Assessing Electricity Resource Adequacy in Pennsylvania and PJM

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EXECUTIVE SUMMARY

Pennsylvania's electricity system is experiencing a tightening of supply and demand. State and regional load is growing, largely due to data center development, and supply is constrained as aging generators retire and new resource deployment is hindered. These two simultaneous trends cause high electricity prices, and also expose other challenges: recent assessments from grid operator PJM and the North American Electric Reliability Corporation (NERC), the national body charged with regulating electric system reliability, have both identified PJM's system as stressed, with looming reliability concerns.

In the context of ongoing policy proposals, Pennsylvania PUC commissioned an independent analysis aimed at developing load projections and evaluating resource adequacy under a set of likely possible futures. Synapse Energy Economics led a team using capacity expansion and resource adequacy scenario modeling to (a) develop projections of future resources through the long term (2040) in light of different load projections and (b) assess system reliability performance through the near term (2030) to better understand the kinds of stresses Pennsylvania's electric system and the wider PJM grid face.

Key findings

The team modeled three scenarios and found the following: in both the Reference scenario and the High Load And Low Supply scenario, we find that from 2027 through 2030, the PJM planning criterion for resource adequacy (loss of load expectation or "LOLE" of 0.1) is not met in PJM. Meanwhile, in the No New Data Centers scenario, LOLE is below this 0.1 threshold (see Table 1).

In the Reference scenario, which relies on PJM's 2026 Load Forecast, modeled 2030 LOLE is 0.59 or nearly six times worse than the PJM planning criterion. This result is mainly due to large-load additions stemming from data center additions, which are projected to surge in 2030. In 2030, the High Load and Low Supply scenario, a worst-case future of higher-than-expected load additions and constrained resource deployment, has an LOLE of 13.20. This LOLE value is over 100 times worse than PJM's planning criterion and indicates an expectation of more than 13 days with loss of load events per year. As in the Reference scenario, these reliability issues are largely due to surging data center additions. In the High Load forecast, data centers are projected to contribute over 200 TWh of additional new load between 2029 and 2030 PJM-wide. (For reference, the entire state of Pennsylvania's 2025 electricity demand was about 150 TWh). In this High Load and Low Supply scenario, in-state generators are unable to meet between 2 and 19 percent of PJM-wide electricity between 2031 and 2040.

Modeled scenarios

Reference: developed using PJM's 2026 load forecast; represents a future where no additional policy actions are taken and resource supply gradually improves through 2040

High Load and Low Supply: represents a worst-case future, with even higher levels of data center load and constrained supply through 2040

No New Data Centers: represents a future in which no new data center load is built anywhere in PJM in 2027 or any later year, but which otherwise utilizes the Reference-scenario assumptions regarding supply resource availability.

Table 1. Modeled PJM-wide resource adequacy for 2030

Scenario Name	Modeled 2030 LOLE
Reference	0.59 *expected value of 5.9 events every ten years, 6X worse than PJM planning criterion*
High Load and Low Supply	13.20 *expected value of 13.20 events every year, 132X worse than PJM planning criterion*
No New Data Centers	0.05 *expected value of 1 event every 20 years, 2X better than PJM planning criterion*
PJM planning criterion	**0.1**

Additional findings

- Between 2029 and 2030, primarily driven by data center load, LOLE increases by 3 times in the Reference scenario and 48 times in the High Load and Low Supply scenario. The 48 times increase means that PJM customers could expect to experience less than one day with an outage in 2029 and over 13 days with outages in 2030.

- Between 2027 and 2030, in the Reference and High Load and Low Supply scenarios, reliability events (measured in estimated unserved energy or "EUE") become more distributed throughout the year. In the Reference scenario, reliability events remain most concentrated in winter morning hours but gain prevalence in winter and summer evenings. In the High Load and Low Supply scenario, the peak risk hour shifts to summer evenings, but reliability events become more frequent throughout the year as data center load (which is assumed to have a flat load shape) increases demand for electricity in every hour.

- In the High Load and Low Supply scenario, high load growth and constrained new resource additions produce conditions such that by the mid 2030s, hundreds of TWh of load are unmet per year. Given the likelihood that neighboring electricity regions would face similar load and supply pressures, PJM would likely not be able to rely on neighboring regions for electricity during critical periods, and would instead face energy shortfalls in-region. Depending on the year, between 2 and 19 percent of electricity demand would be unmet between 2031 and 2040.

- Under all modeled scenarios, Pennsylvania's share of regional generating capacity shrinks over time (see Table 2). In general, other states with large projected increases in data center load or relatively less expensive resources (e.g., Viriginia, Ohio) see increases in shares of the region's generating capacity.

Table 2. Share of PJM generating capacity in Pennsylvania and other states

	2025	2030			2040		
		Reference	*High Load and Low Supply*	*No New Data Centers*	*Reference*	*High Load and Low Supply*	*No New Data Centers*
Pennsylvania	23%	20%	21%	21%	16%	14%	17%
Other states	77%	80%	79%	79%	84%	86%	83%

- In Pennsylvania, resource additions through 2030 are mostly solar and battery storage at between 3 and 7 GW for each resource type. This does not include the exogenous resource additions assumed for nuclear, distributed solar, distributed storage, and demand response. Through 2040, Pennsylvania's resource additions are primarily limited to gas combined-cycle units (with 5 to 12 GW of additions, depending on the scenario) and solar (with 3 to 4 GW of additions through 2040, depending on the scenario).

- In each scenario, Pennsylvania sees 3 to 4 GW of coal retirements by 2040, largely due to coal plants reaching the end of their useful lives. This leaves between 1.0 and 1.2 GW of coal capacity in the state by 2040, depending on the scenario. Pennsylvania also sees 2 to 8 GW of net retirements of gas steam and gas combustion turbines, as a result of resources reaching the end of their useful lives, and more economic resources becoming available.

- Pennsylvania's role as a large energy exporter is maintained in the Reference scenario and No New Data Centers scenario. However, the total quantity of electricity exported shrinks as in-state demand grows and more resources are built outside of the state. In the High Load and Low Supply scenario, Pennsylvania is projected to be a net energy importer by the late 2030s.

1. INTRODUCTION

Pennsylvania's electricity system is experiencing a tightening of supply and demand. The state faces considerable load growth due largely to data center development, while the retirement of aging generation facilities and delays in new resource deployment is constraining supply.[1] These two simultaneous trends drive high electricity prices, but they also expose other challenges: recent assessments from PJM (the independent authority tasked with running electricity markets in the mid-Atlantic states) and NERC have both flagged that PJM's system is increasingly stressed, with looming reliability concerns.

As a result, Pennsylvania's policymakers are examining regulatory and legislative solutions to address future resource adequacy concerns and increasing electricity supply costs. Recently, the Pennsylvania Public Utility Commission (PUC) has begun to address large-load interconnection and cost allocation, while the Governor's Office has issued an Executive Order addressing large load policy, and members of the Pennsylvania General Assembly have proposed bills that address energy affordability.[2]

The PUC issued an order in May 2026 establishing a model large-load customer tariff, which is a nonbinding tariff that utilities can choose to apply to customers with loads of 50 megawatts (MW) or greater. This tariff clarifies the cost responsibilities of a large-load customer such that a large-load customer will cover the costs that it adds to the system, with the aim of reducing the cost burden on other electric customers. These costs include distribution and

Recent assessments of resource adequacy in PJM

PJM (2026): "RPM cleared at a 14.4% Installed Reserve Margin (IRM) or 5.6 percentage points below the 20% IRM. The IRM is the reserve margin determined to be necessary to maintain a one-day-in-10-year Loss of Load Expectation (LOLE). This is the second BRA in a row where PJM has cleared more than one percentage point below the IRM." *PJM. July 2026. "2028/2029 Base Residual Auction Report". Page 3. Available at: https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2028-2029/2028-2029-bra-results-report.pdf.*

NERC (2026): "LOLH and EUE values for 2027 are 0.61 hours/year and 3,251 MWh/year, respectively, which are values consistent with PJM having a 2027 LOLE slightly worse than the 1 day in 10-year target. For 2029, the metrics significantly increase (LOLH = 9.97 hours/year and EUE = 67,581 MWh/year) due to significant forecasted peak load increases (i.e., more than 12,000 MW in summer and more than 14,000 MW in winter, driven by large load additions in the PJM footprint) and the changing resource portfolio mix (i.e., the retirement of thermal resources and the addition of wind, solar and storage, that do not provide an expected commensurate resource adequacy value when compared to the retired thermal resources)." *NERC. 2026. "2025 Long-Term Reliability Assessment". Page 92. Available at:* *https://www.nerc.com/globalassets/our-work/assessments/nerc_ltra_2025.pdf*.

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[1] PJM. January 2026. "PJM Load Forecast Report." Available at: https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.

[2] Governor Josh Shapiro's Executive Order 2026-05, available at https://www.pa.gov/governor/newsroom/2026-press-releases/governor-shapiro-signs-executive-order-on-data-center-developmen.

transmission upgrade costs and any planning study costs necessary to interconnect the customer. In addition, the PUC approved a large-load customer model tariff for electric distribution companies (EDCs) that, if an EDC filed such a tariff that was adopted by the PUC, would require EDCs to publicly publish a list of all large-load interconnection applications and each project's stage in the interconnection study process.[3] This information is useful for tracking data center demand over time, as well as other trends on data center location, size, and type.

In addition, in January 2025, Governor Shapiro proposed the Lightning Plan. The plan is composed of six pieces of legislation, with four bills specifically targeted to support energy project development in Pennsylvania and to lower electricity costs for consumers.[4] Two of these bills passed the House in 2025 and are currently before the Senate: (1) the Economic Development for a Growing Economy (EDGE) tax credit and (2) the Community Energy Act. The EDGE tax credit is an investment tax credit that would provide $100 million to qualifying energy facilities for three years, with the goal of adding reliable energy sources to the grid. The Community Energy Act would allow rural communities, farmers, and low-income Pennsylvanians to receive bill credits by subscribing to community energy resource connected on their distribution system.[5] In addition, the Pennsylvania legislature is currently deliberating on bills that would establish a streamlined siting board to reduce barriers for new resources and implement new energy efficiency standards.[6,7]

Simultaneously, PJM and the U.S. Department of Energy (DOE) have implemented several initiatives, policies, and programs to address growing concerns about PJM's resource adequacy. PJM initiatives include interconnection queue reforms, the Reliability Resource Initiative (RRI), the Expedited Interconnection Track (EIT), the Reliability Backstop Procurement (RBP), the Interim Resource Adequacy Service proposal, and the capacity market price cap. PJM and its stakeholders are also currently discussing additional initiatives such as load forecasting improvements. DOE has also committed to keeping some coal-fired power plants online beyond their retirement date, in an effort to maintain resource supply in the region. This report discusses each of these below.

In the context of these ongoing policy proposals, the PUC issued a solicitation for an independent analysis of developing load projections and evaluating resource adequacy under a set of likely possible

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[3] Interconnection and Tariffs for Large Load Customers, Docket No. M-2025-3054271 (April 30, 2026).

[4] Commonwealth of Pennsylvania. 2025. "Governor Shapiro's 'Lightning Plan' Moves Forward in General Assembly as Two Key Components Pass House of Representatives." Available at: https://www.pa.gov/governor/newsroom/2025-press-releases/gov-shapiro-s--lightning-plan--moves-forward-two-key-components-.

[5] Pennsylvania General Assembly. 2025. "Senate Bill 504 An Act providing for community energy facilities…" Available at: https://www.palegis.us/legislation/bills/2025/sb504.

[6] Pennsylvania General Assembly. 2025. "Senate Bill 502 An Act Amending Title 27 (Environmental Resources) of the Pennsylvania Consolidated Statutes, establishing the Reliable Energy Siting and Electric Transition Board." Available at: https://www.palegis.us/legislation/bills/2025/sb502.

[7] Pennsylvania General Assembly. 2025. "Senate Bill 505 An Act Amending Title 66 (Public Utilities) of the Pennsylvania Consolidated Statutes, in restructuring of electric utility industry, further providing for energy efficiency and conservation program." Available at: https://www.palegis.us/legislation/bills/2025/sb505.

future scenarios. The following sections provide an overview of these policy proposals as of August 2026. The remainder of the report describes the results of the analysis that the PUC commissioned through this solicitation.

1.1. Interconnection Queue Reform

PJM began reforming its interconnection queue process in 2022. It transitioned from a serial approach to a "first-ready, first-served" cluster approach. The application window of the first cycle of the new "first-ready, first served" cluster study approach closed in April 2026, with resource developers representing 220 GW requesting to interconnect. In August 2026 PJM announced that, of the projects that applied, 200 GW of generation from 715 different projects qualified for inclusion in the first cycle cluster study. Pennsylvania had the greatest amount of generation qualify, with close to 40 GW of generation moving forward in the cluster study.[8] Before 2023, the average interconnection queue processing time was roughly four years.[9] PJM now anticipates that its new process will allow for a one- to two-year timeline for processing interconnection requests and issuing Generation Interconnection Agreements (GIA).[10]

1.2. Reliability Resource Initiative

In addition to its cluster study and interconnection queue reform process, PJM implemented the Reliability Resource Initiative (RRI) as a one-time, accelerated interconnection process for shovel-ready projects that could contribute to reliability on an expedited timeline. In May 2025, PJM selected 51 projects (either new generation or uprates), 90 percent of which are expected to be online by 2030 and the remainder by 2031.[11] Of these 51 projects, 10 had been withdrawn by March 2026. Table 3 shows the capacity assumed to come online as a result of RRI (net of these withdrawals).

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[8] PJM. August 3, 2026. "Over 700 New Generation Projects Accepted Into First Cycle of Reformed Interconnection Process." Available at: https://insidelines.pjm.com/over-700-new-generation-projects-accepted-into-first-cycle-of-reformed-interconnection-process/. Note that this information became available after our analysis was completed and is not factored into any of the results discussed in this document.

[9] Rand, J., N. Manderlink, W. Gorman, R. Wiser, J. Seel, J. Mulvaney Kemp, S. Jeong, F. Kahrl. Lawrence Berkeley National Laboratory. April 2024. Queued Up: 2024 Edition, Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2023. Available at: https://eta-publications.lbl.gov/sites/default/files/queued_up_2024_edition_r2.pdf.

[10] Campbell, L., R. Gramlich, M. Hagerty, R. Peters, R. Seide, S. Kaplan. *Generator Interconnection Interim Progress Report.* Grid Strategies and The Brattle Group for Advanced Energy United. https://gridstrategiesllc.com/wp-content/uploads/GS_Generator-Interconnection-Interim-Progress-Report.pdf.

[11] PJM. May 2, 2025. "PJM Chooses 51 Generation Resource Projects to Address Near-Term Electricity Demand Growth." Available at: 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.

Table 3. Cumulative RRI capacity additions (GW)

	2025	2026	2027	2028	2029	2030	2031
Gas	0.1	0.1	0.3	0.3	0.4	3.4	4.9
Battery storage	-	-	-	-	1.6	1.6	1.6
Nuclear	-	0.1	0.5	0.5	0.6	0.6	0.6

Note: These values reflect the cumulative capacity of RRI projects with an in-service date on or before each given year. Source: Based on data downloaded from PJM's Cycle Service Request Status *webpage on March 5, 2026. Available at* https://www.pjm.com/planning/m/cycle-service-request-status.

1.3. Expedited Interconnection Track

FERC recently approved PJM's Expedited Interconnection Track (EIT), an accelerated pathway for projects with demonstrated financial commitments and state support for expedited permitting and siting. Eligible projects must be at least 250 MW and become operational within three years.[12] PJM will review no more than 10 complete and valid applications per calendar year. FERC made the program effective July 31, 2026, and PJM will end it after 2027.[13] Based on this timeline, selected projects are likely to come online in 2030 and 2031.

1.4. Reliability backstop procurement

The capacity auctions for both the 2027/2028 delivery year and the 2028/2029 delivery year fell short of PJM's reliability requirement, highlighting potential grid reliability risks. As a result, PJM is developing a reliability backstop procurement (RBP) which is currently intended to be a one-time initiative but could be triggered again if there is a reliability requirement shortfall for three auctions in a row. The goal of the RBP is to institute long-term commitments for firm capacity by attracting new generation supply. The proposal has been approved by PJM stakeholders and filed with FERC.[14]

In the first of two stages, PJM and Charles River Associates will match buyers (load) to sellers (new generation) to create bilateral contracts. A request for proposals for this initial stage was issued on June 9, 2026, and responses were due by July 21, 2026.[15] Initial matches are expected in August 2026.[16] The second stage will be a central procurement design with the procurement target based on the capacity shortfall in the 2028/2029 BRA. The duration of the contracts that clear through the second phase will

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[12] In UCAP or accredited capacity, rather than nameplate capacity.

