Tackling the PJM Electricity Cost Crisis

An Analysis of the Benefits of PJM Interconnection Reform

Prepared for Evergreen Collaborative

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EXECUTIVE SUMMARY

Electricity customers in the PJM region (which spans all or parts of 13 Mid-Atlantic states and Washington, D.C.) are facing a looming cost crisis stemming from two major issues: (a) worsening barriers to building and connecting new generation resources needed to supply the electric grid, and (b) unprecedented increases in projected electricity demand. Accelerating new resource deployment will be necessary to reliably serve new and existing load without greatly increasing energy costs to electricity customers. Bringing online more clean energy resources will also be critical to reducing carbon dioxide emissions and meeting state climate goals. However, power companies in the region are grappling with several barriers that impede their ability to connect new resources to the grid, including PJM's interconnection queue delays, local permitting and siting processes, and global supply chain challenges.

If PJM's current rate of processing interconnection requests persists, residential electricity bills in the region are expected to increase by nearly 60 percent.

PJM now faces an inflection point. As this report will show, if PJM continues down its current path, residential electricity bills in the region are expected to increase by nearly 60 percent by the 2036–2040 period compared to historical levels. However, if PJM adequately implements interconnection reforms to enable the deployment of more cost-effective energy generation, largely comprised of clean energy sources, electricity bills are projected to decrease 7 percent by the same time period.

This analysis focuses on the interconnection process—PJM's procedure for approving the connection of new generators to the grid. To connect proposed new generation projects to the grid, developers must submit an interconnection request to PJM. PJM then studies the impacts of the new resource on the electric grid, identifies any necessary grid upgrades, and facilitates the allocation of costs and administration of fees to cover the upgrades. In recent years, PJM's outdated processes have been overwhelmed by rising levels of generator interconnection requests, leading to a large backlog. Developers lack certainty in the timelines and costs associated with the interconnection process, making it challenging to bring new projects online and leading to high levels of withdrawals from the queue.

If PJM implements adequate interconnection reforms to enable the deployment of more cost-effective energy generation, largely comprised of clean energy sources, electricity bills are projected to decrease by 7 percent.

While this demand-supply imbalance is occurring across the country, PJM's interconnection woes stand out. In a national ranking of regional transmission organizations in the United States, PJM ranked lowest because of its long timelines and lack of transparency.[1] PJM is also an epicenter of high, data-center-driven, projected load growth. From 2025 to 2040, PJM's annual load is projected to increase by 605 TWh, representing a 72 percent increase (data centers account for 422 TWh of this projected increase).[2]

PJM's interconnection delays are already driving up energy costs. Because new generators have been unable to come online to meet demand, capacity market prices have been rising higher and higher—as supply to meet capacity needs cannot keep up with demand. These rising prices reached a tipping point in the fall of 2024 when Pennsylvania sued PJM over its capacity auction design. This led to a $21 billion settlement agreement in which PJM agreed to temporarily reduce its maximum capacity market price cap for the next two auctions.

PJM has the unique ability and responsibility to reform its interconnection process and enable cost-effective generation to come online to meet rising electricity demand. With swift action to resolve the interconnection queue, it can reduce electricity prices while bringing on new resources to power new demand and enable economic growth. Although PJM has proposed and is starting to implement a range of queue reforms, it has so far failed to implement the interconnection reforms and study deadlines required by FERC Order 2023. Further, PJM efforts lack important measures that could greatly benefit its reforms and lead to higher savings for electric customers.

To quantify the potential costs of continued interconnection queue delays, Synapse Energy Economics compared an Expanded Queue Reform scenario to a Status Quo scenario. The Status Quo scenario includes conservative assumptions around resource builds and assumes the expected near-term pace of interconnection continues throughout the model period. Our Expanded Queue Reform scenario presents a future in which PJM implements an expanded set of interconnection reforms, while other supply-side constraints (such as local permitting and siting processes) are assumed to be more broadly loosened.

We compared these two scenarios in terms of ratepayer bills, system costs, capacity additions, generation, and CO_2 emissions. The modeled level of queue reforms, compared to the Status Quo, leads to:

- **Substantial residential bill savings.** Over the study period (2025–2040), PJM residential customers would see a more than 20 percent reduction, compared to the Status Quo, in electricity costs. Residential customers' savings increase from $62 per year in the near term to $1,062 per year in the long term, averaging around $505 over the study period. Residential electricity bill trajectories for both scenarios are shown in Figure 1 below. State-level bill

[1] Grid Strategies and Brattle Group. 2024. Generator Interconnection Scorecard: Ranking Interconnection Outcomes and Processes of the Seven U.S. Regional Transmission System Operators. Available at: https://gridstrategiesllc.com/wp-content/uploads/Exec-Sum-and-Report-Unlocking-Americas-Energy-How-to-Efficiently-Connect-New-Generation-to-the-Grid.pdf.

[2] PJM. 2025. Load Forecast Development Process. Available at: https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process

results are shown in Table 2 below. Electricity bill savings tend to be greatest in states with the largest projected increases in electricity demand, greatest per capita energy consumption, and the most ambitious RPS programs.

- **Reduced commercial and industrial energy costs.** Commercial and industrial (C&I) customers see near-term cost savings of 3 percent, compared to the Status Quo, increasing to 42 percent in the long term. C&I cost savings average around 23 percent over the study period.
- **Reduced cumulative system costs.** Total cumulative PJM electric system costs decrease by $414 billion over the model period (2025–2040), representing a 24 percent decrease relative to the Status Quo scenario. These system cost savings lead to the electricity bill reductions described above.
- **Increased deployment of clean energy resources.** By 2040, the Expanded Queue Reform scenario adds an additional 57 GW of renewable energy capacity and an additional 117 GW of battery storage capacity. This quantity of incremental renewable energy capacity could power around 17 million households per year.
- **Greater levels of net job additions.** The PJM region stands to gain an average of 313,000 net additional jobs in each year of the study period in the Expanded Queue Reform scenario, relative to the Status Quo scenario.
- **Lower CO_2 emissions.** Cumulative CO_2 emissions over the model period decrease by 825 million short tons, representing a 14 percent reduction relative to the Status Quo scenario. By 2035, coal generation decreases to 5 TWh per year, down from 85 TWh in the 2025 modeled year.

Achieving these benefits requires PJM to move beyond its 2022 interconnection update and do more to make the process faster, more transparent, and more targeted. This additional action includes near-term reforms to comply with FERC Order No. 2023 and longer-term reforms to further speed up PJM's process to reach the pace modeled in this report.

The following immediate reforms are critical to unlocking the modeled benefits:

Table 1. Interconnection queue reform actions

Category	Action
FERC Order 2023 directed reforms	Set mandatory study timelines at 150 days with enforceable penalties.[3] Implement the first-ready, first-served cluster study approach on time for the regular-order queue. Use realistic modeling assumptions for energy storage behavior rather than assuming energy storage will charge during peak and require associated transmission upgrades. Study a range of alternative transmission technologies, including grid enhancing technologies, as part of interconnection studies. Dedicate more resources to interconnection, if needed, to address the large queue backlog, reopen the queue, and achieve Order 2023 deadlines.
FERC Order 1920 directed reforms	Produce a regional transmission plan of at least 20 years to identify long-term needs and the facilities to meet them. Study grid enhancing technologies as part of transmission planning.
Other immediate reforms	Make it easier for developers to use interconnection agreements held by existing power plants and continue to use them after the existing plants retire.
Reforms requiring FERC approval	Increase cost certainty for developers through a fixed interconnection entry fee, calculated through proactive planning and modeling for each zone Develop a fast-track process for projects in areas with available interconnection headroom, which would encourage rapid deployment in regions that have interconnection headroom, as assessed by proactive modeling.

PJM has sought exceptions for many of the FERC Order 2023 requirements in its 2024 compliance filing to the agency. In order to unlock the benefits modeled in this report, PJM will need to comply with the FERC ordered reforms and seek FERC approval for the additional reforms listed above.

While solving the interconnection queue will remove a critical bottleneck to protecting ratepayers from large cost increases, policy interventions in other areas, particularly siting reform at the state level, will also be needed to fully unlock the modeled benefits.

Combined with the long lead time to build new resources and the accelerated pace of projected load growth, the magnitude of the potential cost savings in the PJM region described in this report provides a case for rapid action. Even with rapid modeled queue reforms, cost declines and emissions reductions do not begin until 2029 and are not substantial until 2032.

