the construction of an AI data center in their local area, including 48% who stated that they were "strongly opposed." In contrast, only 27% supported such construction, with just 7% expressing "strong support."[78]

Figure 10. Reasons for Opposition to Data Center Construction in the United States (Multiple Responses)



Note: As multiple responses were allowed, the total percentage exceeds 100%.
Source: Prepared by IEEJ based on Jones, J. M. (2026). Americans oppose AI data centers in their area. Gallup. Retrieved August 15, 2026, from https://news.gallup.com/poll/709772/americans-oppose-data-centers-area.aspx

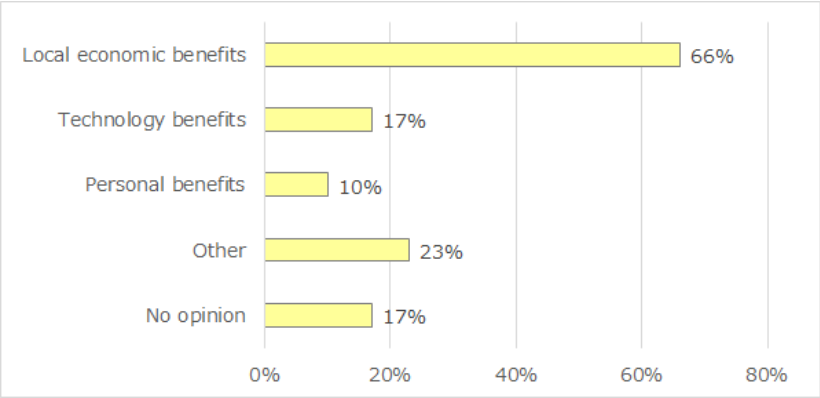
Among those opposed, 50% cited excessive resource consumption as a reason for their opposition, with water use and electricity use each accounting for 18%. In addition, 22% cited

[78] Jones, J. M. (2026). Americans oppose AI data centers in their area. Gallup. Retrieved August 30, 2026, from https://news.gallup.com/poll/709772/americans-oppose-data-centers-area.aspx

impacts on their living environment, while 20% cited cost-related impacts.

On the other hand, although relatively few respondents supported data center construction in their local communities, their reasons for doing so were concentrated on economic benefits. Among those in favor, 66% cited benefits to the local economy as a reason for their support, particularly increased employment opportunities and tax revenues.

Figure 11. Reasons for Support for Data Center Construction in the United States (Multiple Responses)



Note: As multiple responses were allowed, the total percentage exceeds 100%.
Source: Prepared by IEEJ based on Jones, J. M. (2026). Americans oppose AI data centers in their area. Gallup. Retrieved August 15, 2026, from https://news.gallup.com/poll/709772/americans-oppose-data-centers-area.aspx

Thus, local residents have expressed concerns about data center construction, including rising electricity rates, water consumption, noise, and impacts on property values. These concerns are not limited to opinions expressed in public surveys but have manifested in concrete opposition activities across the country, including online petitions, public comments at government meetings, lobbying of local authorities, and lawsuits. In some cases, these activities have resulted in the cancellation or delay of data center development projects.[79]

According to Reuters, data compiled by Data Center Watch, which tracks local community responses to data center development in the United States, indicate that at least 75 data center development projects nationwide, representing approximately $130 billion in investment, faced local opposition in the first quarter of 2026 alone. In response to growing opposition, financial institutions have reportedly begun examining local community concerns and support, as well as the status of permits and approvals, as part of their risk assessments during loan evaluations. There is also a growing tendency to select projects for financing more cautiously, including a preference for projects in areas where local communities are relatively receptive to data centers. Local opposition is thus influencing financial institutions' lending decisions as a risk factor that could

[79] Data Center Watch. (n.d.). Data Center Watch report. Retrieved September 18, 2026, from https://www.datacenterwatch.org/report

lead to project delays or cancellations.[80] In this way, opposition from local residents is becoming an increasingly important factor affecting the timing and feasibility of individual data center development projects.

3.7. Siting and Grid Connection Restrictions Imposed by State and Local Governments

3.7.1. State-Level Moves Toward Temporary Moratoriums on Construction and Permitting

As discussed above, concerns about data center construction have led not only to opposition movements among local residents but also to restrictions on siting and permitting imposed by state and local governments.