[13] PJM. June 10, 2026 "FERC OKs Temporary Process to Fast-Track Large Capacity Projects." Available at: https://insidelines.pjm.com/ferc-oks-temporary-process-to-fast-track-large-capacity-projects/.

[14] Howland, Ethan. 2026. "PJM stakeholders advance data center backstop procurement plan." July 2. Available at: https://www.utilitydive.com/news/pjm-backstop-procurement-connect-manage-data-centers/824317/.

[15] PJM. June 30, 2026. "Critical Issue Fast Path – Reliability Backstop Procurement PJM Proposal." Available at: https://www.pjm.com/-/media/DotCom/committees-groups/cifp-rbp/2026/20260630/20260630-item-02a---pjm-reliability-backstop-procurement-proposal---paper.pdf.

[16] PJM. July 27, 2026. "PJM Board Directs Action on Resource Adequacy, Affordability and Large Loads." Available at: https://insidelines.pjm.com/pjm-board-directs-action-on-resource-adequacy-affordability-and-large-loads/.

be 15 years, which is the same as the contracts in the first phase. The second stage will begin in September 2026. Participating generation projects must be operational by June 1, 2032.[17]

1.5. Interim Resource Adequacy Service Proposal (IRAS)

PJM has also filed a proposal to establish a new Interim Resource Adequacy Service (IRAS) to govern the connection of new large loads with demands greater than 50 MW.[18] This proposal replaces PJM's previous "Connect and Manage" proposal. PJM's proposal includes the development of a public Large Load Registry to track the location, size, and whether large loads bring their own supply. Under IRAS, large loads that do not bring their own supply and do not acquire supply contracts through the RBP would be the first to be curtailed during electricity shortage events, prior to any other pre-emergency load management reductions.[19]

1.6. Capacity market price collar

The capacity market shortfalls described above are also leading to market cost impacts on ratepayers. To mitigate the short-term cost impacts on consumers, Governor Shapiro filed a complaint with FERC with specific proposals to fix PJM's capacity market immediately, before the next BRA that was to take place in July 2025. A settlement was reached in January 2025 with PJM agreeing to file tariff revisions with FERC to allow PJM to establish a price "collar" (minimum price and maximum price) for the BRAs for the 2026/2027 and 2027/2028 delivery years. Without this price collar, it is estimated that capacity market prices would have been $550 per MW-day.[20] On April 28, 2026, FERC approved PJM's proposal to extend the existing price collar on the capacity auction, maintaining the price cap of $325 per MW-day and the price floor of $175 per MW-day for the 2028/2029 and 2029/2030 delivery years.[21]

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[17] PJM. June 30, 2026. "Critical Issue Fast Path – Reliability Backstop Procurement PJM Proposal." Available at: https://www.pjm.com/-/media/DotCom/committees-groups/cifp-rbp/2026/20260630/20260630-item-02a---pjm-reliability-backstop-procurement-proposal---paper.pdf.

[18] PJM. August 13, 2026. "PJM Proposes Framework to Connect Data Centers Without Compromising Reliability, Affordability." Available at: https://insidelines.pjm.com/pjm-proposes-framework-to-connect-data-centers-without-compromising-reliability-affordability/.

[19] PJM. July 27, 2026. "CIFP Framework for Service During Periods of Insufficient Resource Adequacy – PJM Proposal." Available at: https://www.pjm.com/-/media/DotCom/about-pjm/who-we-are/public-disclosures/2026/20260727-cifp-framework-for-service-during-periods-of-insufficient-resource-adequacy-executive-summary.pdf.

[20] PJM. March 2, 2026. "PJM Files Price Collar, Expedited Interconnection as Part of Large Load Plant." Available at: https://insidelines.pjm.com/pjm-files-price-collar-expedited-interconnection-as-part-of-large-load-plan/.

[21] PJM. April 30, 2026. "FERC Approves Capacity Auction Price Collar to Next Two Capacity Auctions" Available at: https://insidelines.pjm.com/ferc-approves-capacity-auction-price-collar-to-next-two-capacity-auctions/.

1.7. DOE Section 202(c) orders

DOE has committed $525 million in funding to build, modernize, retrofit, recommission, and extend the life of coal-fired power plants. The agency selected a total of 10 projects to receive funding. Six of these projects are in PJM (West Virginia, Ohio, Maryland), while the remainder are in Kentucky, North Carolina, Alaska, and Puerto Rico.[22] This is in addition to the 202(c) orders issued by DOE to prevent the retirement of several fossil-fueled facilities across the country. Under the Federal Power Act section 202(c), the Secretary of Energy may issue orders temporarily requiring generation to be available to resolve emergencies due to a sudden increase in energy demand or a supply shortage. 202(c) orders expire after 90 days but may be renewed. Historically, 202(c) orders have been issued in response to industry or RTO requests in anticipation of short-term weather emergencies such as hurricanes and heat waves. Since 2025, DOE has issued 202(c) orders that have prevented the scheduled retirement of six fossil fuel plants.

The Eddystone plant in Pennsylvania is the only plant located in Pennsylvania included in this set of plants. The owner of the Eddystone plant, Constellation Energy, intended to retire the facility by May 31, 2025. However, Energy Secretary Wright issued a 202(c) order on May 30, 2025, to prevent its retirement. The order has been renewed every 90 days, requiring that Eddystone continue to be available for economic dispatch.[23]

1.8. Load forecast improvements

The rapid expansion of data centers has introduced a new source of uncertainty into PJM's load forecast. In 2025, PJM created the Load Adjustment Request Implementation to provide transparency in how PJM evaluates large-load adjustment requests from the electric distribution companies. Through this process, longer-term load additions were considered non-firm and derated. This resulted in a lower 2026 Long-Term Load Forecast, compared to the 2025 forecast.[24] It is expected that the large-load registry will also improve the accuracy and transparency of load forecasts. PJM is also pursuing other enhancements to its load forecast, starting with the 2027 Load Forecast. These changes include State review of large-load adjustments and identification of duplicate interconnection requests within or outside of the PJM region.[25]

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[22] U.S. Department of Energy. 2026. "Energy Department to Invest $350 Million to Build, Modernize, and Restart Coal Plants." Available at: https://www.energy.gov/articles/energy-department-invest-350-million-build-modernize-and-restart-coal-plants.

[23] State Power Project. 2026. "Challenges to DOE 202(c) Orders." Available at: https://statepowerproject.org/challenges-to-doe-202c-orders/#Eddystone.

[24] PJM Resource Adequacy Planning Department. January 14, 2026. "PJM Load Forecast Report." Available at: https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.

[25] PJM. November 11, 2025. "Executive Summary: PJM Large Load Additions CIFP Stage 4 Package. Available at: https://www.pjm.com/-/media/DotCom/committees-groups/committees/mc/2025/20251119/20251119-item-01a---pjm-lla-cifp-stage-4-package---executive-summary.pdf.

2. METHODOLOGY

To provide this independent assessment, the Synapse Team conducted detailed power sector analyses. To do so, we evaluated three scenarios using capacity expansion and resource adequacy analysis.

2.1. Modeled scenarios

The consulting team evaluated three different scenarios using the EnCompass capacity expansion model (see Table 4). Each of these scenarios is meant to provide a “bookend” to a set of assumptions. In other words, even though the assumptions built into the scenarios may be uncertain, the results of the scenarios, and the differences between them, provide insights into Pennsylvania’s future electricity system.

Table 4. List of modeled scenarios

Scenario Name	Load Assumptions	Supply Assumptions
Reference	PJM loads and peak demand in line with PJM’s 2026 load forecast	Moderate assumptions on resource availability; resource builds are constrained but gradually loosen through 2040
High Load and Low Supply	Data centers and electric vehicle deployment in line with higher trajectories; less demand response assumed.	New resource deployment tightly constrained through 2040
No New Data Centers	Same load assumptions as Reference, except all new load associated with data centers in 2027 and later years is removed	Same supply availability assumptions as Reference

The Reference scenario is meant to represent a “most likely” future. It uses the same load assumptions as PJM’s 2026 Load Forecast.[26] It assumes that through 2030, the initiatives described above supplement historical rates of resource additions. Post-2030, resource availability gradually improves through 2040 as the rate of maximum annual resource additions grows.

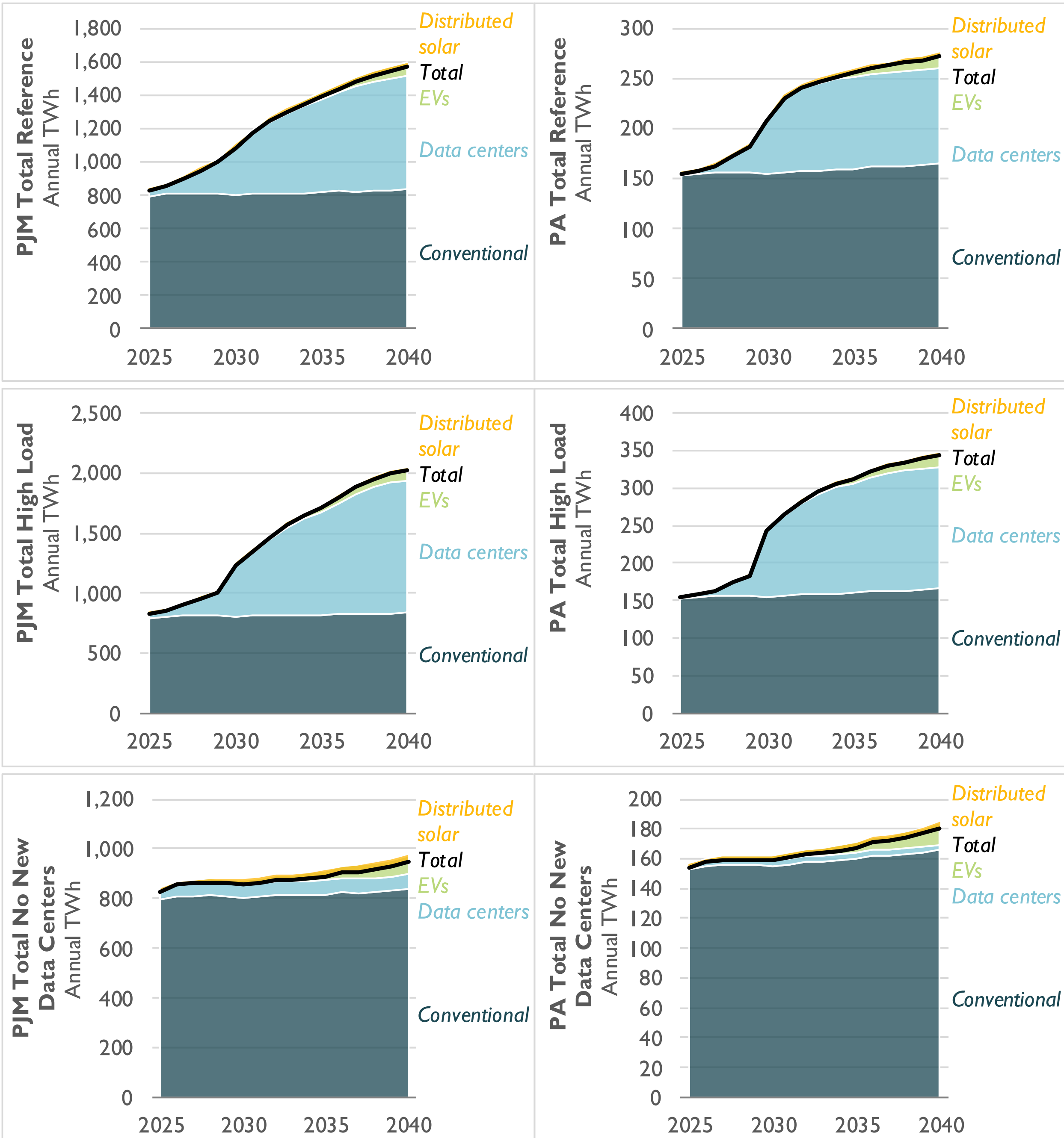
The High Load and Low Supply Scenario is meant to represent a “worst case” future. It assumes higher levels of load due to data centers and other components, and less load flexibility. While it makes the same supply assumptions as the Reference scenario through 2030, it assumes that resource availability remains tightly constrained through 2040 as cumulative build limits continue to increase linearly over time (maintaining the historical rate of maximum annual resource additions).

Finally, the No New Data Centers scenario modifies the Reference scenario by removing new data center load in 2027 and all later years. It otherwise has the same assumptions about load and resource availability, and it is meant to represent a future where data centers self-supply or do not materialize.

[26] 2026 Load Forecast and associated materials are available online at https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.

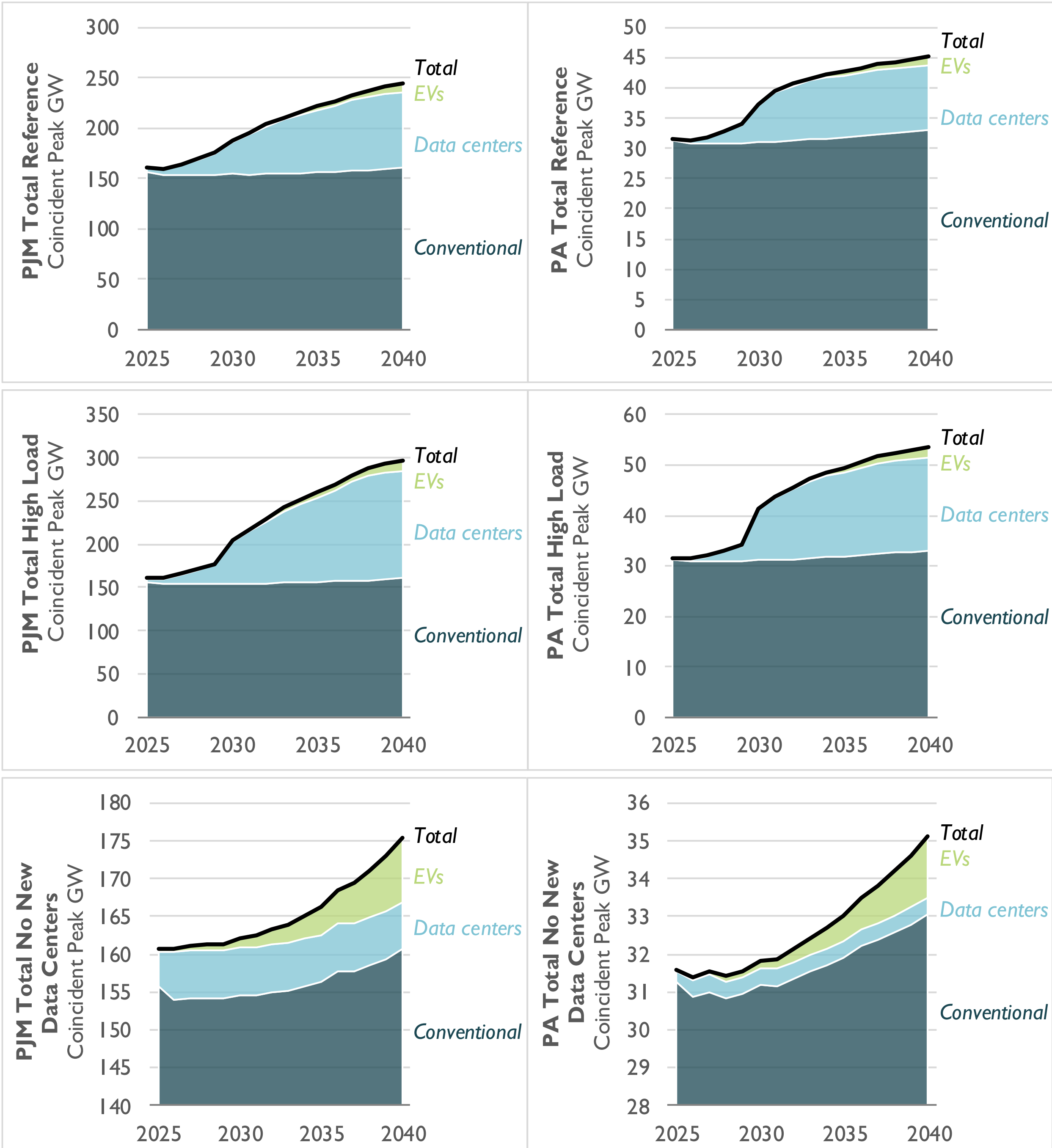
Figure 1 and Figure 2 show how all three scenarios compare in terms of annual load (in terawatt-hours, or TWh) and coincident peak demand (in gigawatts, or GW), for both Pennsylvania and PJM as a whole. The majority of load growth through 2040 in both Pennsylvania and PJM is attributable to data centers.