[3] FERC Order 2023 requires that RTOs set penalties for delays. Any penalties should include safeguards to ensure that penalties do not raise costs for electricity customers.

Figure 1. Annual residential household energy costs, average in PJM

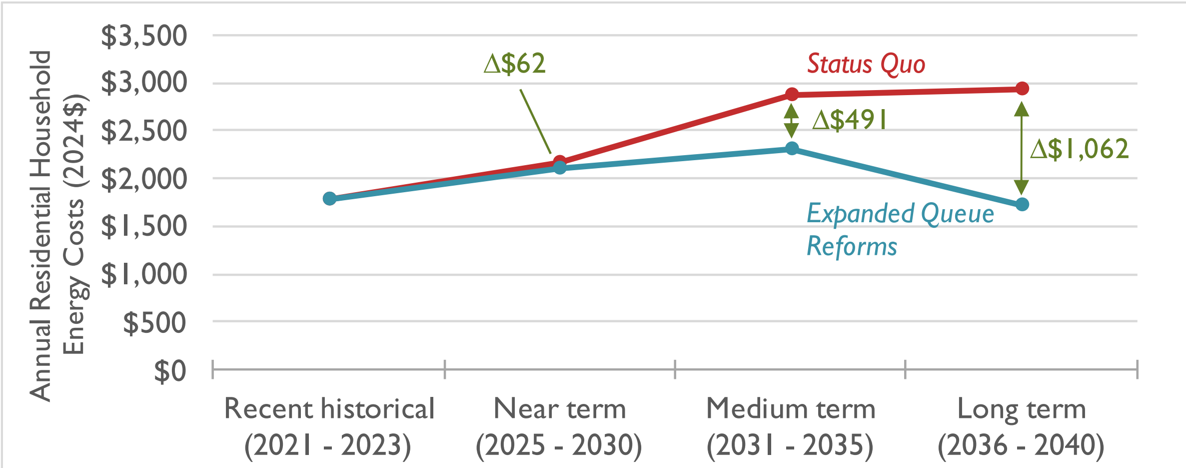

Table 2. Annual residential household energy costs, state-level average over 2025-2040 period (2024 dollars)

	Status Quo	Expanded Queue Reform	Savings
DC	$1,814	$1,351	-$462
DE	$2,311	$1,809	-$502
MD	$2,358	$1,813	-$546
NJ	$2,003	$1,598	-$405
OH	$2,183	$1,750	-$433
PA	$2,531	$2,030	-$501
VA	$2,690	$1,963	-$727
WV	$2,630	$2,052	-$578
PJM Average	**$2,327**	**$1,821**	**-$505**

1. INTRODUCTION

PJM Interconnection, which operates the transmission grid in all or parts of 13 Mid-Atlantic and Midwest states and Washington, D.C., is projecting unprecedented growth in electricity demand. This is primarily due to new data center loads (data center loads make up 70 percent of projected load growth in PJM). Meanwhile, there are considerable challenges to bringing online new generation resources in the region. These dynamics are leading to an imbalance in electricity demand and supply in PJM, which is driving up capacity market prices and increasing costs to electricity customers. Rising capacity prices reached a tipping point in the fall of 2024 when Pennsylvania sued PJM over its capacity auction design. This led to a $21 billion settlement agreement in which PJM agreed to temporarily reduce its maximum capacity market price cap for the next two auctions. Accelerating new resource deployment will be necessary to reliably serve new and existing load without greatly increasing costs to ratepayers.

However, PJM's interconnection process makes it hard to bring new resources online. Forty-five percent of new energy generation projects added to the queue since 2020 have withdrawn before completing PJM's interconnection process, largely due to PJM's study delays, lack of transparency in timing and fees, and high network upgrade costs. Many projects still waiting in the queue have already experienced long wait times. Indeed, 64 projects (over 5 gigawatts of total capacity) that are currently in the queue submitted their interconnection requests before 2020. Meanwhile, network upgrades costs associated with interconnection in the region reached an average of $240/kW in 2020–2022, up from $29/kW in 2017-2019.[4] In February 2024, GridLab's Generation Interconnection Scorecard rated PJM's interconnection process as a "D-" based on its slow timelines and lack of data transparency.[5] This was the lowest ranking of any regional transmission organization in the country, according to the scorecard. The queue backlog has been so large that PJM paused accepting new applications from proposed projects.

1.1. Review of recent PJM interconnection reforms

To try to address these challenges, PJM has been making necessary but insufficient reforms to its interconnection process.

After a lengthy stakeholder process, during which PJM paused new entry to the interconnection queue, PJM filed a proposal overhauling its interconnection procedures with the Federal Energy Regulatory

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[4] Lawrence Berkeley National Laboratory. 2023. Interconnection Cost Analysis in the PJM Territory. Available at: https://eta-publications.lbl.gov/sites/default/files/berkeley_lab_2023.1.12-_pjm_interconnection_costs.pdf.

[5] Grid Strategies and Brattle Group. 2024. Generator Interconnection Scorecard: Ranking Interconnection Outcomes and Processes of the Seven U.S. Regional Transmission System Operators. Available at: https://gridstrategiesllc.com/wp-content/uploads/Exec-Sum-and-Report-Unlocking-Americas-Energy-How-to-Efficiently-Connect-New-Generation-to-the-Grid.pdf.

Commission (FERC) on June 14, 2022.[6] This proposal described several reforms aimed at moving resources through the queue more quickly where possible and ensuring that resources under study are as commercially ready as possible. The reforms include a transition to a first-ready, first-served process and a switch from conducting studies on a serial basis to a cluster process.[7] PJM's transition to its new process began in July 2023.

About a year after PJM filed its initial interconnection update proposal, FERC issued Order Number 2023 on July 28, 2023, establishing new requirements for transmission providers to update their interconnection processes. Rather than filing a new interconnection proposal in response to the Order, PJM requested that FERC accept its 2022 interconnection proposal as compliant with Order No. 2023. PJM claimed that its existing procedures largely met the intent of Order No. 2023, and where PJM's procedures fall short, the grid operator asked FERC to provide exceptions. Several stakeholders raised issues with the requested exceptions, including the fact that PJM's study timelines far exceed the timelines required in Order No. 2023.[8,9]

In December 2024, PJM proposed the Resource Reliability Initiative (RRI) in a filing to the FERC, and FERC approved it on February 11, 2025.[10] According to PJM's filing, the RRI will be a "one-time expansion of eligibility criteria for Transition Cluster #2 (TC2) to add more resources" to the grid and address resource adequacy concerns in the region in the 2029/2030 delivery year.[11] The RRI will expand TC2 eligibility to 50 additional projects, which PJM will select based on a scorecard comprised of a set of weighted criteria. The most heavily weighted of these criteria will be the size of the resource's unforced capacity and reliability ratings.

Several stakeholders raised concerns about the RRI based on its ability to adequately address reliability issues, as well as fairness and environmental impacts. PJM's scorecard does not prioritize the speed of resource development and does not include any requirements that the projects actually be in service by 2030.[12] Furthermore, it is

PJM's RRI scorecard does not prioritize the speed of resource development and does not include any requirements that the projects actually be in service by 2030.

[6] PJM Interconnection, L.L.C. June 14, 2022. Tariff Revisions for Interconnection Process Reform, Docket No. ER22-2110-000.

[7] PJM Interconnection, L.L.C. June 14, 2022. Tariff Revisions for Interconnection Process Reform, Docket No. ER22-2110-000.

[8] *Protest of the Clean Energy Associations.* Docket No. ER4-2045-000. (June 20, 2024). Available at: https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20240620-5311&optimized=false.

[9] *Protest of Public Interest Organizations to PJM Order 2023 Compliance.* Docket No. ER24-2045. (June 20, 2024). Available at: https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20240620-5242&optimized=false.

[10] *Order Accepting Tariff Revisions Subject to Condition.* 190 FERC ¶ 61,088 (2025).

[11] PJM is moving from a serial review process to a cluster review for projects in the interconnection queue. The future clusters will move through the fully reformed queue process. PJM's Transition Clusters are the groups of projects that it will study during this transition period.