According to the University of Virginia's Data Center Policy Database[81] and the National Conference of State Legislatures (NCSL)[82], as of July 2026, bills to temporarily suspend or restrict data center construction or permitting statewide had been introduced in 15 states. In Maine, the bill failed to become law following a gubernatorial veto, while bills were defeated or failed to advance in 6 states: Maryland, Minnesota, New Hampshire, Oklahoma, South Dakota, and Wisconsin. In Virginia, consideration of the bill was carried over, while deliberations were ongoing in 6 states: Delaware, Georgia, Michigan, Pennsylvania, South Carolina, and Vermont. In New York, a bill passed both chambers of the state legislature, but the actual moratorium was introduced through a separately issued executive order rather than through the governor's signing of the bill into law.[83]

These bills generally seek to investigate the impacts of data centers and temporarily suspend permitting for a specified period, rather than necessarily imposing permanent bans on their construction.[84]

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[80] Azhar, S., & Bautzer, T. (2026). Lenders scrutinize US data center financing as community opposition builds. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/legal/transactional/lenders-scrutinize-us-data-center-financing-community-opposition-builds-2026-08-10/

[81] Bridges, L., Gould, G., Coelho Herrera, C., Scoresone, I., & Hauger, J. (2026). The Data Center Policy Database. Retrieved August 15, 2026, from https://www.datacenterpolicy.com/database

[82] National Conference of State Legislatures. (2026). Which states are banning data centers? Retrieved August 15, 2026, from https://www.ncsl.org/fiscal/which-states-are-banning-data-centers

[83] Office of Governor Kathy Hochul. (2026). First statewide moratorium on new hyperscale data centers launched by Governor Kathy Hochul. New York State. Retrieved August 15, 2026, from https://www.governor.ny.gov/news/first-statewide-moratorium-new-hyperscale-data-centers-launched-governor-kathy-hochul

[84] National Conference of State Legislatures. (2026). Which states are banning data centers? Retrieved August 15, 2026, from https://www.ncsl.org/fiscal/which-states-are-banning-data-centers

Table 5. Status of State Legislation on Temporary Moratoriums on Data Center Construction and Permitting in the U.S. (As of July 2026)

State	Bill	Overview	Legislative Status
Delaware	SB 353	Suspends the issuance of permits for data centers exceeding 100 MW until January 2027	Introduced / Under consideration
Georgia	HB 1059	Prohibits local governments from issuing permits for data centers until December 2028	Introduced / Under consideration
Maine	LD 307	Suspends permitting and approvals for data centers exceeding 20 MW until November 2027	Vetoed by the governor
Maryland	HB 120	Prohibits the construction and permitting of data centers	Failed to pass
Michigan	HB 5594 / HB 5595	Prohibits local governments and the state public utility commission from issuing permits or approvals for new data centers until April 2027	Introduced / Under consideration
Minnesota	HB 4888 / SB 4298	Prohibits the issuance of permits for new data centers until the state public utility commission submits a comprehensive report, and at least until July 2027	Failed to pass
New Hampshire	HB 1265	Imposes a 1-year moratorium on data center construction	Failed to pass
New York	AB 10141 / SB 9144	Imposes a 1-year moratorium on permitting and approvals for data centers exceeding 20 MW	Passed both chambers of the state legislature
Oklahoma	SB 1488	Imposes a moratorium on data center construction until November 2029	Failed to pass
Pennsylvania	SB 1359 / HB 2533	Establishes a 3-year moratorium on new data centers accompanied by an impact study, or grants local governments the authority to prohibit data centers	Introduced / Under consideration
South Carolina	H 5526	Prohibits local governments from approving data centers until the state legislature establishes a "comprehensive oversight framework"	Introduced / Under consideration
South Dakota	SB 232	Imposes a 1-year moratorium on the construction of new data centers and the expansion of existing facilities	Failed to pass
Vermont	S 205	Requires an impact study and imposes a moratorium on data center construction and related activities until 2030	Introduced / Under consideration
Virginia	HB 1515	Prohibits final approval of new data centers until all grid connection applications have been processed or until July 2028	Carried over to the next legislative session
Wisconsin	SB 1061 / AB 1099	Prohibits data center operations until 14 specified conditions are satisfied	Failed to pass

Source: Prepared by IEEJ based on National Conference of State Legislatures. (2026). Which states are banning data centers? Retrieved August 15, 2026, from https://www.ncsl.org/fiscal/which-states-are-banning-data-centers

3.7.2. Developments Concerning Moratoriums in Maine and New York

One early case that attracted attention was Maine's LD 307, which proposed suspending state and local permitting and approvals for data centers with electricity demand of 20 MW or more until November 1, 2027. During the suspension period, a council would be established to examine the impacts of data centers on the electricity grid, electricity rates, the environment, siting policies, and the local economy, and to consider the design of future regulatory frameworks.[85]

Maine's LD 307 was passed by the state House of Representatives on April 14, 2026, by a vote of 79 to 62, and by the state Senate by a vote of 21 to 13. However, Democratic Governor Janet

[85] Mills, J. T. (2026). L.D. 307, An Act to Establish the Maine Data Center Coordination Council and Place a Temporary Limitation on Certain Data Centers [Veto message]. Office of Governor Janet T. Mills. Retrieved August 15, 2026, from https://www.maine.gov/governor/mills/official_documents/veto_messages/2026-04-ld-307-act-establish-maine-data-center-coordination