Figure 1. Assumed loads for PJM (left) and Pennsylvania (right)



Note: The "Total" load shown in this figure is net of the quantity met from distributed solar.

Figure 2. Assumed coincident peak demands for PJM (left) and Pennsylvania (right)



Note: This figure does not include coincident peak impacts from distributed solar as it is not possible to disaggregate this resource's contribution to peak demand reductions from other resources.

All modeled scenarios incorporate the supply-side impacts of known PJM and federal government initiatives. Specifically, we assume the following:

- **Reliability Resource Initiative:** RRI will be implemented prior to 2030. RRI consists of an accelerated interconnection process for shovel-ready projects that can contribute to reliability on an expedited timeline, including uprates and new generation. We model the specific known capacity additions that PJM approved under RRI explicitly, accounting for withdrawn projects.
- **Reliability Backstop Procurement:** Under the RBP, selected projects must be operational by 2031. This procurement consists of long-term commitments for firm capacity. PJM proposed a two-stage process (consisting of both bilateral contracts and a centralized auction), with a draft total procurement target of 14.9 GW. We represent these additions implicitly through increasing long-term build constraints.
- **Expedited Interconnection Track:** Based on the EIT timeline, selected projects are likely to begin coming online in 2030 and 2031. EIT is an accelerated interconnection pathway for projects with demonstrated financial commitments and state support for expedited permitting and siting. PJM will study no more than 10 completed and valid applications per calendar year (250 MW minimum per project). We represent these additions implicitly through increasing long-term build constraints.

Appendix A and Appendix B have additional detail on load and supply input assumptions.

2.2. Modeling methods

This analysis used two different modeling tools: capacity expansion and resource adequacy modeling (see Figure 3).

EnCompass, a capacity expansion model, allows users to develop a least-cost portfolio of resources to meet electricity supply for a typical weather year, subject to a set of constraints. Capacity expansion models simulate the production and consumption of electricity over time (in this case, for each year through 2040). These types of models rely on a single year of typical weather data. Key input assumptions include annual load forecasts, peak demand forecasts, resource costs (for new and existing generators), fuel costs, and the availability of new resources. Outputs include resource additions and retirements, resource dispatch, energy prices, capacity prices, and other metrics.

SERVM, a resource adequacy model, allows users to evaluate the reliability of a fixed resource portfolio across a wide range of weather conditions and resource performance permutations. These models involve analyzing a single year over hundreds or thousands of cases consisting of different weather, load, and forced generator outage conditions. Outputs include data on the frequency, duration, and magnitude of power outages for each modeled case. Results for each case can be combined to provide a probabilistic assessment of power outage risk.

Our EnCompass capacity expansion modeling topology consists of a zonal representation of PJM (see Figure 4). Within electric zones (shown in the white labels in the figure) the model can freely transfer electricity. Across zones, energy transfers are limited by transmission capacities. In the SERVM model, these areas are aggregated into three larger regions.

Figure 3. Diagram of interactions between capacity expansion and resource adequacy (reliability) models

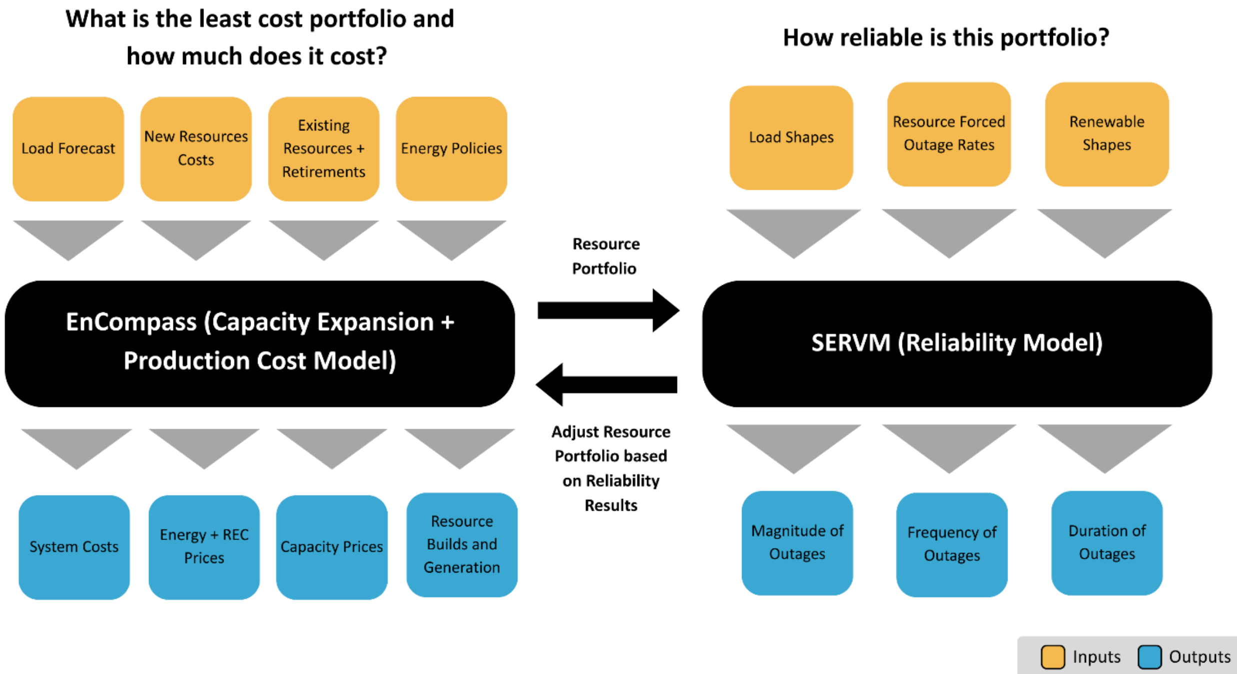
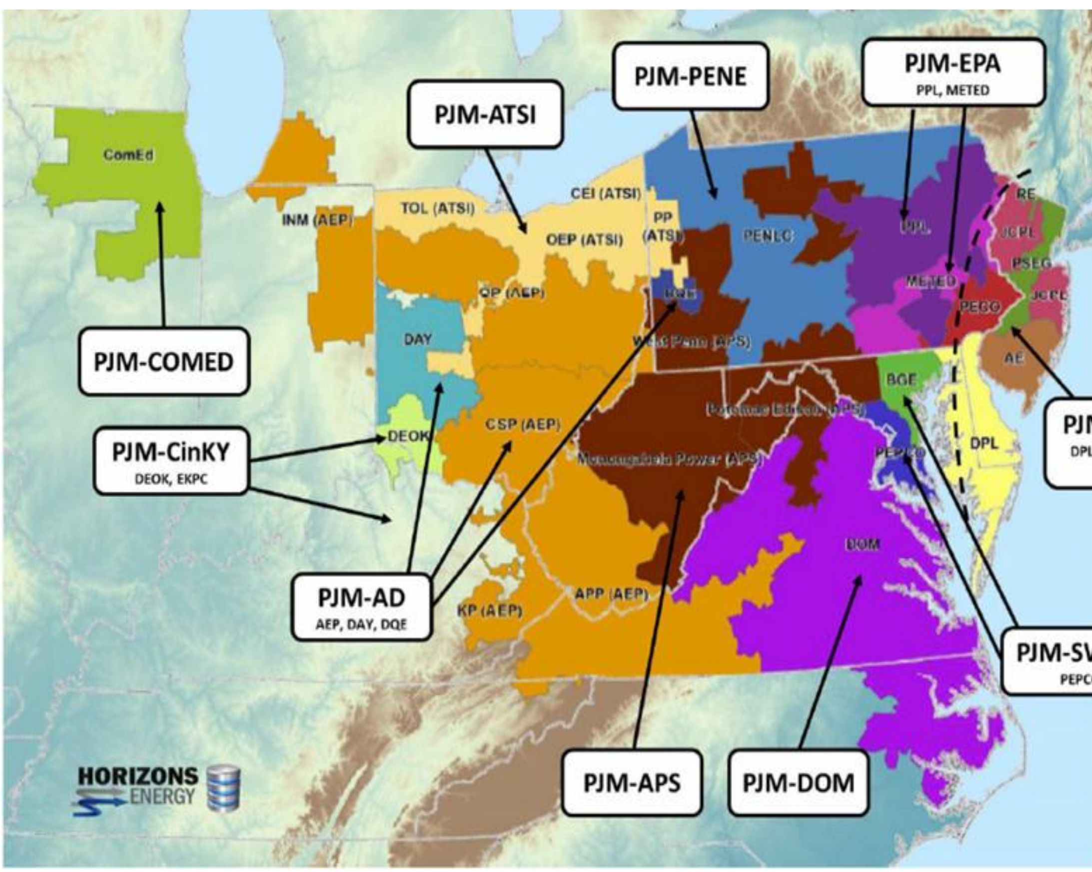


Figure 4. PJM modeling topology utilized in EnCompass capacity expansion modeling



Note: In SERVM, these zones are aggregated into three regions (PJM-Mid Atlantic, PJM-South and PJM-West).

3. RESULTS AND FINDINGS

Through the use of capacity expansion and resource adequacy analysis, we assessed the impacts of varying supply and demand parameters over both the short and long terms. This section provides results and discussions related to resource additions and retirements, dispatch, imports and exports, and system reliability.

3.1. Capacity expansion analysis

Capacity expansion analysis allows us to understand the resources that may be built over the long term given a set of constraints including electricity demand, resource availability, and resource costs. These parameters differ across scenarios, and change over time, impacting which resources are added or removed from the system. Resource quantities may change as a result of exogenous parameters (i.e., a deployment specified by the modeler), or endogenous parameters (i.e., the model building the least-cost resources in response to the set of specified parameters, including exogenous resource changes).

Table 5 provides information on modeled outputs for operational capacity (in GW) by resource for 2025 and 2030 under each of the three modeled scenarios. PJM-wide, we observe that the model chooses to primarily add new solar, gas combined-cycle units, battery storage and onshore wind. In both the Reference and the High Load and Low Supply Scenarios, the system is tightly constrained. The model selects to build most resources up to their respective build limits. The No New Data Centers scenario, which has minimal load growth, also has substantial capacity additions of solar, gas combined-cycle units, and onshore wind, but it has more endogenous retirements, with over 10 GW of gas steam and coal resources retired in response to low loads.

In Pennsylvania, solar and battery storage are the main resources added through 2030, beyond the exogenous resource additions specified for nuclear, distributed solar, distributed storage, and demand response. Solar and battery storage resource additions range between 3 and 7 GW, depending on the scenario. Solar and storage additions are lower in the No New Data Centers scenario (compared to other scenarios with greater load), with an increased level of endogenous gas steam retirements.

Table 6 provides analogous information for 2040. As with the 2030 results, PJM-wide, we observe large quantities of resource additions for solar, gas combined-cycle units, and wind, ranging from 11 to 85 GW of additions, depending on the resource and scenario. The No New Data Center scenario has the fewest additions (as a result of low loads), with the High Load and Low Supply scenario next (as a result of more constrained resource availabilities). In the Reference scenario, 6 GW of nuclear additions occur in 2040, the first year new nuclear resources are assumed to be endogenously available. All three scenarios see between 14 and 29 GW of coal retirements, due in part to many coal plants reaching the end of their useful life, as well as competition from more economic resources (even in scenarios with increasing load and resource availability constraints). Both the Reference and the No New Data Centers scenarios also see net retirements of gas steam and gas combustion turbines, for similar reasons.

In Pennsylvania, resource additions through 2040 are primarily limited to gas combined-cycle turbines (with 5 to 12 GW of additions, depending on the scenario) and solar (with 3 to 4 GW of additions, depending on the scenario). Pennsylvania sees 3 to 4 GW of coal retirements by 2040, in each scenario, largely a result of coal plants reaching the end of their useful lives. Pennsylvania also sees 2 to 8 GW of net retirements of gas steam and gas combustion turbines, as a result of resources reaching their announced retirement year, and more economic resources becoming available.

Table 5. Modeled capacity through 2030 (GW)

	Pennsylvania				**PJM**			
		2030				**2030**		
	2025	*Reference*	*High Load and Low Supply*	*No New Data Centers*	2025	*Reference*	*High Load and Low Supply*	*No New Data Centers*
Nuclear	9.8	10.6	10.6	10.6	34.6	35.8	35.8	35.8
Coal	4.6	4.6	4.6	4.4	35.7	26.0	26.1	20.2
Gas CC	20.0	20.0	20.0	20.0	61.4	71.8	69.9	71.6
Other Gas	8.7	8.6	6.9	6.4	42.1	43.9	43.9	38.4
Wind	1.6	1.9	1.9	1.9	11.0	21.0	20.1	18.2
Solar	0.7	5.5	4.3	3.4	14.7	56.1	51.9	52.1
Battery Storage	0.1	1.5	1.3	0.5	0.5	7.9	5.8	3.7
Distributed Storage	<0.1	<0.1	<0.1	<0.1	0.1	0.3	0.3	0.3
Distributed Solar	2.1	2.9	2.7	2.9	10.6	16.6	15.1	16.6
Demand Response*	1.5	2.3	1.8	0.9	8.0	11.9	12.5	8.5
Other**	2.9	3.1	1.4	1.4	5.1	4.8	4.8	4.8

** Includes load flexibility from data centers.*
*** Includes hydro, biomass, and other miscellaneous resources.*

Table 6. Modeled capacity through 2040 (GW)

	Pennsylvania				PJM			
		2040				2040		
	2025	*Reference*	*High Load and Low Supply*	*No New Data Centers*	2025	*Reference*	*High Load and Low Supply*	*No New Data Centers*
Nuclear	9.8	10.6	10.6	10.6	34.6	40.6	35.8	35.8
Coal	4.6	1.0	1.2	1.0	35.7	9.6	21.4	7.0
Gas CC	20.0	32.0	25.3	27.0	61.4	146.2	109.4	109.5
Other Gas	8.7	5.4	6.9	0.8	42.1	35.6	42.6	23.4
Wind	1.6	2.7	3.1	3.6	11.0	46.6	23.6	22.1
Solar	0.7	5.5	5.0	3.4	14.7	74.6	78.6	74.6
Battery Storage	0.1	1.9	2.9	0.5	0.5	19.5	43.2	3.9
Distributed Storage	<0.1	0.2	0.2	0.2	0.1	1.3	1.1	1.3
Distributed Solar	2.1	3.6	3.2	3.6	10.6	26.2	22.3	26.2
Demand Response*	1.5	2.9	3.4	0.9	8.0	18.0	20.5	8.8
Other**	2.9	2.0	<0.1	1.1	5.1	4.4	4.4	4.4

** Includes load flexibility from data centers.*
*** Includes hydro, biomass, and other miscellaneous resources.*

Today, Pennsylvania is home to about 23 percent of operational capacity in PJM and is the state with the largest amount of generating capacity in all of PJM (see Table 7). By 2030, this falls to 20 to 21 percent, depending on the scenario. By 2040, this falls to 14 to 17 percent, depending on the scenario. In most cases, other states with large projected increases in data center load or relatively less expensive resources (e.g., Viriginia, Ohio) see increases in shares of the region's generating capacity.