[12] In her dissent to FERC's approval, Commissioner Chang wrote, "By facilitating queue jumping for large generators, which are the most challenging to develop, acquire the necessary environmental permits, and obtain adequate material supplies and labor for construction and focusing primarily on large generators over speed of development, PJM's proposal may not

expected to primarily favor gas projects since they have relatively high reliability ratings and unforced capacity ratings.[13,14] The potential impact of RRI on resources that are currently in the TC2 cluster (which is mainly comprised of renewable resources) is uncertain, but PJM does not plan to protect them from any network upgrade cost increases associated with adding RRI-eligible resources in the TC2 cluster. The prioritization of gas resources may also present a barrier to states' abilities to achieve their clean energy goals.

Concurrently, PJM is exploring two main ways to deploy new clean energy resources at existing interconnection points. Both of these reforms could help bring more renewable resources online quickly. Doing so would improve resource adequacy, drive down costs, and enable states to meet their renewable portfolio standard (RPS) goals.

In December 2024, PJM filed a proposal with FERC to remove barriers for surplus interconnection service (SIS), which FERC approved on February 11, 2025.[15] SIS involves locating new renewable energy or battery storage near power plants to more efficiently utilize their existing interconnection capacity. Locating renewable energy resources near fossil peaker plants can increase the utilization of the interconnection point in terms of energy. During off-peak periods when peaker plants are not running, the lower cost renewable energy can use the interconnection point, and thereby drive down energy prices. Locating energy storage at existing renewable energy interconnection points can increase the aggregate firm capacity located behind the interconnection point, driving down capacity prices. Recent analysis indicates that SIS has the ability to enable the integration of up to around 190–225 GW of solar and wind at existing interconnection points in PJM.[16] PJM is also exploring ways to streamline the transfer of Capacity Interconnection Rights (CIRs) from retiring resources to new generation resources to better enable generator replacement. Without streamlining CIR transfers, it will be difficult for developers to use the SIS process, as the new generator will only have interconnection rights until the existing generator retires, after which the outlook for the new generator is uncertain.

PJM has been making some progress in improving its interconnection process, but its current set of proposals is unlikely to be enough to fully resolve its queue delays. PJM could pursue an expanded set of

actually resolve its impending capacity shortage." See: Commissioner Chang's Dissent on PJM's RRI in Docket ER25-712. (February 11, 2025), available at: https://www.ferc.gov/news-events/news/commissioner-changs-dissent-pjms-rri-er25-712.

[13] Inside Climate News. 2024. "Clean Energy Industry Questions a New PJM Proposal That Could Move Fossil Fuel Projects to the Front of the Interconnection Queue." Available at: https://insideclimatenews.org/news/08122024/grid-operator-pjm-proposal-could-prioritize-fossil-fuel-projects/.

[14] *Order Accepting Tariff Revisions Subject to Condition.* 190 FERC ¶ 61,088 (2025).

[15] *Order Accepting Tariff Revisions.* 190 FERC ¶ 61,083 (2025).

[16] GridLab and Goldman School of Public Policy, UC Berkeley. 2025. "Existing power plants sharing grid access with renewables can lower costs and double U.S. generation capacity." Available at: https://surplusinterconnection.s3.us-east-1.amazonaws.com/2025-02-21_GridLab_Surplus_Interconnection_Technical_Paper.pdf.

interconnection queue reforms to address the high levels of projected load growth and long lead times to build new resources. These queue reforms should not unduly discriminate against any specific resource types; rather they should target a diverse portfolio of cost-effective generation resources that can move through the queue and come online quickly.

Queue reforms should not unduly discriminate against any specific resource type; rather they should target a diverse portfolio of cost-effective generation resources that can move through the queue and come online quickly.

1.2. Overview of analytical methods

To quantify the potential costs of continued interconnection queue delays, Synapse Energy Economics performed an analysis using a detailed PJM-wide capacity-expansion and production-cost analysis from 2025 through 2040, coupled with post-processing analyses. Our analysis assessed the impacts of the PJM interconnection queue delays on ratepayer bills, system costs, resource builds, generation, and carbon dioxide (CO_2) emissions.

We modeled two scenarios: a business-as-usual "Status Quo" scenario and an "Expanded Queue Reform" scenario. The Status Quo scenario reflects a future in which PJM's current pace of resource additions is held constant (except for a one-time, near-term addition of greater levels of gas, storage, and solar resources—to represent RRI). This scenario includes conservative assumptions around interconnection rates and serves as a lower-bound on PJM's ability to build new resources. While PJM has proposed and is starting to implement a range of queue reforms, the timing, impact, and effectiveness of their implementation remains uncertain.

The Expanded Queue Reform scenario reflects a future in which PJM implements an expanded set of interconnection reforms and at the same time other supply-side constraints (such as local permitting processes) are assumed to be more broadly loosened. In the Expanded Queue Reform scenario, the model is also able to select new transmission projects starting in 2031 (the cost of new transmission is included in our bill analysis).[17] In both scenarios, we assume that all other variables, including load growth, resource costs, and fuel costs are held constant. Appendix A contains a more detailed description of modeling assumptions that are consistent across both scenarios.

In the time since we conducted this modeling, FERC approved a few additional changes to PJM's capacity market design, including requiring Reliability Must-Run (RMR) resources to participate in the capacity market and more broadly eliminating capacity market must-offer exemptions for all resources.[18,19] PJM's approval of the RMR unit participation requirement will require the Brandon

[17] We assume new, dynamically selected transmission projects are not able to come online until 2031 due to the long timelines associated with building new transmission lines.

[18] PJM Inside Lines. 2025. "FERC Approves PJM Capacity Market Design changes to Support Reliability, Affordability." Available at: https://insidelines.pjm.com/ferc-approves-pjm-capacity-market-design-changes-to-support-reliability-affordability/

[19] PJM Inside Lines. 2025. "FERC Accepts Additional PJM Capacity Market Design Changes." Available at: https://insidelines.pjm.com/ferc-accepts-additional-pjm-capacity-market-design-changes/

Shores and Wagner RMR units to participate in the capacity market, until their expected retirement dates in 2028. Neither of our modeled scenarios includes capacity market participation by RMR units. The inclusion of RMR units in the capacity market may lead to lower near term capacity market prices, especially in Maryland.[20] However, this near term impact in both scenarios would likely be similar, causing any potential impacts on the deltas between the scenarios to be negligible. Regarding the elimination of the must-offer exemptions, our capacity expansion model assumes that all active resources participate in the capacity market, meaning there are no exemptions allowed (except for the previously mentioned RMR treatment).

Interconnection queue assumptions

Our capacity expansion model is able to economically decide which resources to build, up to a maximum allowable annual build limit. To model the interconnection queue, we developed a set of assumptions around the maximum quantity of each resource that can be built in a given year, under each scenario. Table 3 shows these assumptions, which we discuss in more detail below. This set of assumptions covers additions of onshore wind, utility-scale solar, battery storage, and gas-fired power plants.[21]

[20] Maryland Office of People's Counsel. 2024. "Bill and Rate Impacts of PJM's 2025/2026 Capacity Market Results & Reliability Must-Run Units in Maryland." Available at: https://www.synapse-energy.com/sites/default/files/RMR%20Bill%20and%20Rates%20Impact%20Report_2024-08-13%208-29-24%2023-067.pdf

[21] We assume that the same set of named offshore wind projects with commercial operation dates comes online in both scenarios. These specific offshore wind projects often represent a subset of state targets for offshore wind; however, these larger state targets are not modeled.

Table 3. Modeled annual PJM-wide maximum resource additions (MW)

	2027	2028-2035	2036-2040
Status Quo Scenario			
New Gas	1,300	1,300*	1,300
New Solar	3,200	3,200	3,200
New Storage	800	800*	800
New Onshore Wind	800	800	800
Expanded Queue Reform Scenario			
New Gas	1,300	1,300-11,700	No queue constraints
New Solar	3,200	4,000-39,000	No queue constraints
New Storage	800	1,300-32,000	No queue constraints
New Onshore Wind	800	1,200-8,400	No queue constraints

** The Status Quo scenario also allows the model to build an additional 6.6 GW of gas, 9.4 GW of storage, and 1.6 GW of solar over 2031–2033 to reflect PJM's RRI.*

Our modeled maximum resource additions are based on the following phases in each scenario:

Status Quo scenario

- **2025 to 2026:** Endogenous capacity builds are not allowed. We modeled known, planned resources that have commercial operation dates in this period exogenously.
- **2027 to 2030:** The maximum allowable resource additions in each year are determined based on current interconnection queue data. We assume that only projects with an in-service year between 2025–2030 and those projects that are either "under construction" or in the "engineering & procurement" stage can come online before 2031. This represents the subset of projects that are most likely to be built in the near term. These quantities are then allocated across states in PJM based on the geographical distribution of resources currently in the queue and are evenly distributed across 2027–2030.
- **2031 to 2040:** We extrapolate the allowable endogenous capacity build trajectory through 2040 using the same rate of resource builds as in 2027–2030. However, instead of being defined at the state level, the build constraints in this period are implemented as PJM-wide maximum additions, meaning the model economically optimizes which states to build resources in. We also implement an additional RRI adjustment based on our review of PJM's scorecard eligibility criteria and the current projects in PJM's "Active" section of the queue. The RRI adjustment allows the model to build an additional 6.6 GW of gas, 9.4 GW of storage, and 1.6 GW of solar from 2031–2034, incremental to the assumed constant pace of resource additions in the rest of the model period.