Mills vetoed the bill. A principal reason was that the bill did not exempt a proposed data center project involving an investment of approximately $550 million at the site of a paper mill in the town of Jay that had closed in 2023. According to the governor's veto message, the project had already secured a land agreement and obtained several permits. It was expected to create more than 800 jobs during construction and at least 100 permanent jobs after completion, as well as generate substantial property tax revenues for the local community. The governor regarded the project as a valuable opportunity for revitalizing a community that had been adversely affected by the closure of the paper mill. She stated that she would have signed the bill if this project had been exempted from its provisions. [86]

In contrast, in New York, A11560, which included a temporary suspension of permitting and approvals for large data centers, passed the state Assembly on June 4, 2026, by a vote of 103 to 38, and the state Senate by a vote of 43 to 17. The votes reflected bipartisan support. In the Assembly, 94 Democrats and 9 Republicans voted in favor, while 3 Democrats and 35 Republicans voted against.[87] In the Senate, 37 Democrats and 6 Republicans voted in favor, while 1 Democrat and 16 Republicans voted against.[88] In addition to a 1-year moratorium on permitting and approvals for large data centers, the bill included provisions for establishing separate electricity, gas, and water tariff classifications for such facilities, allocating associated infrastructure reinforcement costs and other expenses to data centers, setting and enforcing energy efficiency targets, requiring financial contributions to community benefit measures, and establishing labor standards during construction.[89]

However, the measures that actually took effect in New York were not introduced through this bill. Instead, they were based on Executive Order No. 62, issued by Governor Kathy Hochul on July 14, 2026. The executive order applies to discretionary permits, approvals, licenses, and other authorizations relating to the construction or expansion of data centers with a maximum electricity demand of 50 MW or more, where applications were pending before the New York State Department of Environmental Conservation as of July 14, 2026, or were submitted on or after that date, and had not been determined to be complete before that date. Applications falling within its scope are held in abeyance until the New York State Department of Public Service submits a Generic Environmental Impact Statement and a final report.[90]

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[86] Mills, J. T. (2026).
[87] LegiScan. (2026a). New York Assembly Bill 11560: Assembly floor vote—final passage [Roll-call vote]. Retrieved August 15, 2026, from https://legiscan.com/NY/rollcall/A11560/id/1706547
[88] LegiScan. (2026b). New York Assembly Bill 11560: Senate floor vote—final passage [Roll-call vote]. Retrieved August 15, 2026, from https://legiscan.com/NY/rollcall/A11560/id/1706274
[89] New York State Senate. (2026). Assembly Bill A11560: Responsible Data Center Development Act [Bill]. Retrieved August 15, 2026, from https://www.nysenate.gov/legislation/bills/2025/A11560
[90] Hochul, K. (2026). Executive Order No. 62: Establishing a temporary moratorium on data centers in New York while the state develops higher standards for data center development and benefits blueprint to

3.7.3. Expansion to the Local Government Level and Legal Challenges

Moves to temporarily restrict data center siting have spread not only at the state level but also among local governments. According to data tracking data center moratoriums maintained by Interconnected Capital, a research and advisory firm specializing in data centers and digital infrastructure, 360 local government moratoriums had been identified across the United States as of September 1, 2026, of which 299 were in effect.[91]

Meanwhile, restrictions applied retroactively to projects that have already progressed through land acquisition agreements or other arrangements may lead to litigation. In Hill County, Texas, for example, data center developer RCM Hill filed a lawsuit in federal court seeking $100 million in damages, arguing, among other things, that the county's moratorium of up to 1 year exceeded its legal authority. The county withdrew the moratorium approximately two weeks after its introduction.[92] Similarly, in Eagan, Minnesota, data center owner Eagan Capital filed a lawsuit challenging the city's 1-year moratorium on new and expanded data centers as unjustified.[93]

Thus, concerns about increasing electricity and water demand associated with the rapid growth of data centers, impacts on local infrastructure, and the shifting of costs to other electricity consumers have manifested in some regions not only as opposition movements among residents but also as temporary suspensions of construction and permitting by state and local governments. However, most of these measures do not seek to permanently prohibit data center construction. Rather, they are intended to temporarily restrain new development while regional impacts are assessed and rules concerning siting, cost allocation, and other matters are established. At the same time, because data centers are also expected to generate economic benefits through investment, employment, and tax revenues, states and local governments have adopted differing approaches regarding the extent to which their development should be restricted.