Table 7. Share of PJM generating capacity by state

	2025	2030			2040		
		Reference	*High Load and Low Supply*	*No New Data Centers*	*Reference*	*High Load and Low Supply*	*No New Data Centers*
PA	**23%**	**20%**	**21%**	**21%**	**16%**	**14%**	**17%**
Other states	**77%**	**80%**	**79%**	**79%**	**84%**	**86%**	**83%**
DC	*0%*	*0%*	*0%*	*0%*	*2%*	*2%*	*2%*
DE	*2%*	*1%*	*1%*	*1%*	*2%*	*2%*	*1%*
IL	*16%*	*15%*	*15%*	*12%*	*11%*	*11%*	*10%*
IN	*5%*	*6%*	*5%*	*6%*	*4%*	*4%*	*5%*
KY	*3%*	*3%*	*3%*	*4%*	*2%*	*2%*	*3%*
MD	*6%*	*4%*	*4%*	*5%*	*4%*	*7%*	*6%*
MI	*2%*	*2%*	*2%*	*2%*	*1%*	*1%*	*2%*
NC	*1%*	*2%*	*2%*	*2%*	*9%*	*7%*	*6%*
NJ	*8%*	*7%*	*8%*	*8%*	*7%*	*6%*	*7%*
OH	*15%*	*16%*	*16%*	*16%*	*20%*	*12%*	*19%*
TN	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
VA	*14%*	*17%*	*16%*	*18%*	*18%*	*18%*	*18%*
WV	*6%*	*6%*	*6%*	*6%*	*3%*	*6%*	*3%*
Imports	*0%*	*0%*	*0%*	*0%*	*0%*	*11%*	*0%*

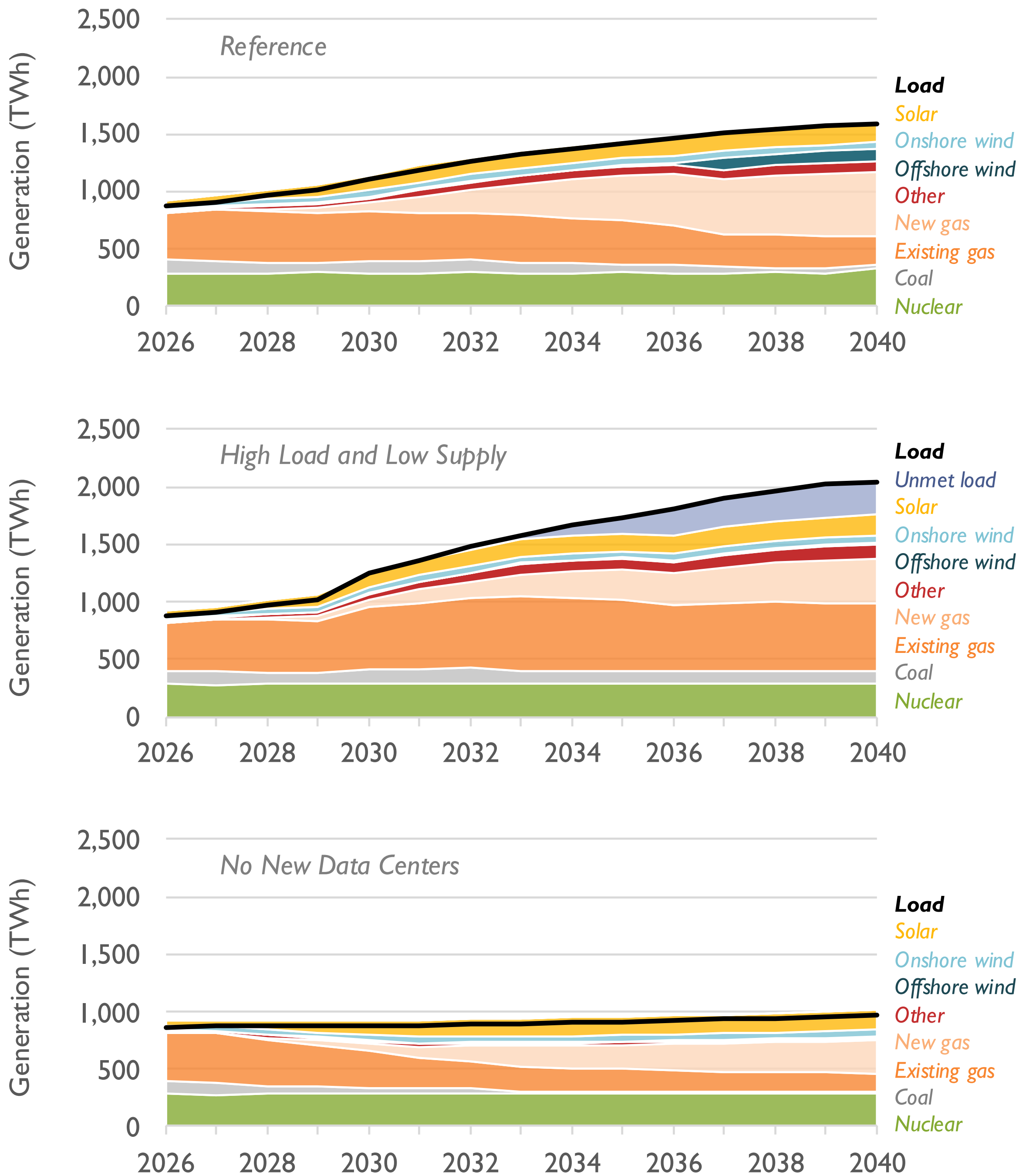
Notes: Percentage shares are based on generating capacity MW and have not been adjusted for firm or peak availability. Capacity shares are inclusive of demand-side measures, including demand response, distributed solar, and distributed storage. "Imports" are calculated by summing the total of any net imports and unserved energy (in TWh) and converting this quantity to MW using the average modeled capacity factor observed for gas combined-cycle units in PJM in 2025 (67 percent).

Figure 5 illustrates changing loads and generation by resource, PJM-wide, for each scenario. By 2040, the High Load and Low Supply scenario has 453 more TWh than the Reference scenario. The PJM peak load is 54 GW (22 percent) greater. In contrast, by 2040, the No New Data Centers scenario has 620 fewer TWh than the Reference scenario, with a PJM-wide peak load that is 68 GW (28 percent) lower.

Most of the incremental generation in the High Load and Low Supply scenario comes from existing gas. In 2040, there is 345 TWh of additional generation from existing gas, relative to the Reference scenario. Meanwhile, in both the Reference and No New Data Centers scenarios, a greater share of the load growth is met by generation from new gas, and in the case of the Reference scenario, offshore wind.

Importantly, the High Load and Low Supply scenario shows a large quantity of unmet load starting in 2031. Depending on the year, between 2 and 19 percent of electricity load is unmet between 2031 and 2040. This unmet load stems from the limited ability of in-region resources to serve the large quantities of modeled load additions, even with in-region resources dispatching near their maximum capacity factors. Although it is possible PJM could rely on neighboring regions to meet a small part of this unmet load, this ability may be limited: in a future where PJM is experiencing high load and low supply, neighboring electric regions are likely facing the same pressures.

Figure 5. Modeled annual generation and loads, PJM-wide



Historically, Pennsylvania has been a net exporter of electricity, with one-quarter to one-third of all electricity produced in the state (or about 55 to 85 TWh) exported to neighboring states.[27] Figure 6

[27] *Pennsylvania Electricity Profile 2024*. U.S. Energy Information Administration. Accessed July 2026. Available at https://www.eia.gov/electricity/state/pennsylvania/.

illustrates the net exports in Pennsylvania for all three scenarios. In the Reference scenario, Pennsylvania remains a net energy exporter, but exports decrease from about 91 TWh in 2025 to about 69 TWh by 2035 and 38 TWh by 2040. The No New Data Centers scenario has a similar result: Pennsylvania remains a net energy exporter, but exports decrease from about 91 TWh in 2025 to about 61 TWh by 2035 and 51 TWh by 2040.

In the High Load and Low Supply scenario, Pennsylvania exports decrease to 26 TWh in 2035, while Pennsylvania becomes a net importer of 5 TWh by 2040 as in-state load exceeds in-state generation. Because this scenario has a large amount of unmet load in 2031 and later years, it is likely that some amount of this 2035 and 2040 load will be unmet, as there will not be enough regional generation to meet PJM-wide load requirements.

In general, across all scenarios, new in-state generation additions do not keep pace with the growth of in-state load. This limits the ability for the state to continue exporting electricity at historical levels.

Figure 7 illustrates capacity and energy prices for PJM, for each scenario. As described above, we assume the PJM capacity market price cap remains in place through the 2029/2030 delivery year and is replaced by a maximum price of gross cost of new entry (CONE) in years after that. In the High Load and Low Supply scenario, capacity prices remain at or near the cap in every year. In the Reference scenario, capacity prices are at or near the cap through 2030. Prices remain very high, falling in real-dollar terms as load increases and resources are slowly added. Finally, in the No New Data Centers scenario, capacity prices are slightly below the cap through 2029. Prices are volatile throughout the remainder of the study period, as resource additions sometimes lead or lag increases in peak demand.

In terms of energy prices, we first note that Figure 7 uses $300 per MWh as an indicative energy price for years where we observe large quantities of unserved energy (which results in extremely high energy prices). In the years when these prices occur, the PJM system is experiencing unserved energy, which produces large penalty prices within the model (modeled at $10,000 per MWh). As a result, annual reported locational marginal prices are distorted for these years. In the High Load and Low Supply scenario, we observe average annual energy prices to be very high, in the range of $100–225/MWh. In the Reference scenario, energy prices gradually increase over time as gas prices increase and resource additions remain constrained, which forces the model to rely on less efficient (and more expensive) power generating units. In the No New Data Centers scenario, load increases more slowly, keeping energy prices low. Energy prices do rise gradually in response to increasing gas prices.

In general, the near-term differences in capacity prices are similar in percentage terms to energy prices. For example, in 2029, capacity prices in the Reference and High Load and Low Supply scenarios are 20 percent higher than capacity prices in the No New Data Centers scenario, while energy prices are 18 percent higher. Because energy prices make up a larger portion of system costs, differences in energy prices tend to have a larger impact on system costs (and therefore customer costs) than capacity price changes.

Figure 6. Modeled net exports, Pennsylvania

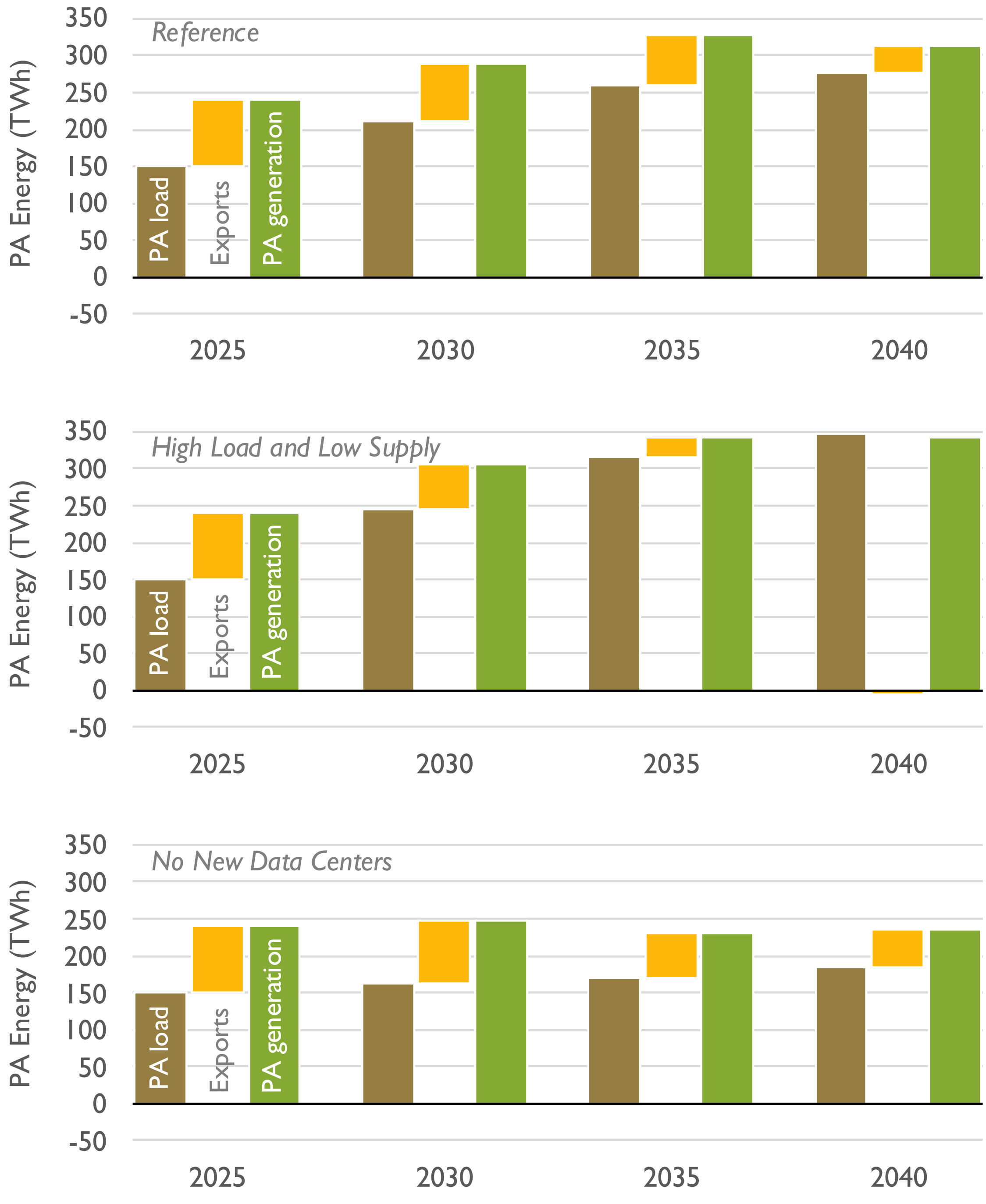
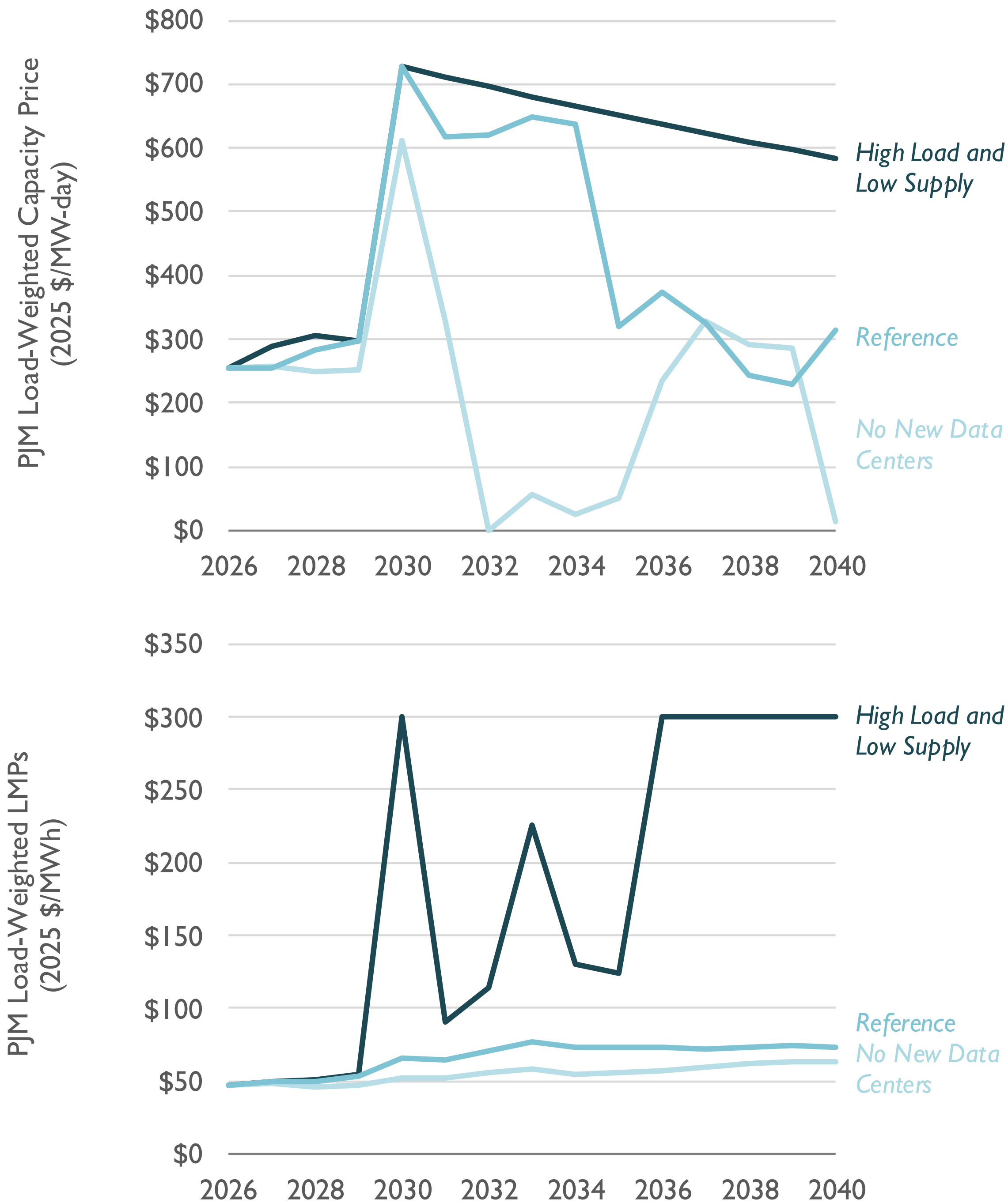


Figure 7. Modeled energy and capacity prices, PJM-wide



Note: Energy prices of $300 per MWh that appear in the High Load and Low Supply scenario are indicative prices. In the years when these prices occur (2030, 2036-2040), the PJM system is experiencing unserved energy, which produces very large penalty prices within the model (i.e., $10,000 per MWh). As a result, annual reported locational marginal prices are distorted for these years.