Expanded Queue Reform scenario

- **2025 to 2026:** Resource builds in this period are the same as the Status Quo scenario (i.e., the model cannot choose to build resources endogenously).
- **2027:** Maximum resource additions are the same as those used in the Status Quo scenario this year (i.e., based on interconnection queue data).
- **2028 to 2035:** In this period, we gradually increases the maximum amounts of new resources that can be built in a year to represent incremental improvements to the interconnection process. The assumed future resource build caps are reflective of the mix of resource types that are currently in the "Active" stage of the queue.
- **2036 to 2040:** We assumed all interconnection queue delays would be resolved by 2036. At this point, the model is freely able to optimize capacity additions based on economics. Resource additions in this period are unlimited, subject to technical resource potential.

Bill analysis assumptions

For each state in PJM, we analyzed electricity bill impacts for two customer groups: residential customers, and commercial and industrial (C&I) customers. We calculated monthly bills using energy, capacity, new transmission, and Renewable Energy Credit (REC) costs from our capacity expansion modeling results. Legacy system costs (existing transmission, distribution, and other sunk costs) are assumed to be held constant in both scenarios and do not contribute to bill impacts. Regional Greenhouse Gas Initiative (RGGI) revenues are credited to RGGI states to account for RGGI revenue recirculation. Appendix B provides further detail on our bill analysis methodology.

Job impact analysis assumptions

For each state in PJM, we analyze the jobs that would be foregone by adhering to the Status Quo scenario, rather than unlocking the benefits modeled in the Expanded Queue Reform scenario. This analysis was performed using cost data generated via capacity-expansion modeling, alongside job-per-million-dollar-spent factors generated from the IMPLAN model.[22] Appendix C provides further detail on our job impact analysis methodology.

[22] For more information on the IMPLAN model, see https://implan.com./.

2. RESULTS

This section describes the key findings of our analysis, including results related to bill impacts, system costs, capacity, generation, CO_2 emissions, and other findings.

2.1. Expanding interconnection reforms unlocks ratepayer bill savings

Figure 2 shows the trajectory of projected annual PJM residential household spending in both scenarios. Relative to the Status Quo scenario, the Expanded Queue Reform scenario has average annual household saving around $62 per year in the near term (2025–2030), $491 in the medium term (2031–2035) and $1,062 in the longer term (2036–2040). This averages savings of $505 per year over the entire study period.

While bills continue to rise in the medium term in both scenarios, bill increases are substantially lower in the Expanded Queue Reform scenario.

In the near term, bills rise in both scenarios relative to recent historical levels (2021–2023). This is because of rising capacity market costs due to low levels of resource deployment caused by long interconnection times in recent years. This dynamic is also causing projected energy prices to rise, due to a greater reliance on inefficient, costly, fossil fuel-powered resources.

In the medium term, while bills continue to rise in both scenarios, bill increases are substantially lower in the Expanded Queue Reform scenario. In this period, bill savings in the Expanded Queue Reform scenario are primarily driven by lower energy market costs, while capacity market costs remain high in both scenarios (Section 0 below further discusses trends in energy and capacity market costs).

In the long term, once interconnection queue constraints are assumed to be entirely resolved in the Expanded Queue Reform scenario, there are savings in both energy and capacity market costs that lead to greater bill reductions. During this period, bills are lower than in recent historical years. Under the Status Quo scenario, residential electricity bills are expected to increase by nearly 60 percent compared to historical levels in the next 10–15 years. In the Expanded Queue Reform scenario, bills are projected to decrease by 8 percent over the same time period.

Table 4 and Table 5 summarize state-level bill impacts.[23] Table 4 shows the average state-level residential bill impacts over the whole model period, Table 5 shows the trajectory of residential bills over time and Table 6 shows the state-level bill impacts for C&I customers. While each state contains multiple utilities, these bill impacts represent the average bill impacts across all ratepayers.[24] In general, savings are greatest in states with the largest projected increases in electricity demand, greatest per capita energy consumption, and the most ambitious RPS programs. In Pennsylvania, for example, the

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[23] We conducted this state-level analysis for states that are either entirely, or almost entirely, located within PJM's territory.

[24] These bill impacts are also averaged across retail choice and non-retail choice customers.

average household saves $501 per month over the study period. Bill impacts are smaller in states with greater quantities of imported energy from neighboring regions.

Figure 2. Annual residential household energy costs, average in PJM

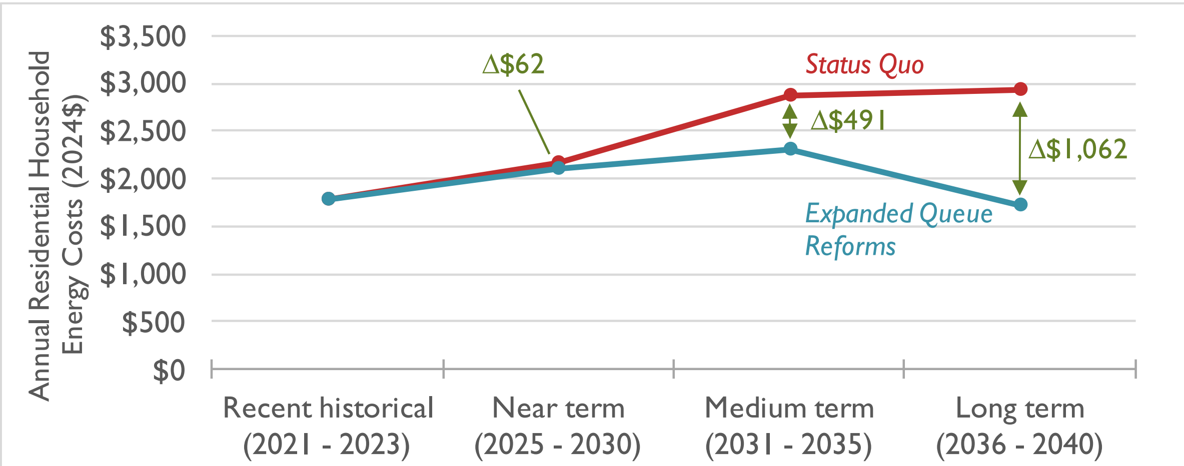

Table 4. Annual residential household energy costs, state-level average over 2025-2040 period (2024 dollars)

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PA	$2,531	$2,030	-$501
VA	$2,690	$1,963	-$727
WV	$2,630	$2,052	-$578
PJM Average	$2,327	$1,821	-$505

Table 5. Annual residential household energy costs, state-level trajectories (2024 dollars)

		Status Quo			Expanded Queue Reform			Savings		
	Recent Histor-ical	Near term	Mid term	Long term	Near term	Mid term	Long term	Near term	Mid term	Long term
DC	$1,266	$1,468	$2,043	$1,999	$1,408	$1,470	$1,164	-$60	-$573	-$835
DE	$1,664	$1,997	$2,402	$2,597	$1,882	$2,040	$1,492	-$115	-$363	-$1,105
MD	$1,794	$2,048	$2,633	$2,456	$1,956	$2,003	$1,451	-$93	-$630	-$1,006
NJ	$1,468	$1,775	$2,092	$2,189	$1,694	$1,744	$1,336	-$81	-$347	-$853
OH	$1,544	$1,774	$2,431	$2,427	$1,780	$2,001	$1,464	$5	-$430	-$963
PA	$1,707	$2,151	$2,638	$2,881	$2,047	$2,266	$1,773	-$104	-$372	-$1,108
VA	$1,801	$2,154	$3,205	$2,818	$2,041	$2,355	$1,478	-$113	-$851	-$1,340
WV	$1,771	$2,165	$2,876	$2,943	$2,110	$2,317	$1,719	-$55	-$559	-$1,224
PJM Avg.	**$1,605**	**$1,918**	**$2,585**	**$2,557**	**$1,856**	**$2,094**	**$1,495**	**-$62**	**-$491**	**-$1,062**

Note: Recent historical data includes 2021–2023. Near-term period includes 2025–2030, mid-term includes 2031–2035 and long term includes 2036–-2040.