4. Constraints on the Development of Demand Facilities

4.1. IT Equipment Procurement Constraints

4.1.1. Rapid Growth in Demand for AI Semiconductors and U.S. Dependence on Overseas

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support localities [Executive order]. New York State. Retrieved August 15, 2026, from https://www.governor.ny.gov/executive-order/no-62-establishing-temporary-moratorium-data-centers-new-york-while-state-develops

[91] Interconnected Capital. (2026). US data center moratorium tracker. Retrieved September 8, 2026, from https://www.interconnectedcapital.com/research/data-center-moratoriums

[92] Goldenstein, T. (2026). Texas county rescinds its data center moratorium after $100 million lawsuit from developer. The Texas Tribune. Retrieved August 15, 2026, from https://www.texastribune.org/2026/06/05/texas-hill-county-moratorium-rescinded-data-centers/

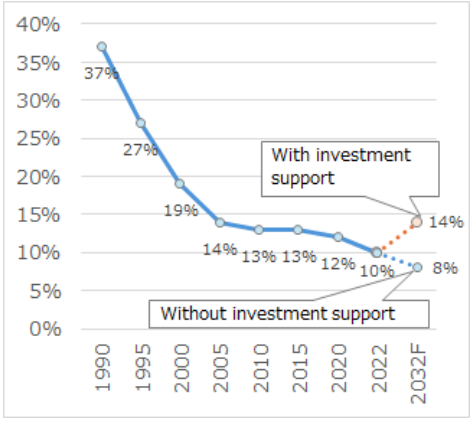
[93] Hassan, A. (2026). Lawsuit filed against city of Eagan over one-year data center moratorium. MPR News. Retrieved August 15, 2026, from https://www.mprnews.org/story/2026/07/07/city-of-eagan-faces-lawsuit-over-data-center-moratorium

Manufacturing

The rapid development and increasing scale of data centers have also created challenges in procuring the materials and equipment required for their construction. In particular, AI data centers require large quantities of semiconductors for AI computing, such as Graphics Processing Units (GPUs), as well as servers equipped with these semiconductors. Consequently, if data center construction becomes concentrated within a short period, the supply of such IT equipment could become a constraint. Furthermore, because the United States remains heavily dependent on overseas semiconductor manufacturing, securing a stable supply of the semiconductors needed to meet rapidly expanding domestic data center demand has become an important challenge.

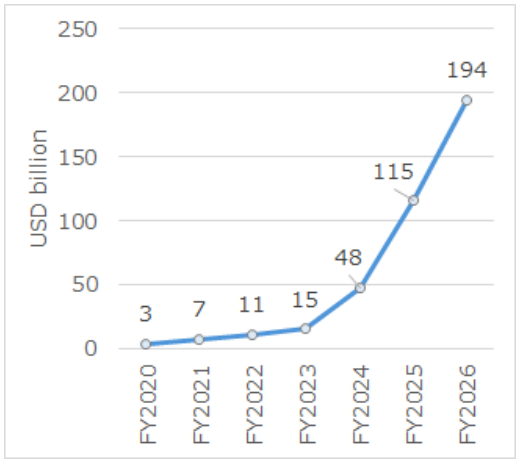
The U.S. share of global semiconductor manufacturing capacity declined substantially from 37% in 1990 to 10% in 2022. Without policy support, this share was projected to fall further to 8% by 2032. However, with the implementation of support measures, it is now projected to recover to 14%. Nevertheless, domestic semiconductor manufacturing capacity remains limited, and reducing dependence on overseas semiconductor supplies continues to be an important policy challenge.

Figure 12. Trends in the U.S. Share of Global Semiconductor Manufacturing Capacity



Source: Prepared by IEEJ based on Semiconductor Industry Association and Boston Consulting Group. (2024). Emerging resilience in the semiconductor supply chain. Retrieved August 15, 2026, from https://www.semiconductors.org/wp-content/uploads/2024/05/Emerging-Resilience-in-the-Semiconductor-Supply-Chain_SIA-Summary.pdf

Figure 13. Trends in NVIDIA's Data Center Semiconductor Revenue



Source: Prepared by IEEJ based on NVIDIA Corporation's Forms 10-K filed with the U.S. Securities and Exchange Commission (2022, 2024, and 2026).

4.1.2. Strengthening Domestic Semiconductor Supply Capabilities and Diversifying Procurement Options

In addition to growing semiconductor demand, dependence on overseas semiconductor

supplies has become an economic security concern for the United States. In January 2026, the U.S. government stated that domestic semiconductor manufacturing capacity was insufficient to meet future national defense requirements and expanding civilian demand.[94] While the United States accounts for approximately one-quarter of global semiconductor demand, only about 10% of the semiconductors it requires can be manufactured entirely domestically, leaving the country heavily dependent on overseas supply chains. The U.S. government regards this dependence as a significant risk to economic and national security, warning that disruptions to import-dependent supply chains could undermine U.S. industrial and military capabilities. Furthermore, advances in AI are creating a growing need for improvements in existing technologies, including high-performance computing and low-power electronics. To address these technological challenges, the United States is investing in research and development aimed at improving overall system performance.[95]

Specifically, the U.S. government is strengthening domestic semiconductor research and development and manufacturing capabilities through the CHIPS for America initiative under the CHIPS and Science Act, enacted in 2022. The Act allocated $50 billion to the Department of Commerce, of which the CHIPS R&D Office is investing $11 billion in developing domestic research and development capabilities, while the CHIPS Program Office is providing $39 billion in incentives to encourage investment in facilities and equipment in the United States.[96]