3.2. Resource adequacy analysis

Resource adequacy analysis allows us to zoom into a particular set of years and examine different metrics related to grid reliability, across a wide range of load, outage, and weather conditions. We populate SERVM, a resource adequacy model, with load and resource information derived from our capacity expansion analysis for years 2027 through 2030. Then, for each of those years, we perform hundreds of runs assessing how the modeled PJM resources respond to changing load, weather, and forced generator outage conditions. Each of these runs is assigned a probability (e.g., likelihood of occurring). Synapse then combines the results of these runs to produce probability-weighted expected resource adequacy metrics. In this analysis, resource adequacy refers to outages at the bulk power system level due to insufficient generation availability, as opposed to outages on the transmission or distribution infrastructure.

In PJM, the primary metric for assessing resource adequacy is loss-of-load expectation, or LOLE. This metric describes the probabilistic expectation of experiencing a bulk power outage over a period of time. In PJM, the planning criterion is a 0.1 LOLE.[28] This planning criterion corresponds to a system having an expected value of one day of lost load in 10 years and is a common standard or target for the electricity industry across North America.

Table 8 describes the modeled LOLE values for each of the modeled scenarios, for 2030. It provides a summary of the resource adequacy challenges faced by PJM over the short term. In the Reference scenario, the observed 2030 LOLE for PJM as a whole is 0.59, or nearly six times worse than the PJM planning criterion. It effectively implies a daily outage could statistically occur in six out of ten years. In the High Load and Low Supply scenario, system reliability is—as expected—even worse, with a 2030 LOLE of 13.20, or more than 132 times worse than the PJM planning criterion. This implies a statistical expected value of 13.2 days of system outages somewhere in the PJM footprint in the year 2030. The No New Data Centers scenario fares better than the other two scenarios, with a 2030 LOLE of 0.05. This is two times better than the PJM planning criterion, indicating that in a future with no new data centers, system reliability is better than the planning threshold.

[28] *PJM Manual 20A: PJM Resource Adequacy Analysis, Revision: 3*. PJM, prepared by Resource Adequacy Planning. 2026. Available at: https://www.pjm.com/-/media/DotCom/documents/manuals/m20a.pdf.

Table 8. Modeled PJM-wide resource adequacy for 2030

Scenario Name	Modeled 2030 LOLE
Reference	0.59 *expected value of 5.9 events every ten years, 6X worse than PJM planning criterion*
High Load and Low Supply	13.20 *expected value of 13.20 events every year, 132X worse than PJM planning criterion*
No New Data Centers	0.05 *expected value of 1 event every 20 years, 2X better than PJM planning criterion*
PJM planning criterion	**0.1**

LOLE is only one way to measure resource adequacy and mainly focuses on the frequency of expected outages. Other metrics can aid understanding of outage duration and outage depth, as well as other dimensions of frequency. Table 9 describes seven other metrics, in addition to LOLE, and how the Reference scenario performs for each one in 2030. We find that the 0.59 LOLE observed in 2030 in the Reference scenario corresponds to 11.1 GWh of unserved energy experiencing a power outage, equivalent to 0.14 percent of the PJM system. The average power outage lasts for just over 47 minutes. We also identify that in the worst-case situation, an outage of 5.2 GW is possible, corresponding to 4.2 million households being without power for 1 hour.

Table 10 compares these same metrics across scenarios and years. We observe that in every year modeled in the Reference scenario and the High Load and Low Supply scenario, modeled LOLEs are equal to or greater than the PJM planning criterion of 0.1. In general, LOLEs and other reliability metrics tend to worsen over time from 2027 to 2030, as loads increase without corresponding increases in resource supply. Compared to the Reference scenario, LOLEs and other reliability metrics tend to be slightly worse in the High Load and Low Supply scenario in 2027 through 2029, given the existence of slightly higher loads and similar resource constraints. 2030 marks the first year where the two scenarios substantially diverge in resource adequacy, with the High Load and Low Supply scenario having markedly worse reliability metrics. This is driven by a sharp increase in load and peak demand requirements in this year as a result of data center loads (see Appendix A for more).

Meanwhile, in every year modeled for the No New Data Centers scenario, the observed LOLE is 0.05, or two times better than the PJM planning criterion. This implies that in a hypothetical future with no new data center load, there is a high expectation of a reliable system through 2030.

In particular, we observe that LOLEs in the Reference scenario and the High Load and Low Supply scenario change most sharply between 2029 and 2030, with LOLEs increasing by 3 times in the Reference scenario and 48 times in the High Load and Low Supply scenario. From 2029 to 2030, PJM-wide loads in the Reference scenario increase by a net 86 TWh, with this change almost entirely driven by load additions from new data centers. New data center load additions in Pennsylvania are associated with 29 percent of this data center load increase. In the High Load and Low Supply scenario, the year-to-year change is even more stark: PJM-wide loads increase by a net 229 TWh, again almost entirely driven by new data center load, and with 26 percent of the data center increase from new data center loads in Pennsylvania. This changing LOLE means that in the High Load and Low Supply scenario, PJM customers could expect to experience less than one day with an outage in 2029, increasing to over 13 days with outage events in 2030.

Table 9. Modeled resource adequacy metrics, focused on Reference scenario 2030

Metric	Units	Reference *2030*	Description
Loss of load expectation (LOLE)	*days per year*	0.59	LOLE describes the expected number of days per year with firm load shed. This metric does not indicate the magnitude, duration, or number of events. **The PJM planning criterion is 1 day in 10 years or 0.1 days per year.**
Loss of load hours (LOLH)	*hours per year*	1.2	LOLH describes the expected number of hours per year with firm load shed. This is a measure of the duration and total number of loss-of-load events. There is no defined standard in PJM, but ERCOT uses a standard of 12 hours (allowed to exceed once every 100 years) and SPP uses a standard of 2.4 hours per year.
Expected unserved energy (EUE)	*GWh*	11.1	EUE describes the expected total quantity of unserved energy per year. There is no defined standard in PJM. Alberta, Canada, for example, uses a standard of 0.8 GWh per year.
Normalized EUE (nEUE)	*% of energy load*	0.14%	nEUE represents a normalized version of EUE, as a proportion of total load. This allows for comparison of EUE between systems with differing loads. There is no defined standard in North America, but Australian states use 0.002%.
Expected duration per outage	*minutes*	47.3	The expected outage duration describes the average number of minutes per loss-of-load event. There is no defined standard for this metric in PJM.
Outage maximum magnitude	*GW*	5.2	The maximum outage magnitude describes the expected highest amount of unserved load per year. There is no defined standard in PJM. ERCOT, for example, uses a standard of 19 GW once per 100 years or 0.19 GW per year.
Outage maximum magnitude	*% of PJM peak load*	2.8%	The maximum outage magnitude can be normalized and expressed as a percentage of peak load in PJM.
Outage maximum magnitude	*million households with outage for 1 hour*	4.2	To get a sense of the scale of the maximum outage magnitude, events can be expressed in terms of the number of households in PJM who would lose power for one hour if an event of this magnitude exclusively affected residential customers.

Table 10. Modeled resource adequacy metrics, focused on Reference scenario 2030

Metric	Units	Reference				High Load and Low Supply				No New Data Centers			
		2027	*2028*	*2029*	*2030*	*2027*	*2028*	*2029*	*2030*	*2027*	*2028*	*2029*	*2030*
Loss of load expectation (LOLE)	*days per year*	0.11	0.13	0.21	0.59	0.12	0.11	0.28	13.20	0.05	0.05	0.05	0.05
Loss of load hours (LOLH)	*hours per year*	0.4	0.4	0.5	1.2	0.5	0.4	0.7	34.0	0.2	0.2	0.2	0.2
Expected unserved energy (EUE)	*GWh*	4.1	4.2	5.6	11.1	4.5	3.7	6.9	264.4	2.4	2.6	2.3	2.2
Normalized EUE (nEUE)	*% of energy load*	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	3.2%	0.03%	0.03%	0.03%	0.03%
Expected duration per outage	*minutes*	29.7	26.6	30.2	47.3	29.5	25.0	39.9	141.4	16.7	13.4	12.5	10.1
Outage maximum magnitude	*GW*	1.6	1.9	2.6	5.2	1.7	1.7	3.1	22.3	1.0	1.1	1.1	1.0
Outage maximum magnitude	*% of PJM peak load*	1.0%	1.1%	1.5%	2.8%	1.0%	1.0%	1.7%	10.9%	0.7%	0.7%	0.7%	0.6%
Outage maximum magnitude	*million households with outage for 1 hour*	1.3	1.6	2.1	4.2	1.3	1.4	2.5	18.1	0.9	0.9	0.9	0.8

Figure 8 and Figure 9 present heat maps that illustrate when estimated unserved energy (EUE) is occurring for 2027 and 2030, respectively. In 2027, we observe that in all three scenarios, EUE is concentrated in winter mornings, with the peak risk hour being January at 8 a.m. In 2027, these scenarios have relatively few differences in terms of load and available resources. These trends continue through 2028 and 2029 for all three scenarios (heat maps not shown).

Meanwhile, in 2030, the scenarios diverge. First, we note that in the No New Data Centers scenario, as load and resources change only incrementally relative to 2027, there are relatively few observed differences in the observed risk profile. Second, in the Reference scenario, we observe an overall similar distribution in EUE as in 2027, with January at 8 a.m. identified as the peak risk hour, just as in 2027. We also observe a greater share of EUE occurring in summer evening and winter evening hours. Third, in the High Load and Low Supply scenario, winter mornings continue to feature large amounts of EUE, but summer evenings emerge as the most problematic hours, with almost 15 percent of EUE being observed in July evenings at 8 p.m. Overall, a much larger share of 2030 hours feature at least some amount of EUE. This is largely due to the large increase in data center load, which is assumed to have a flat load shape, which in turn increases resource adequacy challenges throughout the year.

Figure 8. Distribution of estimated unserved energy (EUE) by month and hour, PJM-wide in 2027

Reference

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3	0.5%											
4	2.4%											
5	7.1%	0.2%										
6	13.2%	1.2%										
7	18.7%	4.2%										
8	21.7%	3.9%										
9	10.2%	0.2%										
10	3.5%											
11	1.4%											
12	1.1%											
13	0.1%											
14	0.0%											
15												
16	0.3%						0.0%					
17	0.3%						0.0%					
18	3.1%						0.2%	0.1%				
19	2.1%						1.9%	0.2%				
20	1.0%						0.9%	0.2%				
21	0.0%						0.0%					
22												
23												
24												

High Load and Low Supply

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0%											
2	0.2%											
3	1.1%											
4	3.1%											
5	8.0%											
6	13.8%	0.5%										
7	19.2%	3.0%										
8	20.9%	2.6%										
9	10.7%	0.1%										
10	3.8%											
11	2.0%											
12	1.2%											
13	0.1%											
14	0.1%											
15												
16	0.2%						0.0%					
17	0.2%						0.1%					
18	2.7%						0.5%	0.0%				
19	1.5%						1.9%	0.3%				
20	0.6%						1.3%	0.1%				
21	0.0%						0.1%					
22												
23												
24												

No New Data Centers

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	0.0%											
3	0.3%											
4	2.4%											
5	7.5%											
6	17.4%	0.0%										
7	26.2%	1.7%										
8	29.1%	1.5%										
9	10.0%											
10	1.9%											
11	0.5%											
12	0.4%											
13	0.0%											
14												
15												
16												
17												
18	0.5%											
19	0.2%						0.4%					
20	0.0%						0.1%					
21												
22												
23												
24												

Figure 9. Distribution of estimated unserved energy (EUE) by month and hour, PJM-wide in 2030

Reference

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1	0.6%											
2	1.3%											
3	2.2%	0.0%										
4	4.8%	0.1%										
5	7.1%	0.9%										
6	11.6%	3.0%										0.0%
7	16.2%	6.4%										0.0%
8	20.8%	3.7%										0.0%
9	3.8%											
10												
11												
12												
13												
14												
15												
16												
17								0.0%				
18	1.8%							0.1%				0.1%
19	1.3%	0.0%					0.5%	0.4%				0.1%
20	0.8%	0.0%				0.0%	7.5%	3.3%				0.1%
21	0.7%						0.7%	0.0%				
22	0.0%						0.1%					0.0%
23	0.1%											
24	0.0%											

High Load and Low Supply

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1	0.8%	0.1%					0.0%					0.2%
2	0.8%	0.1%										0.2%
3	1.1%	0.2%										0.2%
4	1.3%	0.4%										0.2%
5	1.9%	0.7%										0.2%
6	2.5%	1.1%										0.2%
7	3.9%	1.9%	0.0%								0.0%	0.3%
8	4.7%	1.8%										0.3%
9	1.3%	0.2%										0.0%
10	0.3%	0.0%										
11	0.1%											0.0%
12	0.1%											
13	0.0%						0.0%					
14	0.0%							0.0%				
15	0.0%						0.0%	0.0%				
16	0.1%	0.0%					0.2%	0.1%	0.0%			0.0%
17	0.1%	0.0%				0.0%	0.5%	0.6%	0.0%	0.0%		0.1%
18	0.9%	0.2%			0.0%	0.1%	1.0%	1.3%	0.5%	0.1%		0.2%
19	1.5%	0.8%	0.0%	0.0%	0.0%	1.0%	9.4%	7.0%	2.3%	0.2%		0.3%
20	1.2%	0.6%	0.0%	0.0%	0.2%	2.3%	15.5%	8.4%	0.9%	0.0%		0.3%
21	1.2%	0.5%	0.0%		0.0%	0.4%	5.6%	2.3%	0.1%			0.2%
22	0.8%	0.2%	0.0%			0.0%	1.2%	0.4%	0.0%			0.2%
23	0.7%	0.2%	0.0%				0.2%	0.1%				0.2%
24	0.4%	0.1%					0.0%	0.0%				0.1%

No New Data Centers

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3	0.0%											
4	0.6%											
5	7.9%	0.0%										
6	20.6%	0.3%										
7	31.4%	2.5%										
8	35.6%	0.5%										
9	0.5%											
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												

Note: In both figures, percentages are estimated based on the total weighted average PJM-wide EUE modeled in each scenario.

4. CONCLUSIONS

The Synapse team modeled three scenarios: (i) a Reference scenario developed using PJM's 2026 load forecast to represent a future where no additional policy actions are taken and resource supply gradually improves through 2040; (ii) a High Load and Low Supply scenario to represent a "worst-case" future, with even higher levels of data center load and constrained supply through 2040; and (iii) a No New Data Centers scenario to represent a future in which no new data center load is built anywhere in PJM in 2027 or any later year, but which otherwise utilizes the Reference-scenario assumptions regarding resource supply.

In the Reference scenario, which relies on PJM's 2026 Load Forecast, modeled 2030 LOLE is 0.59 or nearly six times worse than the PJM planning criterion. This result is mainly due to large-load additions stemming from data center additions, which are projected to surge in 2030. In 2030, the High Load and Low Supply scenario, a worst-case future of higher-than-expected load additions and constrained resource deployment, has an LOLE of 13.20. This LOLE value is over 100 times worse than PJM's planning criterion and indicates an expectation of more than 13 days with loss of load events per year. As in the Reference scenario, these reliability issues are largely due to surging data center additions. In the High Load forecast, data centers are projected to contribute over 200 TWh of additional new load between 2029 and 2030. (For reference, the entire state of Pennsylvania's 2025 electricity demand was about 150 TWh). In this High Load and Low Supply scenario, in-state generators are unable to meet between 2 and 19 percent of PJM-wide electricity between 2031 and 2040.

Appendix A. Load Assumptions

This appendix contains additional detail on the modeling inputs and assumptions used in our analysis, relevant to load.

The consulting team evaluated three different scenarios. The Reference scenario is meant to represent a "most likely" future, adopting the load assumptions from PJM's 2026 Load Forecast.[29] The High Load and Low Supply scenario is meant to represent a "worst case" future, assuming higher levels of load due to data centers and electric vehicles and lower levels of load-reducing resources such as distributed solar and storage. The No New Data Centers scenario uses the same load assumptions as the Reference scenario, except all new load associated with data centers in 2027 and later years is removed. We developed the load forecast for each scenario by component. Our load forecast covers the following components for the study period through 2040:

- Conventional load: This is a projection of electric load from traditional electric end uses such as lighting, HVAC, mechanicals, and refrigeration. Because we aligned conventional load to PJM's 2026 Load Forecast, which does not disaggregate energy efficiency or building electrification measures from conventional load, we assume both historical and future impacts from these measures are included in conventional load. This component does not include any future impacts from data centers, transportation electrification, distributed solar, or other distributed energy resources.

- Data centers: This is a projection of load growth from data centers and other large-load end-users.