Table 6. C&I bill impacts of Expanded Queue Reform scenario, relative to Status Quo scenario

	Near-term	Mid-term	Long-term	Average over study period
DC	-4%	-28%	-42%	-24%
DE	-6%	-15%	-42%	-21%
MD	-5%	-24%	-41%	-23%
NJ	-5%	-17%	-39%	-19%
OH	0%	-18%	-40%	-21%
PA	-6%	-14%	-38%	-20%
VA	-6%	-27%	-48%	-28%
WV	-3%	-20%	-42%	-24%
PJM. Avg.	**-3%**	**-20%**	**-42%**	**-23%**

Note: Recent historical data includes 2021–2023. Near-term period includes 2025–2030, mid-term includes 2031–2035 and long term includes 2036–2040. The average over the study period includes 2025–2040.

2.2. Increased resource additions drive down cumulative energy and capacity market costs

Resolving queue constraints achieves savings in both the energy market and capacity market (see Figure 3). Over the study period, the Expanded Queue Reform scenario saves $414 billion in system costs relative to the Status Quo scenario, representing a 24 percent reduction in costs (see Figure 4).

In the near term (2025–2030), capacity market costs remain high in both scenarios, relative to recent historical prices. Although the Expanded Queue Reform is adding a greater quantity of firm capacity than the Status Quo scenario, the pace of additions is still slower than the rate at which peak load is projected to increase in this period, leading to the capacity market clearing at or near its maximum allowable price in both scenarios. At the same time, near-term energy price increases are slightly lower in the Expanded Queue Reform scenario. This is because there are slightly more zero-marginal cost renewable energy and battery storage resources added, which reduces reliance on inefficient, costly generation.

In the medium term (2031–2035), while the Expanded Queue Reform has lower total system costs in each year, the total capacity market costs are slightly higher in some years. This is because the capacity market prices are hitting the maximum allowable prices in both scenarios and there is a greater quantity of firm capacity in the Expanded Queue Reform scenario. However, energy market costs are significantly lower in the Expanded Queue Reform scenario in this period due to greater levels of renewable energy and battery storage, more than offsetting the rise in capacity costs.

In the long term (2036–2040), we assumed interconnection queue constraints to be entirely resolved in the Expanded Queue Reform scenario, and the model is able to fully economically optimize resource additions. During this period, capacity market costs are reduced by an average of $16 billion per year, relative to the Status Quo scenario. Energy prices are also reduced in this period due to the sizable buildout of onshore wind.

REC costs are present in both scenarios. New transmission costs are present in the Expanded Queue Reform scenario. However, both of these costs are small relative to the size of the annual capacity and energy market costs. While REC costs and new transmission costs do not appear in Figure 3 or Figure 4 below, both of these cost categories are included in the bill analysis described above.

Figure 3. PJM annual energy and capacity market values (2025–2040)

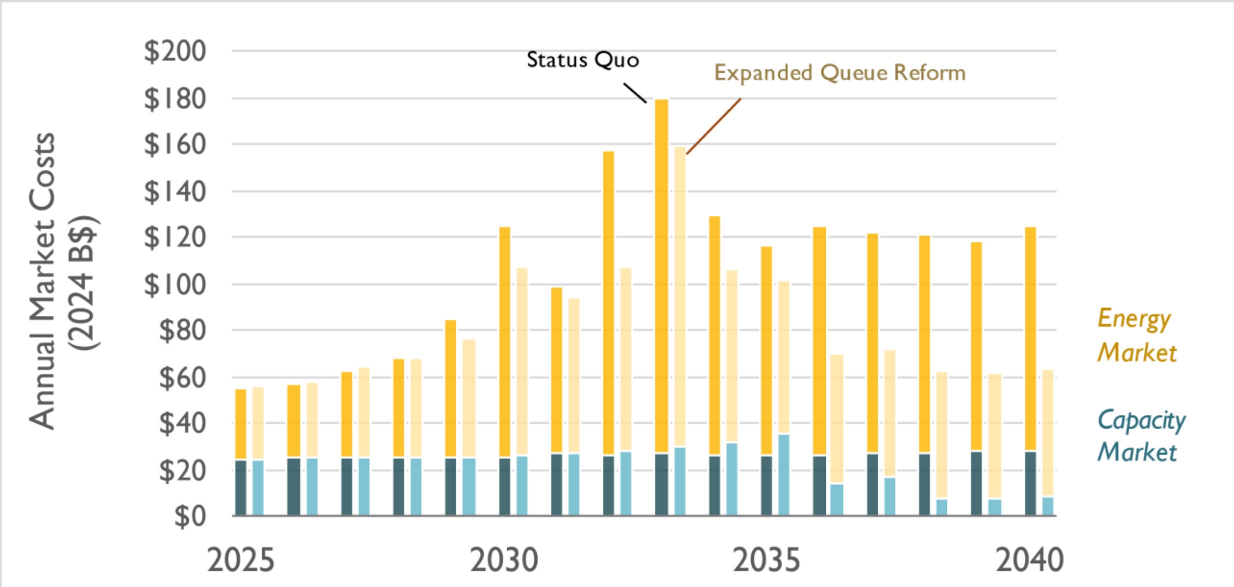
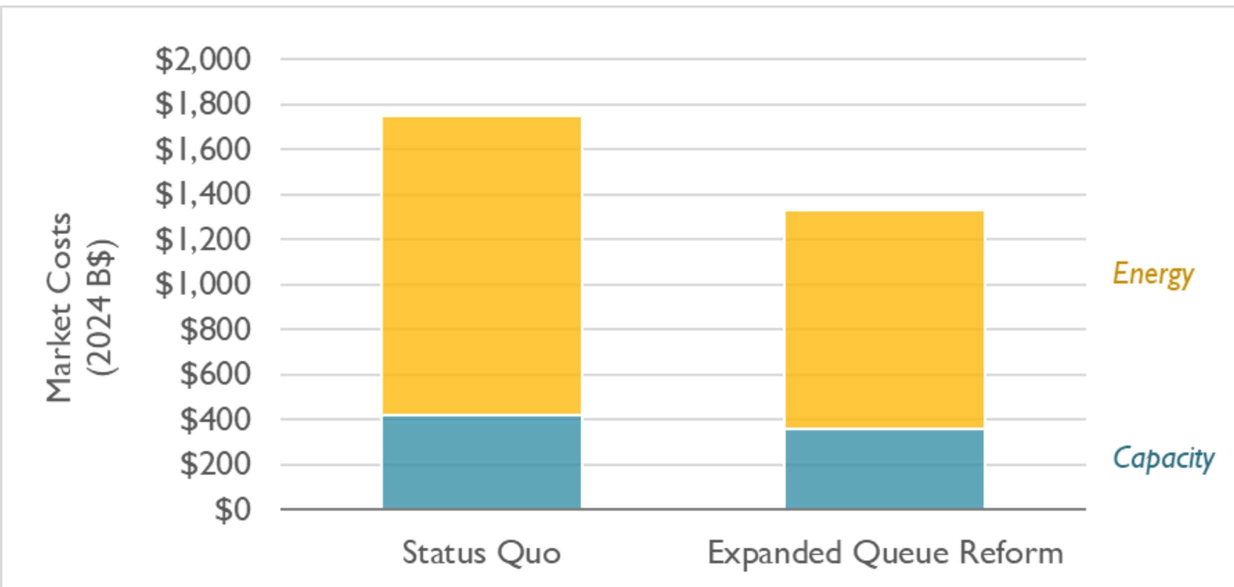


Figure 4. Total cumulative PJM system costs (2025–2040)



2.3. Expanding queue reforms enables greater resource additions and shifts generation to newer resources

Operational capacity is shown in Figure 5 (Status Quo scenario) and Figure 6 (Expanded Queue Reform scenario). By 2040, the Expanded Queue Reform scenario builds an additional 57 GW of clean energy and 117 GW of battery storage, relative to the Status Quo scenario. This quantity of clean energy generation could power around 17 million households.