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[94] The White House. (2026a). Adjusting imports of semiconductors, semiconductor manufacturing equipment, and their derivative products into the United States. Retrieved August 30, 2026, from https://www.whitehouse.gov/presidential-actions/2026/01/adjusting-imports-of-semiconductors-semiconductor-manufacturing-equipment-and-their-derivative-products-into-the-united-states/
"The Secretary found that the United States' capacity to manufacture semiconductors is too low to meet projected national defense needs and to match the requirements of a growing commercial industry. The United States consumes roughly one quarter of the world's semiconductors. The United States currently fully manufactures only approximately 10 percent of the chips it requires, making it heavily reliant on foreign supply chains. This dependence on foreign supply chains is a significant economic and national security risk. Given the foundational role that semiconductors play in the modern economy and national defense, a disruption of import-reliant supply chains could strain the United States' industrial and military capabilities."

[95] National Institute of Standards and Technology. (2024). CHIPS for America R&D facilities model. Retrieved August 30, 2026, from https://www.nist.gov/system/files/documents/2024/07/11/7.11.2024-Model-Fact-Sheet-508C.pdf
"As one example of a strategic imperative that will be met with this model, emerging artificial intelligence (AI)- driven applications are pushing the boundaries of current technologies like high performance computing and low power electronics, requiring significant advances in microelectronics capabilities. To meet the technical challenges posed by these technologies, the U.S. is investing in integrated R&D activities to improve all aspects of system performance."

[96] National Institute of Standards and Technology. (n.d.). CHIPS for America. Retrieved August 30, 2026, from https://www.nist.gov/chips
"When the CHIPS and Science Act of 2022 was signed into law, it provided the Department of Commerce with $50 billion for a suite of programs to strengthen and revitalize the U.S. position in semiconductor research, development, and manufacturing — while also investing in American workers. CHIPS for America encompasses two offices responsible for implementing the law: The CHIPS Research and Development

The CHIPS R&D Office promotes semiconductor research and development through initiatives such as the National Semiconductor Technology Center (NSTC), the National Advanced Packaging Manufacturing Program (NAPMP), and the CHIPS Metrology Program. It also facilitates collaboration among domestic research institutions, companies, researchers, and research facilities to accelerate the development and practical application of fundamental semiconductor technologies. Meanwhile, the CHIPS Program Office is working to expand domestic semiconductor manufacturing capacity through its incentive programs.[97] In November 2024, the U.S. Department of Commerce finalized awards under the CHIPS Act of up to $6.6 billion in direct subsidies and up to $5 billion in loans for TSMC's Arizona manufacturing facilities, for which NVIDIA is one of the major customers.[98]

While the U.S. government is developing the domestic infrastructure needed to support semiconductor research, development, and manufacturing, major U.S. technology companies, which are among the principal consumers of semiconductors, are also working to secure semiconductor supplies through their own technological development. Private companies such as Google,[99] Amazon,[100] and Microsoft[101] are developing custom-designed semiconductors tailored to specific applications, together with systems incorporating these chips. Although these custom-designed semiconductors are developed primarily to improve performance and power efficiency, expanding the range of available semiconductor options is also expected to help reduce dependence on particular semiconductor manufacturers.

Office is investing $11 billion into developing a robust domestic R&D ecosystem, while the CHIPS Program Office is dedicating $39 billion to provide incentives for investment in facilities and equipment in the United States."

[97] National Institute of Standards and Technology. (2024). CHIPS R&D Program Standards Summit: Summary report. Retrieved August 30, 2026, from https://nvlpubs.nist.gov/nistpubs/CHIPS/NIST.CHIPS.1400-1.pdf

[98] U.S. Department of Commerce. (2024). Biden-Harris Administration announces CHIPS incentives award with TSMC Arizona to secure U.S. leadership in advanced semiconductor technology. Retrieved August 30, 2026, from https://www.commerce.gov/news/press-releases/2024/11/biden-harris-administration-announces-chips-incentives-award-tsmc

"Today, the Biden-Harris Administration announced that the U.S. Department of Commerce awarded TSMC Arizona Corporation (TSMC Arizona), a subsidiary of Taiwan Semiconductor Manufacturing Company Limited (TSMC), up to $6.6 billion in direct funding under the CHIPS Incentives Program's Funding Opportunity for Commercial Fabrication Facilities."