- Electric vehicles: This is a projection of the annual charging load from the adoption of electric light-, medium-, and heavy-duty vehicles.

- Distributed solar: This is a projection of the load decreases due to distributed solar capacity additions.

- Distributed storage: This is a projection of the changes to electric load due to distributed energy storage.

- Demand response and data center load flexibility: This is a projection of the electric load impacts due to "load shifting" resources—resources capable of workload shifting, power modulation, or geographic shifting.

[29] 2026 Load Forecast and associated materials are available online at https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.

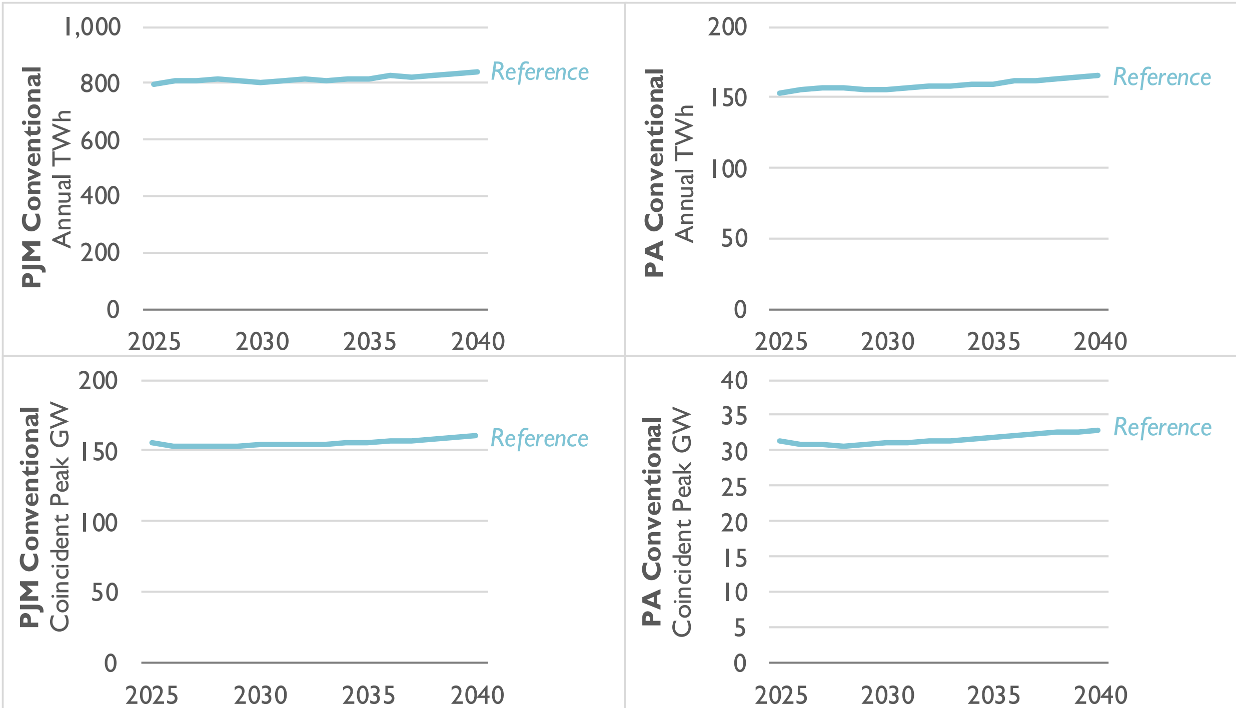
- Other load: This is a projection of the load impacts of additional components, including energy efficiency, combined heat and power (CHP), and building electrification.

Conventional load

The conventional load forecast includes impacts from "traditional" electric end uses (e.g., lighting, refrigeration, HVAC, industrial uses), and excludes future load impacts from data centers, transportation electrification, distributed solar, and other distributed energy resources. For the Reference scenario, we relied on PJM's 2026 Load Forecast, which includes component-level load forecasts for each zone in PJM. PJM's forecast was created based on historical regressions of energy use to population and GDP, and then forecasted into the future based on energy use and population forecasts. Rather than reporting a conventional load component, PJM reports a final net load forecast, inclusive of conventional load, data centers, electric vehicles, and other end uses. We disaggregated the conventional load forecast using PJM's other component-specific load forecasts. Based on this forecast, we expect annual conventional load in PJM to grow modestly, from 794 TWh in 2025 to 841 TWh in 2040. We expect conventional load in Pennsylvania to grow at a similar rate, from 153 TWh in 2025 to 166 TWh in 2040 (see Figure 10).

Because conventional load has historically grown at a low and predictable rate, we applied the Reference conventional load forecast to all three scenarios in the study. To model the load shape for this component in our capacity expansion modeling, we relied on data from Horizon's National Database, which uses a single weather year for load shapes. For the resource adequacy modeling stage, we applied 30 years of weather-specific load shape data, aligning with PJM's stakeholder-vetted input assumptions for its effective load-carrying capability (ELCC) modeling.

Figure 10. Conventional load and coincident peak demand forecasts for PJM (left) and Pennsylvania (right)



Data centers

Data centers have quickly become one of the fastest growing drivers of electric load growth. To help understand the potential impacts of data centers in PJM, we modeled three data center load growth scenarios: High Load, Reference, and No New Data Centers.

We based the Reference scenario on PJM's 2026 large-load adjustments forecast.[30] Rather than an annual energy load forecast, for this component PJM only provides an annual peak demand forecast. To convert this into annual energy load, we assumed a flat load shape, consistent with typical data center operations.[31] In addition to data center load, PJM includes other types of large-load adjustments in its forecast, including port electrification, peak shaving, and voltage optimization adjustments. Where possible to disaggregate, we removed these adjustments from our data center forecast.[32]

[30] 2026 Load Forecast and associated materials are available online at https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.

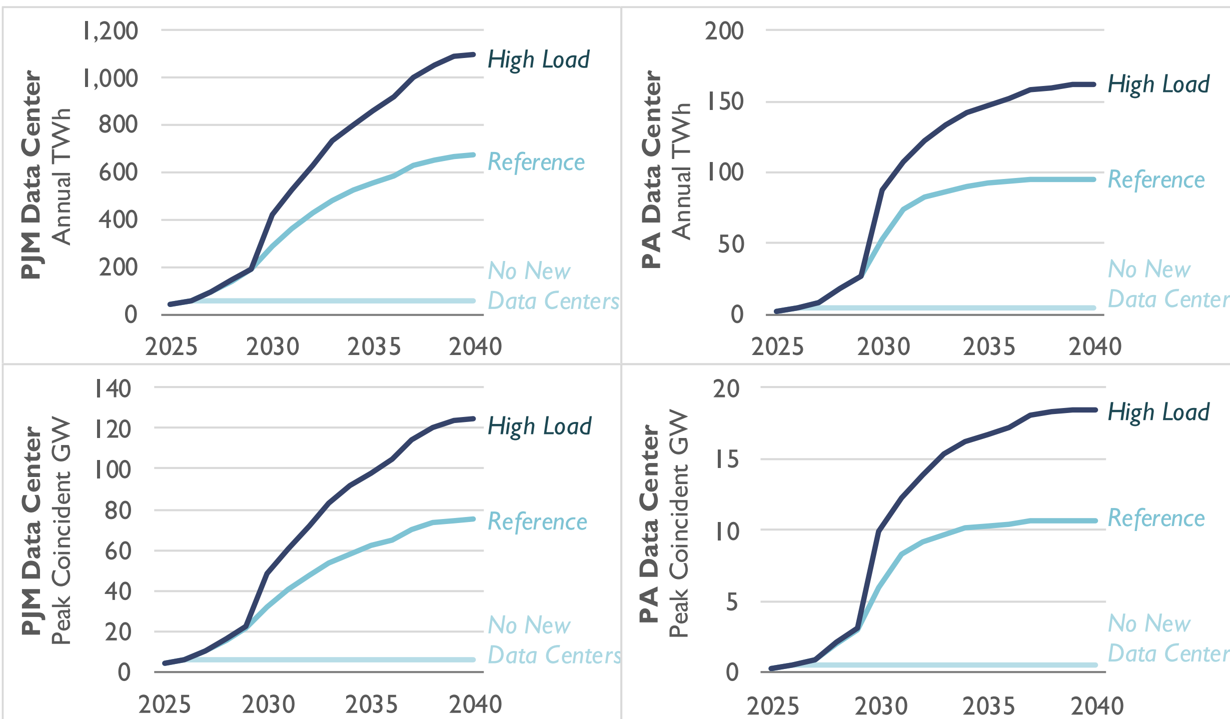
[31] See, for example, assumptions used by U.S. Energy Information Administration in its Annual Energy Outlook: "Data center servers are assumed to have an end-use load shape that is essentially flat, meaning, in effect, that demand for electricity to power servers is consistent across all hours in a day." *Data center server energy use grows across the commercial building stock*. U.S. Energy Information Administration. May 19, 2026. Available at: https://www.eia.gov/todayinenergy/detail.php?id=67704.

[32] PJM specifies the zones in which each type of large load is expected to occur. The "DOM" (Dominion) zone includes large-load adjustments from both data centers and voltage optimization. In this zone, we were unable to disaggregate the two and

To develop the High Load forecast, we adopted all utility large-load forecasts at 50 percent of face value.[33] We reduced these forecasts to account for potential overlapping assumptions where data center additions may occur (i.e., multiple utilities including the same potential data center projects in their forecasts). We also applied smoothing to this forecast, to average sudden increases in expected load from one year to the next over multiple years. Finally, we modeled a No New Data Centers scenario, in which no new data center load is added in 2027 or any year after.

In the High Load scenario, data center load increases to 1,097 TWh in PJM by 2040, compared to 676 TWh by 2040 in the Reference scenario. In both of those scenarios, roughly 14 to 15 percent of this load is expected to occur in Pennsylvania. In the No New Data Centers scenario, data center load remains at a flat 55 TWh per year through 2040, with 7 percent of the load occurring in Pennsylvania. Figure 11 shows the data center load and coincident peak demand forecast for each scenario.

Figure 11. Data center load and coincident peak demand forecasts for PJM (left) and Pennsylvania (right)



instead included both resources in the data center forecast. We expect the impacts from voltage optimization to be small relative to the data center impacts.

[33] We obtained utility large-load forecasts from Table B1 of PJM's *2026 Load Forecast Report*. The High scenario reflects 50 percent of the utility-reported large-load forecast values, with an S-curve applied to align the Reference forecast trajectory and smooth abrupt year-to-year increases. Available at: https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.

Electric vehicles

The electric vehicles forecast includes the charging demand impacts from the electrification of light-duty vehicles, medium-duty vehicles, heavy-duty vehicles, and buses. We examined Reference and High Load scenarios for this component.

To model the Reference scenario, we adopted PJM's 2026 Plug-In Electric Vehicle load forecast.[34] To develop the High Load scenario, we used Synapse's in-house Electric Vehicle Regional Emissions and Demand Impacts (EV-REDI) tool.[35] EV-REDI is a stock-flow tool that estimates future adoption rates and annual energy consumption from electric vehicles by applying a technology adoption curve (S-curve) to historical trends (e.g., vehicle-miles traveled, existing electric vehicle counts) and a desired target (e.g., X electric vehicles sold or X electric vehicles on the road in Y year). Using EV-REDI, we found that PJM's own forecast (our Reference scenario) resembles a trajectory of about 80 percent of vehicle sales being electric vehicles by 2040. For the High Load scenario, we escalated this to 90 percent electric vehicle sales by 2040 to make a meaningfully different case. For both scenarios, we applied the light-duty and heavy-duty electric vehicle charging load profiles from PJM's 2026 load forecast.

Figure 12 shows the electric vehicle load and coincident peak demand forecasts for PJM and Pennsylvania. In PJM, load from electric vehicles reaches 111 TWh by 2040 in the High Load scenario, and 78 TWh in the Reference scenario. In Pennsylvania, electric vehicle load reaches 19 TWh in the High Load scenario, and 15 TWh in the Reference scenario.

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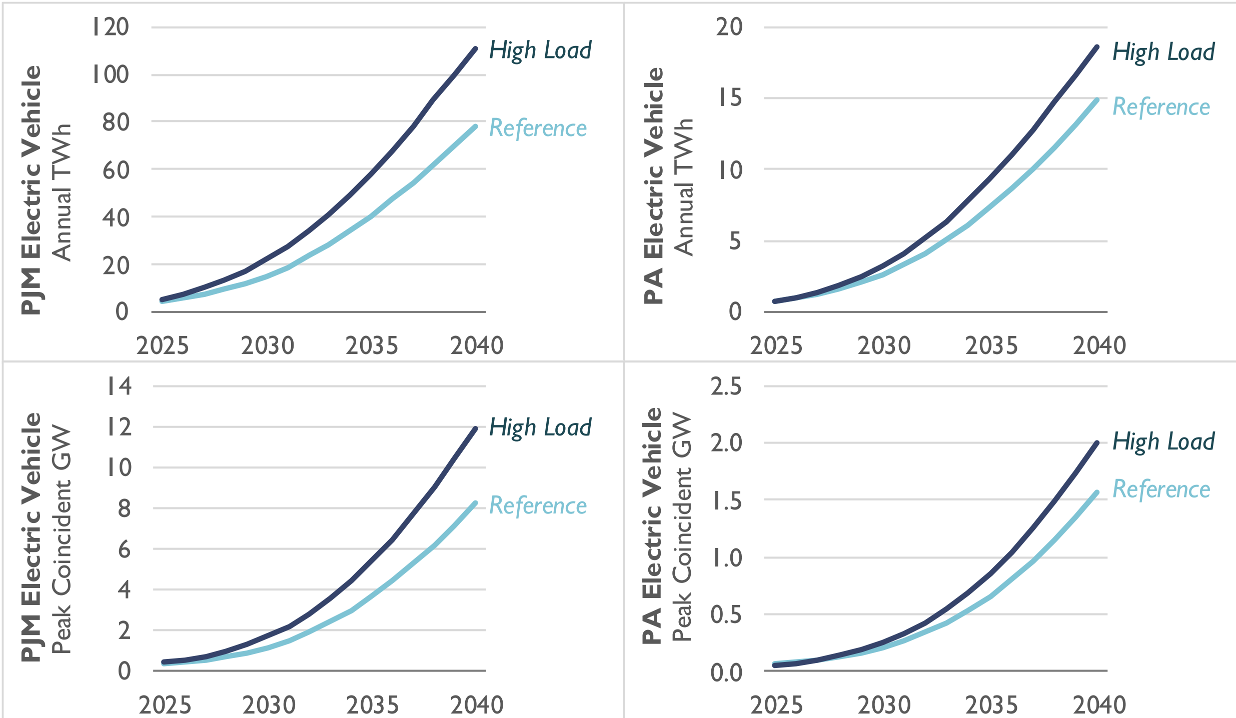
[34] 2026 Load Forecast and associated materials are available online at https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.

[35] For more on Synapse's EV-REDI model, see https://www.synapse-energy.com/project/ev-redi-electric-vehicle-regional-emissions-and-demand-impacts-tool.

Figure 12. Electric vehicle load and coincident peak demand forecasts for PJM (left) and Pennsylvania (right)



Distributed solar

In addition to modeling resources that increase electric demand, we modeled load decreases due to distributed solar capacity additions. As with the electric vehicle component, we examined Reference and High Load scenarios for this component. Note that because distributed solar is a load-decreasing resource, for this component we defined the High Load scenario as having fewer distributed solar capacity additions than the Reference scenario (e.g., fewer load reductions, or higher load growth).