In the Status Quo scenario, the new resource build constraints are binding in almost every year, with only minor variations in annual builds. In the near term (2025–2030), the model builds an average of 3 GW of utility-scale solar per year, an average of 1 GW of wind (onshore and offshore combined) per year, 1.4 GW of new gas per year, and less than 1 GW per year of battery storage per year. Builds continue similarly in the medium term (2031–2035) and long term (2036–2040), except for the RRI gas and storage additions, which are modeled as coming online in 2031.

In the Expanded Queue Reform scenario, new resource builds start to diverge from the Status Quo scenario in 2028. By 2030, the Expanded Queue Reform scenario has 10 GW more solar and 5 GW more battery storage than the Status Quo scenario. In the medium term (2031–2035), the Expanded Queue Reform scenario builds twice as much new gas, six times as much onshore wind, and ten times as much battery storage as the Status Quo scenario. In the long term (2036–2040), 6 GW more existing gas is retired while 31 GW of additional new gas is built compared to the Status Quo scenario.

Figure 5. Operational capacity in Status Quo scenario (2025–2040)

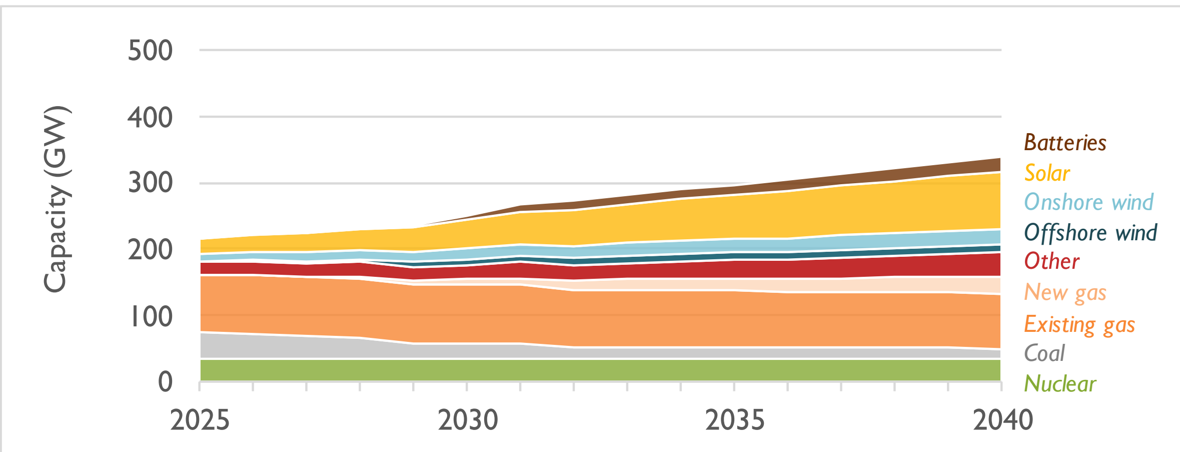
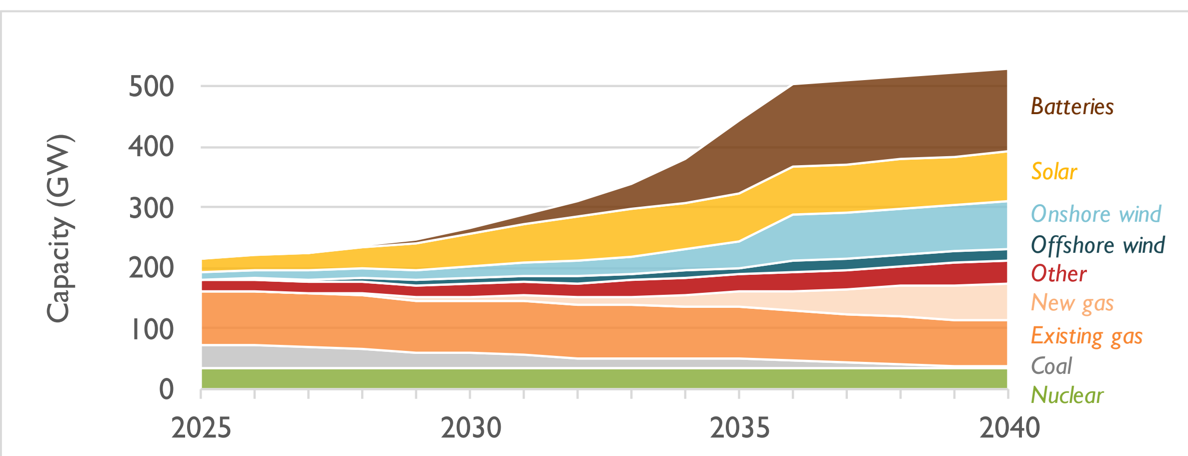


Figure 6. Operational capacity in Expanded Queue Reform scenario (2025–2040)



Due to the reduced resource additions, the Status Quo scenario has worse resource adequacy compared to the Expanded Queue Reform scenario. Peak load grows by 95 GW (60 percent increase) from 2025 to 2040 in both scenarios. In the Status Quo scenario, these increases in peak load outpace increases in firm capacity throughout the model period. Although our model is able to serve load in every hour for the weather year that we modeled, the Status Quo portfolio of resources would be unlikely to reliably serve load under a range of weather years. In the Expanded Queue Reform scenario, firm capacity additions ramp up significantly from 2030 to 2036 to keep pace with peak load increases. As the interconnection queue constraints gradually loosen and resource additions accelerate, the resource adequacy of the Expanded Queue scenario improves. The largest differential contributors to firm capacity in the Expanded Queue Reform scenario by 2040 are battery storage (59 GW more firm capacity than Status Quo), new gas combined-cycle units (25 GW more firm capacity than Status Quo), and onshore wind (8 GW more firm capacity than Status Quo).

Load grows by 640 TWh (79 percent increase) over the modeled period. The majority of this load growth is due to data centers, which are projected to grow by 422 TWh. Generation, loads, and net imports for each scenario are shown in Figure 7 and Figure 8. By 2040, the Expanded Queue Reform scenario has:

- **Increased renewable energy generation:** This scenario has 171 TWh more renewable energy generation. The share of generation from solar and wind increases from 19 percent in the Status Quo scenario to 31 percent in the Expanded Queue Reform scenario.

- **Reduced fossil generation:** Coal generation is reduced by 95 percent and total gas generation is reduced by 8 percent in 2040, relative to the Status Quo scenario. Although there is 28 percent more gas capacity in this scenario, gas has a lower utilization rate.

- **Reduced reliance on imports:** This scenario has 75 TWh fewer imports from other regions. The share of generation from imported energy is reduced from 12 percent in the Status Quo scenario to 7 percent in the Expanded Queue Reform scenario.

Figure 7. Generation, loads, and net imports for Status Quo scenario (2025–2040)