[99] Marini, A. (2025). 3 things to know about Ironwood, our latest TPU. Google. Retrieved August 30, 2026, from https://blog.google/innovation-and-ai/infrastructure-and-cloud/google-cloud/ironwood-google-tpu-things-to-know/

[100] Schultz, I. (2026). How Amazon became one of the world's top chip companies in a decade. Amazon. Retrieved August 30, 2026, from https://www.aboutamazon.com/news/aws/amazon-ai-chips-business-history

[101] Guthrie, S. (2026). Maia 200: The AI accelerator built for inference. Microsoft. Retrieved August 30, 2026, from https://news.microsoft.com/source/asia/features/maia-200-the-ai-accelerator-built-for-inference/

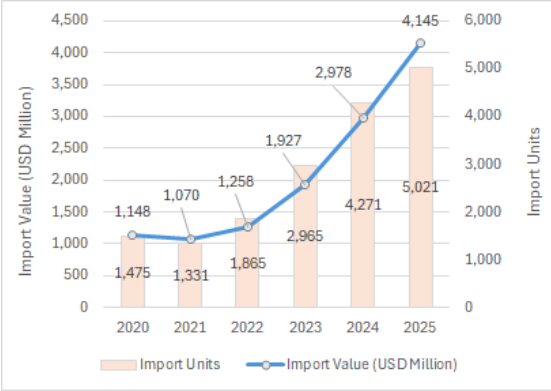
4.2. Procurement Constraints for Electrical Equipment, Including Transformers

4.2.1. Increasing Demand and Supply Constraints for Large Power Transformers

Connecting large data centers to the electricity grid also requires electrical equipment such as transformers and switchgear. In regions where data center construction is concentrated, the procurement of such equipment has become another constraint. In particular, because large power transformers require long manufacturing lead times, the timing of equipment availability can affect schedules for both grid reinforcement and data center construction.

In the United States, demand for large power transformers has been increasing due to growing electricity demand and the expansion and modernization of transmission networks. However, limited domestic manufacturing capacity has resulted in a high degree of dependence on imports. The number of imported liquid dielectric transformers with capacities exceeding 10,000 kVA increased approximately 3.4-fold, from 1,475 units in 2020 to 5,021 units in 2025. Their import value also increased approximately 3.6-fold over the same period, from approximately $1.15 billion to approximately $4.15 billion. Against the backdrop of expanding demand, constraints on domestic manufacturing capacity, and dependence on imports, efforts are underway in the United States to strengthen domestic manufacturing capacity and supply chains for transmission and substation equipment, including transformers.[102]

Figure 14. Trends in U.S. Imports of Liquid Dielectric Transformers with Capacities Exceeding 10,000 kVA



Source: Prepared by IEEJ based on World Bank. (n.d.). World Integrated Trade Solution (WITS): UN Comtrade—U.S. imports of liquid dielectric transformers with a power handling capacity exceeding 10,000 kVA (HS 850423), 2020–2025. Retrieved August 15, 2026, from https://wits.worldbank.org/trade/comtrade/en/country/USA/year/[2020–2025]/tradeflow/Imports/partner/ALL/product/850423.

4.2.2. Expansion of Domestic Manufacturing Capacity and Diversification of Procurement Sources and Methods

In the United States, efforts are underway to expand domestic manufacturing capacity for transmission and substation equipment, including transformers. Major manufacturers such as

[102] World Bank. (n.d.). World Integrated Trade Solution (WITS): UN Comtrade—U.S. imports of liquid dielectric transformers with a power handling capacity exceeding 10,000 kVA (HS 850423), 2020–2025. Retrieved August 15, 2026, from https://wits.worldbank.org/trade/comtrade/en/country/USA/year/[2020–2025]/tradeflow/Imports/partner/ALL/product/850423.

Hitachi Energy and Siemens are also increasing investment in manufacturing facilities for large power transformers and related components.[103] In Presidential Determination No. 2026-10, issued in April 2026, the U.S. government designated transmission and distribution equipment, including transformers, transmission and distribution lines, substation equipment, and electrical steel, as well as the upstream supply chains supporting their manufacture, as resources and materials essential to national defense.[104] Based on this determination, the government is strengthening domestic manufacturing capacity and related supply chains through government purchases, purchase commitments, financial support for the development and expansion of production capacity, and other measures under Section 303 of the Defense Production Act (DPA).[105]

Workforce shortages have also become a concern, particularly the lack of skilled workers required for the manufacture, installation, and maintenance of large power transformers. As medium-term responses, the need to revise educational curricula in cooperation with industry and expand apprenticeship programs and internship opportunities has been identified.[106]

However, constructing or expanding manufacturing facilities and developing skilled workers take time, making it difficult to resolve supply constraints in the short term even if domestic manufacturing capacity is increased. Consequently, electric utilities and other companies are also reviewing their procurement practices to secure necessary equipment at an earlier stage. Some are

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[103] Ford, N. (2026). US power transformer buyers scramble for imports, factory slots. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/business/energy/us-power-transformer-buyers-scramble-imports-factory-slots--reeii-2026-05-11/
"As transformer demand surges, major grid equipment makers are ramping up U.S. capacity.
Hitachi Energy has announced more than $1 billion investment, including $457 million in a new large transformer facility in south Boston due online in 2028 and $106 million in a transformer component plant in Alamo, Tennessee due for completion by mid-2027. The global technology supplier forecasts U.S. demand for grid infrastructure will increase for at least the next decade. In February, Siemens announced it would increase spending on manufacturing facilities in North Carolina from $150 million to $421 million. This includes a new transformer factory in Charlotte due online this year. GE, Hyosung HICO and WEG are also investing in transformer manufacturing."