For the Reference scenario, we adopted PJM's 2026 distributed solar forecast as-is. PJM's forecast is based on S&P Global's 2025 PJM Solar and Battery Forecast's "Base Case" scenario.[36] This report also includes solar forecasts for two alternate scenarios: (1) "Higher Costs," which assumes increasing costs and supply chain constraints limit growth in solar deployment, and (2) "Bounce Back Solar Build," which assumes declining technology costs and the extension of net energy metering (NEM) policies yield greater solar deployment. For the High Load scenario, we adopted S&P Global's "Higher Costs" scenario. For the load shapes for these forecasts, we applied a set of assumptions consistent with the conventional load shape data sources. For the capacity expansion modeling, we relied on data from Horizon's National Database, which also uses a single weather year for renewable shapes consistent with the weather year assumed for load. For the resource adequacy modeling, we used data from the

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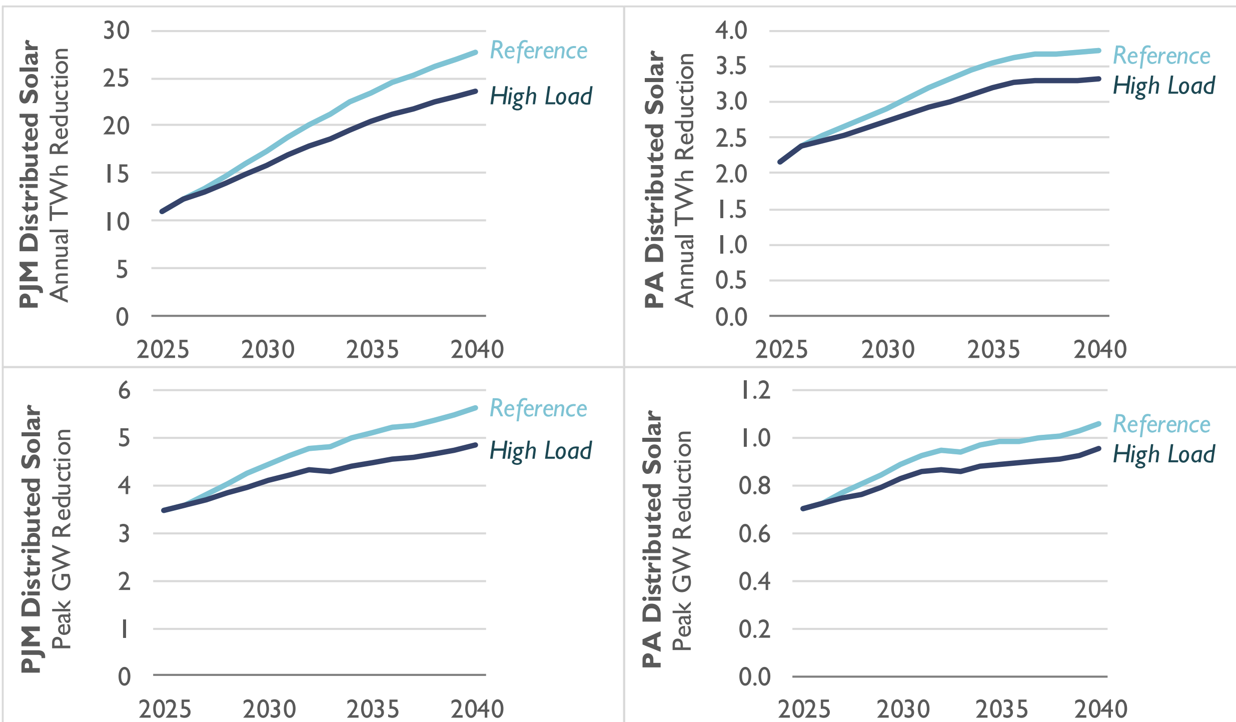
[36] S&P Global Commodity Insights. 2025. "PJM Solar and Battery Forecast 2025: Phase II – Forecasts". Available at: https://www.pjm.com/-/media/DotCom/committees-groups/subcommittees/las/2025/20251028/20251028-reference---spglobal---pjm-dg-solar-battery-forecast.pdf.

SERVM model to produce load shapes that are consistent with load for all weather years from 1993 to 2022.

Figure 13 shows the distributed solar load and peak demand reduction forecasts for PJM and Pennsylvania. Note that, compared to the previous load components, these figures show reductions in load, as opposed to increases. Under the Reference scenario, distributed solar achieves 5.6 GW in peak coincident demand reductions in 2040, or 28 TWh in reduced electric load. Under the High Load scenario, in 2040 distributed solar reaches 4.8 GW in reduced annual peak coincident demand, or 24 TWh in reduced electric load.

Figure 13. Distributed solar load reduction and peak demand reduction forecasts for PJM (left) and Pennsylvania (right)



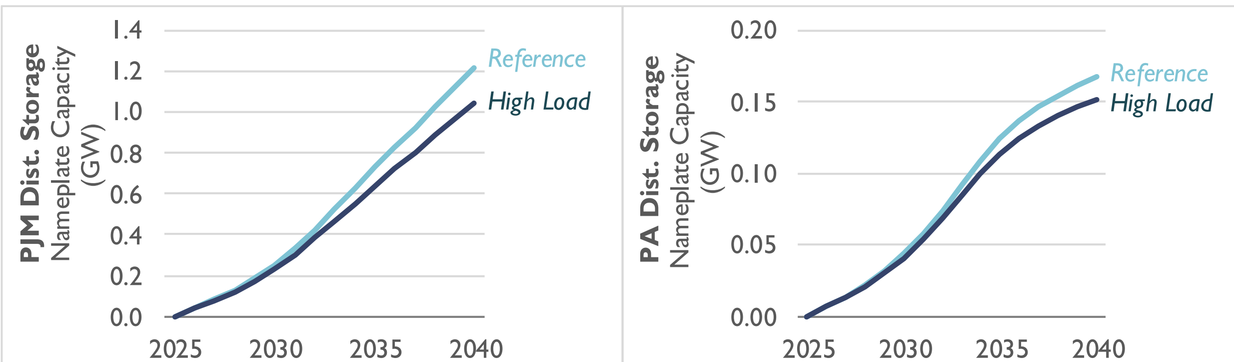
Distributed storage

The distributed storage forecast includes the peak demand reduction impacts of distributed battery capacity additions. We modeled distributed storage as a supply-side resource in the EnCompass model. While storage additions typically increase load due to round-trip efficiency losses, they are used to reduce overall strain on the electric grid by decreasing peak demand. We modeled a Reference scenario and a High Load scenario for distributed storage. As with distributed solar, for this component we defined the High Load scenario as having fewer distributed storage capacity additions than the Reference scenario.

To develop these load forecasts, we followed the same methodology as for the distributed solar component. For the Reference scenario, we adopted PJM's 2026 distributed batteries forecast, which is based on S&P Global's 2025 PJM Solar and Battery Forecast's "Base Case" scenario.[37] For the High Load scenario, we adopted S&P Global's "Higher Costs" scenario. We modeled distributed storage additions as flexible, price-responsive demand measures, with parameters related to dispatch price, round-trip-efficiency, dispatch length, and dispatch depth drawn from the Horizons National Database defaults.

Based on these forecasts, we expect distributed storage capacity additions to reach 1.22 GW by 2040 in PJM in the Reference scenario, or 1.04 GW in the High Load scenario. In Pennsylvania, we expect additions to reach 0.17 GW in the Reference scenario, or 0.15 GW in the High Load scenario. Figure 14 shows the distributed storage cumulative nameplate capacity forecasts for PJM and Pennsylvania.

Figure 14. Distributed storage annual cumulative nameplate capacity forecasts for PJM (left) and Pennsylvania (right)



Demand response and data center load flexibility

We also modeled different levels of "flexible load" resources associated with data centers. This included resources capable of workload shifting, power modulation, or geographic shifting. These resources were modeled as reducing coincidence demand during a limited number of system stress hours, while leaving total annual energy load unchanged. In our modeling, we priced these resources at the market cost of energy, such that they will dispatch when the system deems it to be economically efficient to do so.

We applied different flexibility assumptions to the Reference and High Load scenarios, corresponding to the data center loads assumed in the Reference and High Load and Low Supply scenarios. To develop these load forecasts, we relied on a literature review of publications from Lawrence Berkeley National

[37] S&P Global Commodity Insights. 2025. "PJM Solar and Battery Forecast 2025: Phase II – Forecasts." Available at: https://www.pjm.com/-/media/DotCom/committees-groups/subcommittees/las/2025/20251028/20251028-reference---spglobal---pjm-dg-solar-battery-forecast.pdf.

Lab,[38,39] the American Council for an Energy-Efficient Economy,[40] and the Electric Power Research Institute.[41] For the Reference scenario, we assumed 13 percent of peak data center load is flexible in 0.50 percent of annual hours. To model the High Load scenario we assumed lower load flexibility: 10 percent of peak data center load in 0.25 percent of annual hours.

Other load

We also explored other types of load components, including building electrification, energy efficiency, and CHP. We ultimately did not model any load implications for these components beyond that implied in PJM's own forecast. We describe our rationale for each component below.

Building Electrification

PJM does not include building electrification as a standalone load component. We therefore assumed that, for the Reference scenario, any building electrification was already implied in the conventional load component. We explored developing a High Load scenario for building electrification by modeling additional heat pump conversions for homes that currently use oil, propane, or electric resistance for space heating. However, high levels of existing electric resistance heating equipment in the region, which can be two to four times less efficient than heat pumps, resulted in more aggressive levels of heat pump conversions yielding lower electric load.[42] We therefore decided to not model a more aggressive heat pump adoption rate than the Reference scenario.

Energy Efficiency

Energy efficiency load adjustments represent additions of programmatic, ratepayer-funded energy efficiency savings. As with building electrification, PJM does not break out energy efficiency as an independent load component. We therefore assumed PJM's conventional load forecast is inclusive of energy efficiency impacts and did not model any additional impacts.

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[38] Lawrence Berkeley National Laboratory (LBNL). 2025. "Data Center Load Flexibility Workshop Summary". Available at: https://eta-publications.lbl.gov/sites/default/files/2025-03/final_doe_data_center_load_flexibility_workshop_summary.v0307.pdf.

[39] Lawrence Berkeley National Laboratory (LBNL). 2025. "Large Load and Load Flexibility Review Update". Available at: https://eta-publications.lbl.gov/sites/default/files/2025-10/lbnl_lllreview_sept_update_2025_1.pdf.

[40] American Council for an Energy-Efficient Economy (ACEEE). 2025. *Opportunities to Use Energy Efficiency and Demand Flexibility to Reduce Data Center Energy Use and Peak Demand*. Available at: https://www.aceee.org/sites/default/files/pdfs/opportunities_to_use_energy_efficiency_and_demand_flexibility_to_reduce_data_center_energy_use_and_peak_demand.pdf.

[41] Electric Power Research Institute. 2025. *The Economics of High Load Factor Customers: How AI Datacenters Can Reduce System-Wide Electricity Rates*. Available at: https://restservice.epri.com/publicattachment/96018.

[42] We based building stock characterizations on data from the National Laboratory of the Rockies' ResStock and ComStock databases, available at: https://www.nlr.gov/buildings/buildstock.

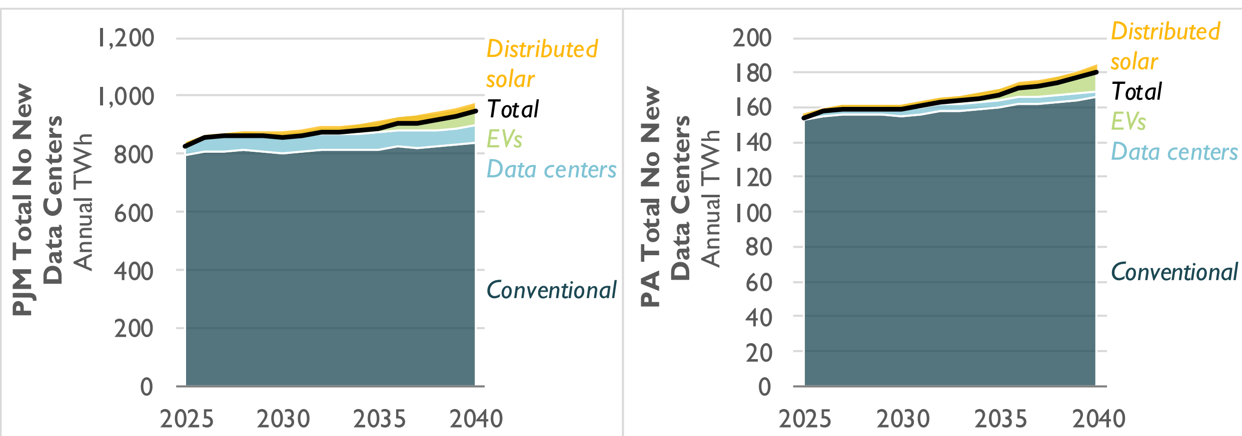
CHP

Finally, we explored developing a load forecast for CHP measures, with a focus on impacts in Pennsylvania. Potential studies for CHP in Pennsylvania indicate relatively low potential for these measures.[43] We therefore did not model these impacts, for the purposes of simplicity.

Total load

Figure 15, Figure 16, and Figure 17 show the total annual electricity load for each of the three scenarios, by component, for PJM and Pennsylvania. Under the No New Data Centers scenario, between 2025 and 2040 total annual PJM load grows by 14 percent, to 947 TWh. In this scenario, load increases from conventional load, data centers, and electric vehicles are all on a similar scale (roughly 50 to 80 TWh each). In the Reference scenario, data center additions drive substantially higher load growth. In this scenario, total annual load in PJM grows by nearly 90 percent from 2025 to 2040, to 1,567 TWh. By 2040, data centers are responsible for 676 TWh of this load, or 43 percent of all load in PJM. Under the most aggressive scenario, High Load, from 2025 to 2040 total annual load in PJM grows by 144 percent, to 2,024 TWh. In this scenario, by 2040 data center load makes up over half (54 percent) of all load in PJM.

Figure 15. No new data centers scenario total annual load, by component, for PJM (left) and Pennsylvania (right)



Note: The "Total" load shown in Figure 15, Figure 16, and Figure 17 is net of the quantity met from distributed solar.

[43] See, for example, slide 29 of NV5's 2025 market potential study, which suggests 273 GWh online by 2030, or about 0.2 percent of conventional load in that year.
NV5. 2025. "Pennsylvania Energy Efficiency and Peak Demand Reduction Market Potential Study Report". Prepared for Pennsylvania Public Utility Commission. Available at: https://www.puc.pa.gov/media/3317/phasev_act129_eepdr_mps_stakeholder_meeting_presentation_020425.pdf.

Figure 16. Reference scenario total annual load, by component, for PJM (left) and Pennsylvania (right)

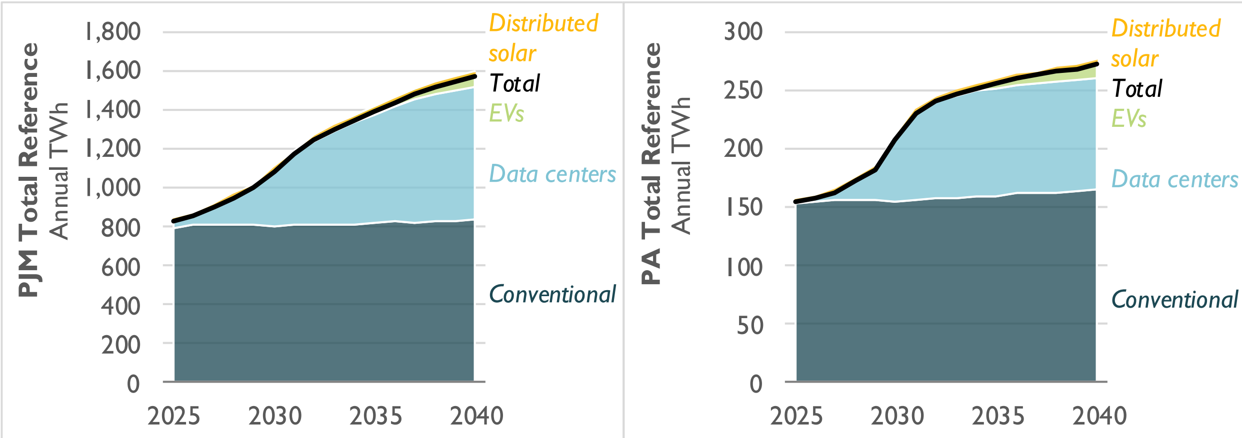
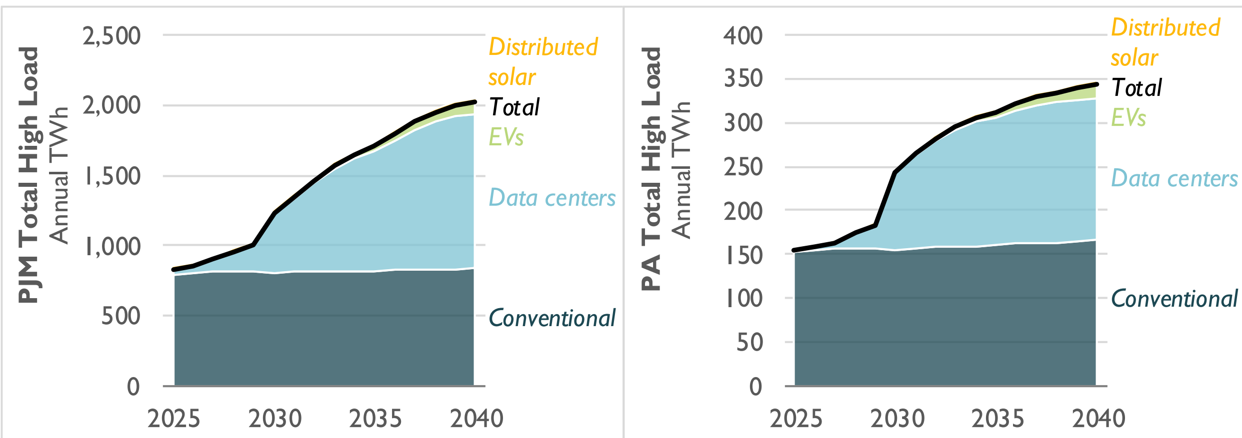


Figure 17. High load scenario total annual load, by component, for PJM and Pennsylvania



Appendix B. Supply-Side Assumptions

This appendix contains detail related to supply-side assumptions. First, Table 11 describes the near-term assumptions for resource build limits, i.e., the total quantity of resources that the capacity expansion model is allowed to build PJM-wide if it is economic to do so. Next, Table 12 describes the set of assumptions used for resource availability in each of the modeled scenarios over both the near- and long-terms, and it includes assumptions related to resource retirements and availability. Table 13 describes the various PJM initiatives related to resource deployment, and how they are rendered in our analysis. Table 14 describes the assumed costs and operational parameters for new resources that the capacity-expansion model may select to build.