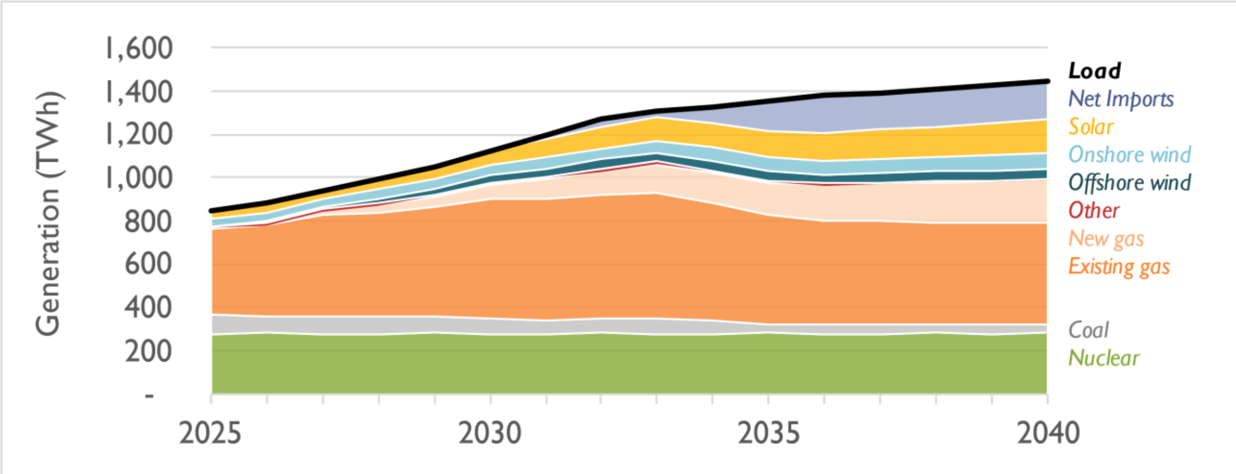
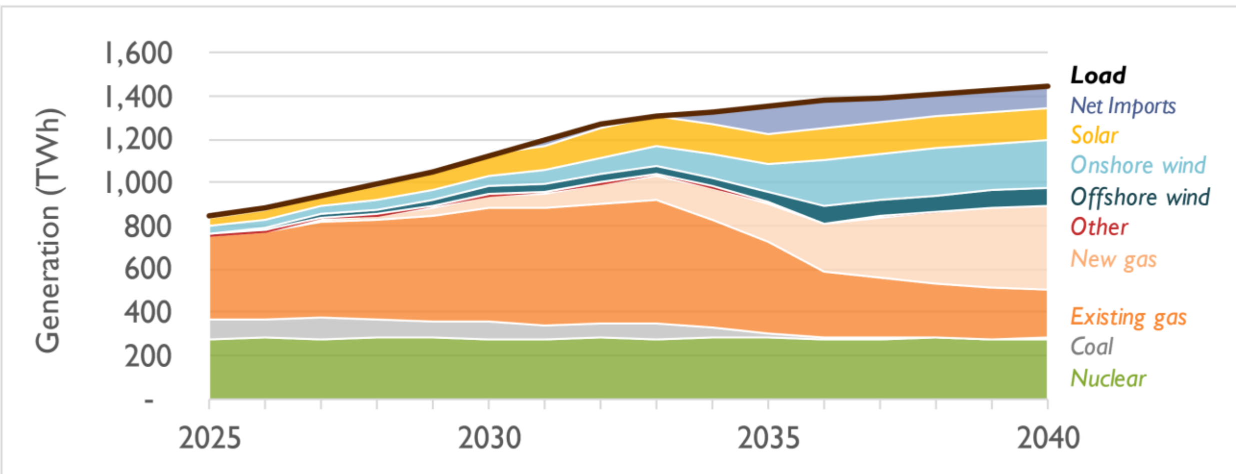


Figure 8. Generation, loads, and net imports for Expanded Queue Reform scenario (2025–2040)



2.4. Unlocking the interconnection queue would boost jobs in the PJM region

To estimate the job impacts of the PJM interconnection queue delays, we conducted a forward-going analysis of the projected net job impacts from 2025 through 2040 based on our EnCompass modeling and bill analysis results. We calculated job impacts based on two primary inputs: the amount of money spent on a particular activity in a given year, and the jobs associated with spending money on that activity (a "job factor"). All of our job impact analyses report results in terms of full-time equivalent (FTE) jobs. For further details on our job impact methods, see Appendix C.

Using data from the IMPLAN model, we estimated the annual impacts on jobs resulting from the Expanded Queue Reform scenario, relative to the Status Quo scenario Figure 9 shows that over the study period, the PJM region stands to gain an average of more 313,000 per year, or a total of 5 million FTE jobs from 2025-2040. Table 7 shows the breakdown of these impacts by whether they are direct, or indirect and induced jobs. Job impact estimates include those related to initial construction, ongoing fueling, operations and maintenance (O&M), and respending.

Table 7 shows the state-level average annual job impacts per year over the model period. In general, states with larger quantities of incremental resource additions in the Expanded Queue Scenario and states with the largest bill savings tend to have the greatest job impacts. States such as Virginia and Ohio that are assumed to have higher levels of load growth, along with relatively less expensive solar and storage resources, feature the largest annual average direct job impacts.

Figure 9. PJM-wide net job impacts from the Expanded Queue Reforms, relative to the Status Quo scenario

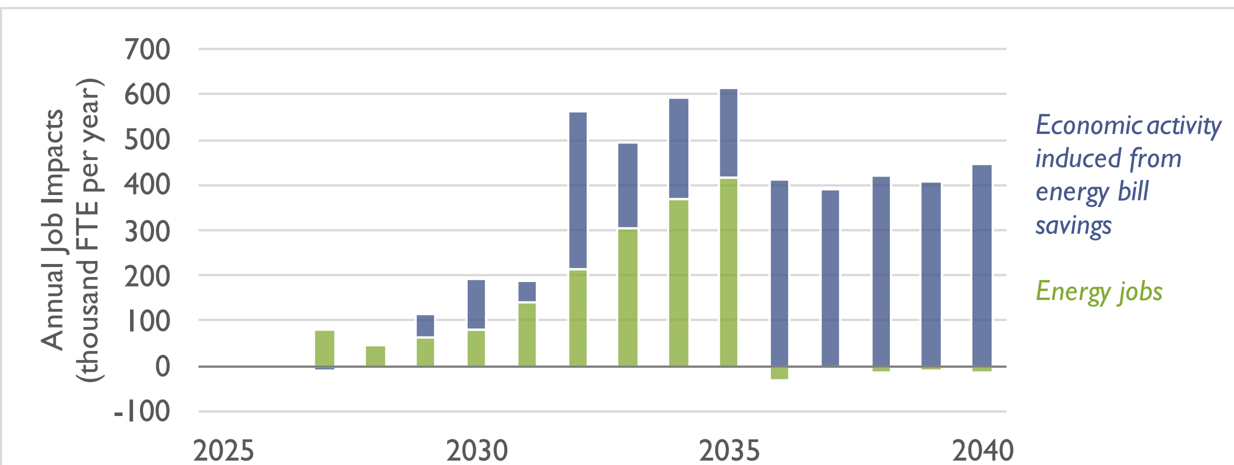


Table 7. State-level average annual net job increases from the Expanded Queue Reforms scenario, relative to the Status Quo scenario (FTE per year)

State	Annual average direct job impacts*	Annual average indirect and induced job impacts	Annual average job impact, all types
DC	3,100	5,700	8,900
DE	200	2,800	3,000
MD	400	17,400	17,800
NJ	400	22,600	23,000
OH	19,700	40,500	60,100
PA	4,900	32,600	37,500
VA	23,700	86,400	110,100
WV	3,600	8,300	11,800
Other states	13,200	27,500	40,800
PJM total	**69,200**	**243,900**	**313,000**

** The majority of direct jobs are due to clean energy additions.*

Note: All job impacts shown are resultant of differences between the two scenarios. This table does not indicate the job impacts resulting from resources deployed in both scenarios (e.g., specific offshore wind projects that are assumed to be built in both scenarios).

Large increases in employment in individual years are linked to in-region construction of solar, wind, and battery storage. In general, job impact trends through the mid-2030s track closely with resource additions. Electricity bill reductions enable consumers to spend less money on electricity, increasing their opportunities to use that money for other purposes and stimulate job growth. In later years, job impacts are primarily driven by bill savings, as customer spending is substantially reduced once the interconnection queue constraints are assumed to be resolved.

The PJM region serves approximately 65 million people. Assuming the employment-population ratio in the PJM region is equal to the current national average (59.9 percent), there are approximately 39 million jobs in the PJM region.[25] An increase in full-time employment of 313,000 jobs represents an increase of about 1 percent.