[104] The White House. (2026b). Presidential determination pursuant to Section 303 of the Defense Production Act of 1950, as amended, on grid infrastructure, equipment, and supply chain capacity. Retrieved September 8, 2026, from https://www.whitehouse.gov/presidential-actions/2026/04/presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended-on-grid-infrastructure-equipment-and-supply-chain-capacity/

[105] U.S. Department of Energy. (2026e). Energy Conservation Program: Energy conservation standards for distribution transformers. Federal Register, 91(114), 35903–35907. Retrieved August 30, 2026, from https://www.govinfo.gov/content/pkg/FR-2026-06-15/html/2026-11971.htm

[106] U.S. Department of Energy. (2024b). Large power transformer resilience: Report to Congress. Retrieved August 30, 2026, from https://www.energy.gov/sites/default/files/2024-10/EXEC-2022-001242%20-%20Large%20Power%20Transformer%20Resilience%20Report%20signed%20by%20Secretary%20Granholm%20on%207-10-24.pdf
An additional potentially effective medium-term focus is to increase LPT workforce training, which could require "a change in both training curricula at various levels and increased apprenticeship and internship opportunities in collaboration with industry" [6, p. ix].

reserving future transformer manufacturing slots during the early stages of project development, in some cases even before specific projects have been finalized. Such long-term contracts and advance sales of future manufacturing slots provide manufacturers with greater revenue predictability, helping them make the investments necessary to expand their factories.[107]

4.2.3. Standardization of Specifications and Sharing of Spare Equipment

Furthermore, efforts are underway in the United States to standardize the specifications of Large Power Transformers (LPTs) and improve interoperability among different electric utilities, with the aim of utilizing limited manufacturing capacity more efficiently and facilitating the sharing or substitution of transformers during emergencies.

However, standardizing the specifications of all LPTs is not straightforward. One reason is that individual electric utilities have adopted design standards tailored to their respective electricity networks over many years.[108] Impedance, which represents opposition to the flow of electric current, is considered particularly difficult to standardize because its requirements depend on the characteristics of the network in which the transformer is installed, including the specifications of other transformers operating in parallel and the protection systems used in downstream networks. Consequently, the development and demonstration of variable-impedance LPTs, whose impedance can be adjusted, are also underway.

The long service life of transformers is another factor that makes standardization difficult. Many U.S. electric utilities were formed through the historical integration of multiple existing electricity networks with different design philosophies, and modifying or harmonizing these design approaches requires considerable cost and effort. Furthermore, design standards established in the 1950s are still used in some cases because of the need to maintain compatibility with equipment that remains in operation, further complicating standardization.

Nevertheless, promoting standardization and improving interoperability wherever feasible could help streamline manufacturing processes. In addition, improving LPT interoperability and facilitating equipment sharing and mutual assistance among electric utilities are expected to make it easier to secure spare LPTs for use during equipment failures or natural disasters, thereby

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[107] Ford, N. (2026). US power transformer buyers scramble for imports, factory slots. Reuters. Retrieved August 30, 2026, from https://www.reuters.com/business/energy/us-power-transformer-buyers-scramble-imports-factory-slots--reeii-2026-05-11/

"Manufacturers are expanding U.S. transformer production but demand is expected to exceed supply for some time."

"Developers are often willing to pay significant premiums or buy production slots well in advance, sometimes without a specific project, Novev said."

"Long-term agreements and the sale of future production slots are providing manufacturers with the "financial certainty needed to invest in facility expansions," noted Logan."

[108] U.S. Department of Energy. (2024b).

enhancing electricity grid resilience.

Thus, the rapid development and increasing scale of data centers are driving demand not only for IT equipment but also for electrical equipment, including transformers required for grid connections. In response, the United States is pursuing various measures to expand supply capacity and facilitate procurement, including expanding domestic manufacturing capacity, procuring equipment from overseas, reserving manufacturing slots at an early stage, and standardizing equipment specifications. However, because expanding manufacturing facilities and developing skilled workers take time, procurement lead times for large power transformers and other equipment are expected to remain one of the factors affecting data center grid connection schedules and construction periods for the foreseeable future.

Conclusion

If data center deployment proceeds rapidly, the development of generation capacity and transmission infrastructure may fail to keep pace with increasing electricity demand. Furthermore, uncertainty remains regarding where and to what extent actual electricity demand will materialize, partly because data center developers submit grid connection applications for multiple locations. A major challenge, therefore, is how to develop the necessary generation capacity and transmission infrastructure in advance while appropriately assessing future electricity demand.