Table 11. Assumed PJM-wide cumulative build limits, apart from PJM initiatives

	2028	2029	2030
Low supply			
Gas	2.5	5.0	7.5
Onshore wind	1.9	3.8	5.7
Solar	11.5	23.0	34.6
Battery storage	2.1	4.1	6.2
Reference			
Gas	3.1	6.3	9.4
Onshore wind	2.2	4.4	6.6
Solar	12.8	25.6	38.4
Battery storage	2.1	4.3	6.4

Notes: This table does not include resource additions in 2026 and 2027; we assume that all resources identified as "planned" or "under construction" in 2026-2027 in EIA's Form 860 (available at https://www.eia.gov/electricity/data/eia860/) come online during that time period. Across all scenarios, we assume that all resources currently in the "under construction" phase of PJM's queue, and 90 percent of resources that are currently in the "engineering and procurement" phase can be built between 2028 and 2030 (if economic). The share of projects that can progress from "active" to "online" vary by scenario: in the Low Supply scenario, builds are limited by historical success rates for projects submitted between 2010-2020, whereas in the Reference scenario, historical success rates are increased by 50 percent. These build limits do not include resources added via RRI, EIT, and reliability backstop auction capacities, which are added separately (see Table 12 for more).

Table 12. Assumed availabilities for supply-side resources

	Low Supply	Reference
Near-term build constraints for new resources (2026-2030)	Conservative assumptions about rate of completion of projects currently in the PJM interconnection queue data. Assume Reliability Resource Initiative (RRI) selected resources come online by projected dates.	Rate of completion of projects currently in PJM interconnection queue is modestly improved. Assume Reliability Resource Initiative (RRI) selected resources come online by projected dates.
Mid/long-term build constraints for new resources (2030-2040)	Assume historical rate of resource additions persists through 2040.	Assume build constraints gradually improve from 2031-2040.
Thermal plant retirement decisions	All units must retire on or before their currently scheduled retirement dates. Early retirement decisions are enabled and based on modeled economics.	All units must retire on or before their currently scheduled retirement dates. Early retirement decisions are enabled and based on modeled economics.
New technology availability	Only include resources that are currently commercially available. • **Offshore wind:** Only include resources that are named and have planned operation dates.	• **Offshore wind:** Include all resources from Low + additional offshore wind can be added starting in 2037. • **LDES:** Assume long duration energy storage (LDES) can be added starting in 2035. • **Small modular reactors (SMRs):** Assume new SMRs can be built starting in 2040.
Load flexibility	Current levels of demand response are assumed to persist through 2040.	Increasing quantities of demand response are available over time. A small portion of data center load is assumed to be curtailable.

Notes: Both the Reference scenario and the No New Data Centers scenario utilize the "Reference" supply-side assumptions, while the High Load and Low Supply scenario utilize the "Low supply" supply-side assumptions. We do not model Expedited Interconnection Track (EIT) or Reliability Backstop Procurement (RBP) resources explicitly and instead assume they are reflected in the mid/long-term build constraints for new resources (2030-2040).

Table 13. Proposed supply-side initiatives by PJM

	Description	Status	Quantity and Scope	Time Frame
Reliability Resource Initiative (RRI)	Process interconnection of shovel-ready projects that can contribute to reliability on an expedited timeline (uprates and new generation). Projects are processed through TC2 (part of PJM's interconnection queue reform transition process).	Approved by FERC. No longer accepting applications.	41 projects (8,000 MW) moving to next phase of study process (10 other projects were originally approved but have since dropped out). 39 uprates (gas, nuclear, coal, onshore wind) and 12 new projects (gas, batteries, nuclear).	One-time initiative. All are expected to be online by 2031 (90% by 2030). Queue processing will begin spring 2026, take 1-2 years.
Reliability Backstop Procure-ment (RBP)	Long-term commitments for firm capacity (white house recommended 15-year term), uprates and new generation. Proposed as two stages, (1) PJM acts as a matchmaker between large loads and new capacity for bilateral contracts, and (2) PJM administers an auction for new capacity, with multi-year commitments, for non-FRR zones only, where costs allocated to zones/EDCs PJM recommends EDCs helps define procurement quantity and willingness-to-pay.	Still being scoped by PJM and its stakeholders	Unclear; 50-60 GW shortfall in next decade. PJM shared 14.9 GW as draft target.	One time initiative (but could be triggered again if there is a reliability requirement shortfall for three years in a row). Sep-March target date for bilateral period, followed by 4-6 month central procurement phase. Projects must be operating by June 2031.
Expedited Inter-connection Track (EIT)	For generation with financial commitments and state commitment to expediate permitting/siting, must be at least 250 MW (uprates and new generation). Processed separately from existing queue, operates in parallel. Large non-refundable deposit required.	Waiting for approval from FERC (filed Feb 27), will likely be approved. Applications on a rolling basis beginning Aug 2026.	PJM will study no more than 10 completed and valid applications per calendar year (250 MW min per project).	One-time initiative (unclear when this will end). Queue processing time is 10 months from application (commercial operation no more than 3 years from date of application), so projects will begin coming online in 2030 and 2031.

Table 14. New resource assumptions

Input	Assumption	Additional Detail
Conventional gas plants	No operational constraints related to EPA 111 rules assumed.	Near-term costs are based on recent estimates from EPRI. We assume current supply chain constraints are resolved by 2035, and interpolate from high near-term costs to ATB's cost trajectory by 2035.
Advanced nuclear reactors / SMRs	Three Mile Island Unit 1 assumed to be repowered in Summer 2027*	We model these resources using cost projections from AEO 2026.
Wind and solar potentials, local cost adders and capacity factors	Based on data from U.S. EPA's IPM modeling.	Utilizes compiled supply curve that varies for each modeled zone. It includes different tranches of wind and solar MW potentials, as well as cost adders that reflect increased costs of building transmission to certain areas. Each tranche of wind and solar has a separate capacity factor.
Utility-scale solar, onshore and offshore wind	NREL Annual Technology Baseline 2024.	Relies on "conservative" trajectory. We include a cost adder on top of ATB's projections to represent supply chain constraints and interconnection queue challenges.
Utility-scale battery storage	4-, 6-, 8-hour storage allowed. Prices based on NREL's Annual Technology Baseline 2024.	Assumes "moderate" trajectory, which is aligned with recent observed costs.
Long-duration storage	100-hour battery costs from Form Energy.	-

** Note that there are sources suggesting that Three Mile Island may not be repowered until 2031. See "TMI owners affirm 2027 restart date despite grid readiness questions. PennLive Patriot News. Published March 27, 2026. Available at https://www.pennlive.com/business/2026/03/tmi-owners-affirm-2027-restart-date-despite-grid-readiness-questions.html.*

ELCCs describe the firm capacity provided by each nameplate MW of capacity, making it an important input into the capacity expansion model's resource selection decisions. PJM calculates ELCC class ratings based on the EUE reduction that a marginal addition of each class produces, compared to the EUE reduction produced by a marginal addition of perfect capacity.[44] We inherit PJM's assumptions for ELCCs in this analysis (see Table 15).

We observe that several resource ELCCs decline over time. For some resource classes, such as wind and battery, adding more capacity reduces the class's marginal impact to reliability as the EUE shifts due to the changes in the resource portfolio.[45] For years beyond PJM's currently published dataset (2036-

[44] *Preliminary ELCC Class Ratings for Period 2027/2028 through 2035/2036*. PJM. June 2025. Available at: https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/discussion-of-preliminary-elcc-class-ratings-for-period-2027-2035.pdf.

[45] 2023 PJM Reserve Requirement Study. PJM Resource Adequacy Planning. December 29, 2023. Available at https://www.pjm.com/-/media/DotCom/planning/res-adeq/2023-pjm-reserve-requirement-study.ashx.

2040), we hold ELCCs constant at their 2035 value, since the ELCC trajectories are generally trending toward relatively stable values by 2035.

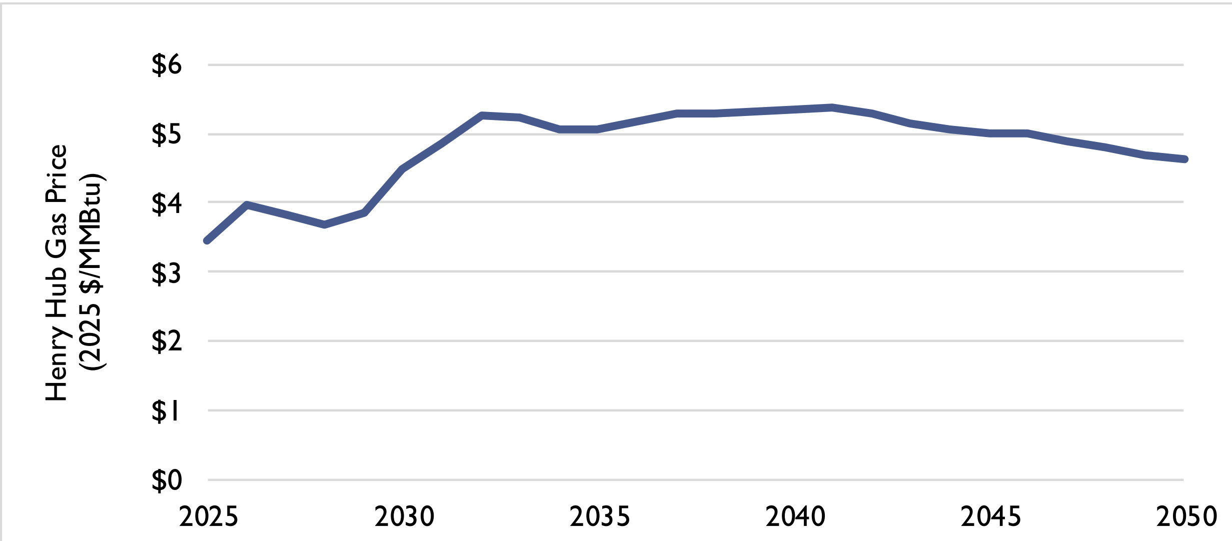
Table 15. Assumed resource ELCCs

ELCC Class	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36
Onshore Wind	41%	37%	35%	34%	31%	26%	22%	20%	19%
Offshore Wind	68%	61%	57%	53%	47%	38%	32%	28%	26%
Fixed-Tilt Solar	7%	6%	6%	6%	6%	6%	6%	6%	6%
Tracking Solar	9%	7%	7%	7%	7%	7%	7%	7%	7%
Landfill Intermittent	50%	51%	51%	50%	50%	50%	50%	51%	51%
Hydro Intermittent	40%	37%	37%	38%	39%	39%	38%	38%	38%
4-hr Storage	52%	50%	42%	37%	30%	25%	25%	24%	23%
6-hr Storage	61%	60%	52%	48%	41%	36%	36%	35%	33%
8-hr Storage	65%	64%	58%	54%	49%	44%	45%	43%	42%
10-hr Storage	74%	73%	68%	64%	59%	55%	56%	54%	53%
Demand Resource	85%	82%	77%	74%	70%	68%	68%	67%	66%
Nuclear	95%	95%	95%	95%	95%	95%	96%	95%	95%
Coal	83%	83%	83%	83%	82%	81%	81%	80%	80%
Gas Combined Cycle	74%	75%	75%	75%	76%	77%	78%	78%	78%
Gas CT	61%	61%	62%	63%	64%	66%	68%	69%	70%
Gas CT Dual Fuel	78%	77%	77%	77%	78%	80%	80%	80%	80%
Diesel Utility	91%	91%	91%	91%	91%	91%	91%	91%	91%
Steam	73%	72%	71%	71%	72%	72%	72%	72%	72%

Note: Table reproduced from PJM one-pager Preliminary ELCC Class Ratings for Period Delivery Year 2027/28 – Delivery Year 2035/36. Available at https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/preliminary-elcc-class-ratings.pdf. In this analysis, 2035/36 ELCCs are extended through 2040/2041 to facilitate capacity expansion modeling through that year.

Henry Hub gas price assumptions used in our capacity expansion analysis are developed by compiling both near-term and long-term projections (see Figure 18). First, historical values (through October 2025) are calculated as the volume-weighted average of daily prices, using price and trade volume data from Natural Gas Intelligence. Next, near-term projections (November 2025 through December 2026) are based on futures prices from Natural Gas Intelligence. Third, long-term projections (2028 through 2040) are based on the EIA's Annual Energy Outlook 2026 Counterfactual Baseline case for Henry Hub. Finally, a transition year (2027) is modeled by calculating the simple average of (a) Natural Gas Intelligence futures for 2026 and (b) projected gas prices for 2028 based on data from Annual Energy Outlook. For years lacking monthly resolution (i.e., 2027 through 2040), monthly variation in gas prices is based on observations of historical monthly variation relative to annual averages. In capacity expansion modeling, gas prices also receive basis prices on top of the Henry Hub price based on data available in the Horizons National Database.

Figure 18. Assumed annual Henry Hub gas price



Our capacity expansion modeling includes consideration of renewable portfolio standard (RPS) policies. In general, RPS requirements are driven by a percentage requirement and a state's retail electricity sales (e.g., X percent of retail sales must be served by solar, wind, etc. in any given year). As of 2026, Pennsylvania, District of Columbia, Delaware, Illinois, Maryland, New Jersey, Ohio, Virginia are the states in PJM that have RPS programs. These percentages act as a demand constraint in the capacity expansion model.

Because of large overlaps in Tier/Class I and II REC eligibility across states and modeling limitations, we model limited distinctions between Tier/Class types. Most notably, we model the demand for Pennsylvania Tier II RECs separately from other states: they have unique eligibility requirements. Solar carve-out requirements are modeled in parallel to ensure compliance, and demand for Pennsylvania solar RECs (SRECs) is modeled separately from other states. Alternative Compliance Payments (ACP) act as a price cap on REC requirements. We note that the Pennsylvania ACP for 2024/2025 is $45 per MWh for Tier I and II and $66.40 per MWh for SRECs.

We model RPS programs as they currently are (e.g., we do not assume any changes to future RPS levels or resource eligibility). We assume that all data-center-related demand is not exempt from RPS requirements. We did not model demand from the voluntary RECs.

Appendix C. Acronyms and Glossary

CONE	Cost of new entry (assumed estimate of the cost to build a new power plant)
DOE	Department of Energy
ELCC	Effective load-carrying capability
EIT	Expedited Interconnection Track (PJM initiative)
EUE	Estimated unserved energy
FERC	Federal Energy Regulatory Commission
IRAS	Interim Resource Adequacy Service Proposal (PJM initiative)
IRM	Installed reserve margin
LMP	Locational marginal pricing (e.g., energy prices)
LOLE	loss of load expectation (the PJM planning criterion for this metric is 0.1)
LOLH	loss of load hours
MW, GW, kW	Megawatts, gigawatts, kilowatts
MWh, GWh, kWh, TWh	Megawatt-hours, gigawatt-hours, kilowatt-hours, terawatt-hours
NERC	North American Electric Reliability Corporation
nEUE	Normalized estimated unserved energy
PJM	PJM Interconnection, LLC, the regional transmission organization coordinating wholesale electricity in Pennsylvania and 12 other states
PUC	Pennsylvania Public Utility Commission
SERVM	Strategic Energy & Risk Valuation Model
SREC	Solar renewable energy certificate
REC	Renewable energy certificate
RBP	Reliability backstop procurement (PJM initiative)
RPM	Reliability Pricing Model (capacity market operated by PJM)
RPS	Renewable portfolio standard
RRI	Reliability Resource Initiative (PJM initiative)
RTO	Regional transmission operator