In Japan, measures are being implemented to address these challenges. Regarding grid connections, procedural requirements have been strengthened to prevent speculative reservations of grid capacity by large loads. These include requiring applicants to submit information on demand size, the planned commencement date of electricity supply, and business plans at the contract application stage, as well as establishing deadlines for payment of construction cost contributions. In addition, measures are being considered to release reserved grid capacity and settle associated costs when contracted demand is not established as planned.

Regarding transmission infrastructure, efforts are underway to coordinate the development of electricity infrastructure with data center siting through initiatives such as Welcome Zone Maps, Watt-Bit Collaboration, and GX Strategic Regions, in addition to proactive, or "push-type," grid development that anticipates future generation locations and demand growth. Furthermore, mechanisms are being considered to enable earlier grid connections for large loads subject to restrictions on electricity consumption during specified hours or under certain conditions. Thus, Japan is pursuing measures both to develop grid infrastructure in response to demand growth and to make effective use of existing facilities.

The experience of the United States offers several implications for Japan.

First, it is important to assess the likelihood that large-load projects will materialize and appropriately reflect this assessment in demand forecasts and grid planning. There is a certain

rationale for data center developers to examine grid connection possibilities at multiple locations in order to identify sites where electricity can be supplied more quickly and at lower cost. However, if all such applications are treated as future demand, generation capacity and transmission infrastructure may be developed in excess of actual requirements. Conversely, if infrastructure investment is postponed until demand becomes certain, the necessary electricity supply may not be available when data centers are actually constructed. It is therefore important to progressively assess the likelihood of demand materializing through factors such as project development progress, contract execution, and financial commitments, and to reflect these assessments in demand forecasts and infrastructure planning. In PJM, efforts are underway to identify duplicate sites and overlapping demand volumes among large-load projects included in future demand forecasts.

Second, a framework should be developed for grid connection studies that evaluate generation facilities and large loads in an integrated manner. To accommodate increasing large-load demand, it is important not only to examine grid connections for demand and generation separately but also to assess their combined impacts on the electricity grid. The Federal Energy Regulatory Commission (FERC) has pointed out the need for a grid connection study framework that evaluates the impacts of large loads electrically proximate to generation facilities or co-located with generation facilities by considering generation output and electricity demand together. In response, PJM has proposed a framework that integrates grid connection studies for generation facilities and transmission service studies for large loads into a single annual process, evaluating generation and demand within the same cluster. Japan could also consider establishing a grid connection study framework that jointly evaluates the impacts of large loads, such as data centers, and the generation facilities, battery storage systems, and other resources intended to serve them.

Third, generation capacity should be secured in conjunction with large-load demand, while promoting the co-location of demand and generation facilities. As data centers become larger, it is increasingly important to secure generation capacity corresponding to new demand in advance, rather than arranging for the necessary generation capacity separately after demand facilities have been connected to the grid. The co-location of generation facilities and large loads, as well as their siting in electrically proximate locations, is being discussed. Japan could also consider mechanisms for securing large loads, such as data centers, together with the generation facilities, battery storage systems, and other resources needed to meet their demand. Furthermore, promoting the co-location or proximity of demand and generation facilities could make it possible to accommodate large loads while securing the necessary generation capacity, reducing impacts on the electricity grid, and limiting the need for grid reinforcement.

Fourth, it is important to ensure appropriate cost allocation for infrastructure investment required by large loads and prevent costs arising from changes in demand plans or other

circumstances from being shifted to other electricity consumers. If transmission infrastructure and other facilities are developed in advance to serve data centers, but actual demand falls below planned levels or projects are withdrawn altogether, the associated costs may be shifted to other electricity consumers. In the United States, measures such as long-term contracts, minimum charges, exit fees, and financial security requirements are being introduced to require long-term commitments from large electricity consumers. For example, AEP Ohio has introduced a framework requiring large data centers to enter into long-term contracts and pay specified minimum charges even when actual demand falls below planned levels. In PJM, the need for Cost Recovery Agreements has also been identified to ensure that large loads bear the necessary costs and prevent grid reinforcement costs associated with such demand from being shifted to other electricity consumers. In Japan, measures such as cost settlements associated with changes in demand plans or postponements of electricity supply commencement are also under consideration. However, there remains scope to examine the extent to which large electricity consumers should be required to make long-term commitments regarding demand and cost responsibility, including when actual demand falls below planned levels after the necessary infrastructure has been developed.

In addition, the rapid growth of data centers in the United States has given rise to various challenges, including impacts on water resources required for cooling, opposition from local residents, and tightening supply-demand conditions for equipment such as semiconductors and transformers. In Japan, if large concentrations of data centers are developed in the future, it will be important to consider not only whether sufficient electricity can be supplied but also the impacts on water resources and local infrastructure, relationships with local communities, and the procurement of necessary equipment. Data center siting and the development of supporting infrastructure should therefore be examined in an integrated manner.

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