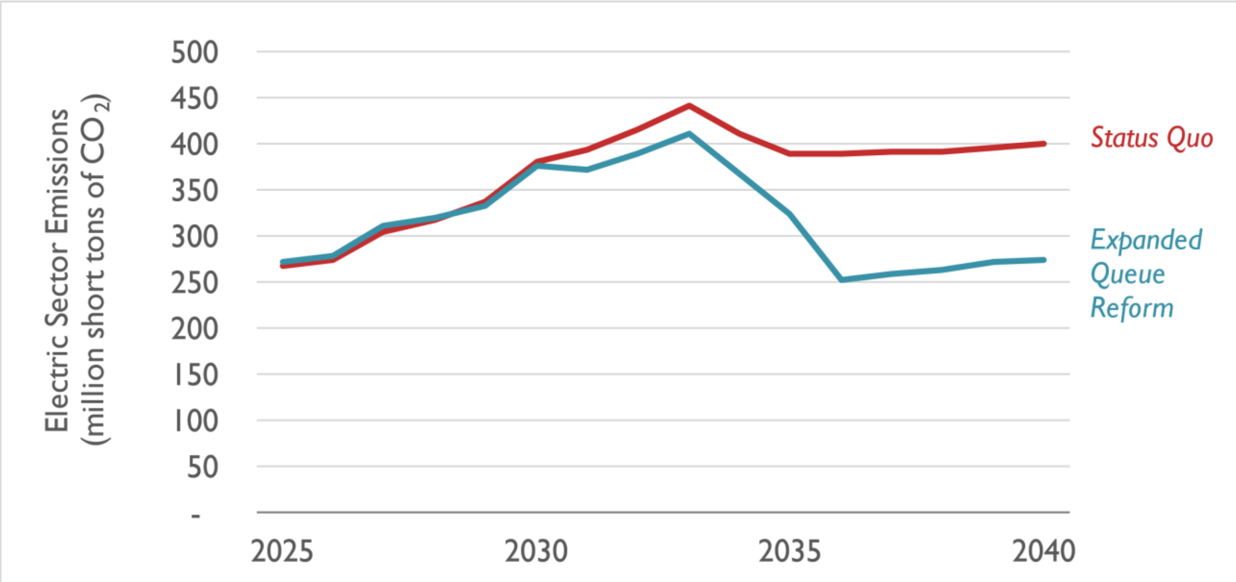
2.5. A more diverse resource portfolio with greater amounts of clean energy reduces carbon dioxide emissions

The Expanded Queue Reform scenario results in a substantial decrease in CO_2 emissions in PJM. Over the entire modeling horizon from 2025 through 2040, electric sector CO_2 emissions from generation in PJM are 825 million short tons lower than in the Status Quo scenario, representing a reduction of 14 percent (see Figure 10). Annual CO_2 emissions in each scenario remain similar through 2030, after which the differences in resource builds begin to compound in the Expanded Queue Reform scenario, leading

[25] Bureau of Labor Statistics. "The Employment Situation – February 2025". Available at: https://www.bls.gov/news.release/pdf/empsit.pdf

to greater levels of renewable energy and less fossil generation. Over the final five years of modeling (2036–2040), the Expanded Queue Reform scenario emits at least 120 million fewer short tons of CO_2 per year compared to the Status Quo scenario.

Figure 10. Electric sector CO_2 emissions from energy consumption in PJM (2025–2040)



Note: This figure includes emissions from imported energy, as well as generation in PJM. We assume the average emissions rate of imported energy is equal to PJM's average emissions rate in each year.

3. DISCUSSION

Our analysis illustrates that an expanded set of interconnection queue reforms would provide economic and environmental benefits to ratepayers. There is a range of possible queue reforms that could enable PJM to reach the levels of resource builds and accompanying cost savings that are modeled in the Expanded Queue Reform scenario. While the Expanded Queue Reform scenario does include an ambitious projected quantity of resource additions, the unprecedented levels of load growth that PJM is projecting will necessitate a hefty amount of new generation resources, should these load projections materialize. Below, we summarize potential reforms that are described more thoroughly in other recent studies.[26]

3.1. General principles to guide interconnection reforms

Overall, effective PJM interconnection reforms could target the following four goals:

- **Improve the interconnection timeline to meet projected load growth.** The interconnection process should move as quickly as is feasible, and interconnection customers should have a high degree of certainty around the expected interconnection wait times.[27] PJM should revise its existing interconnection processes to match the 150-day study timeline required by FERC Order 2023, as mentioned below.

- **Increase data access and transparency to improve project proposal quality and promote competition.** Improving data transparency would improve developer's abilities to screen and site potential projects, facilitate more process automation, and enable auditing of interconnection processes. Transparency also ensures fairness, equity, and competition in the interconnection process.[28]

- **Promote economic efficiency.** Enhanced coordination between transmission planning and interconnection processes would allow for the rightsizing of transmission investments. Updating cost allocation methods would reduce uncertainty for developers and improve allocative efficiency. [29]

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[26] GridStrategies and Brattle Group. 2024. "Unlocking America's Energy." Available at: https://gridstrategiesllc.com/wp-content/uploads/Exec-Sum-and-Report-Unlocking-Americas-Energy-How-to-Efficiently-Connect-New-Generation-to-the-Grid.pdf.

[27] GridStrategies and Brattle Group. 2024. "Unlocking America's Energy." Available at: https://gridstrategiesllc.com/wp-content/uploads/Exec-Sum-and-Report-Unlocking-Americas-Energy-How-to-Efficiently-Connect-New-Generation-to-the-Grid.pdf.

[28] U.S. Department of Energy. 2024. "Transmission Interconnection Roadmap." Available at: https://www.energy.gov/sites/default/files/2024-04/i2X%20Transmission%20Interconnection%20Roadmap.pdf.

[29] U.S. Department of Energy. 2024. "Transmission Interconnection Roadmap." Available at: https://www.energy.gov/sites/default/files/2024-04/i2X%20Transmission%20Interconnection%20Roadmap.pdf.

- **Ensure nondiscriminatory treatment between different resource types.** Equitable treatment across different resource types, as required by the Federal Power Act,[30] increases competition, which ultimately benefits consumers by resulting in the most cost-effective power available. To achieve this, PJM can address the current treatment of energy storage resources, which assumes energy storage operates at times of peak demand and creates unnecessary barriers to storage deployment. PJM can also require interconnection studies to evaluate grid-enhancing technologies like advanced conductors that can reduce interconnection costs.

To achieve this set of goals, PJM will need to implement both FERC Order 2023 and FERC Order 1920 fully and in a timely fashion. More broadly, it will need to better integrate its transmission planning with its interconnection process.

3.2. FERC Order 2023

FERC Order 2023 directs transmission providers to reform their interconnection procedures to reduce queue backlogs, improve certainty in interconnection processes, and ensure access to the transmission system for new technologies.[31] In order to comply with Order 2023, PJM will need to:

- Achieve a 150-day timeline requirement for all interconnection studies;
- Implement the first-ready, first-served cluster study approach on time for the regular-order queue;
- Implement realistic modeling assumptions around energy storage behavior, rather than assuming energy storage will charge during peak and require associated transmission upgrades;
- Require that interconnection studies evaluate a range of alternative transmission technologies, including grid-enhancing technologies; and
- Dedicate more resources to interconnection, if needed, to address the large queue backlog, reopen the queue, and achieve Order 2023 deadlines.

Order 2023 also required that transmission providers face penalties for delays in study timelines. These penalties should come with safeguards that protect electricity customers from price increases. In order for penalties to be effective, the cost-burden must be borne by the entity with control over the outcome, in this case, PJM and its leadership.

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[30] The Federal Power Act requires that rates, terms, and conditions of interconnection services must be reasonable and not unduly discriminatory.

[31] Federal Energy Regulatory Commission (FERC). 2025. "Explainer on the Interconnection Final Rule." Available at: https://www.ferc.gov/explainer-interconnection-final-rule#:~:text=On%20July%2028%2C%202023%2C%20the,%2C%20or%20May%2016%2C%202024.

Other RTOs have begun taking these steps. For example, CAISO matched the 150-day timeline and adopted FERC's requirement that interconnection studies reflect the proposed charging behavior of energy storage to ensure a level playing field for these resources[32], and SPP implemented financial penalties for study delays and adopted FERC's language requiring the study of alternative transmission technologies.[33]

3.3. FERC Order 1920

FERC Order 1920 is a new transmission and cost allocation rule that includes specific requirements regarding how transmission providers must conduct long-term planning.[34] The order includes requirements related to regularly conducting long-term transmission planning to anticipate future needs, assessing a broad set of benefits in the planning process, and considering grid-enhancing technologies (GET). GETs can help unlock increased hosting capacity on the grid and reduce grid upgrade fees.

3.4. Reforms requiring FERC approval

To unlock greater resource additions in the longer term, PJM can better integrate its interconnection study process with its long-term transmission planning. PJM is a region with substantial transmission constraints and PJM’s current piecemeal approach to implementing transmission upgrades will likely perpetuate the existing cost barriers causing projects to drop out. As such, the region would benefit from a proactive and holistic transmission planning process that anticipates likely locations for clean energy resources throughout the region. Such a process will also help address reliability concerns and bring down capacity prices.

Key outstanding reforms that will require FERC approval include:

- Increasing cost certainty for developers through a fixed interconnection entry fee, calculated through proactive planning and modeling for each zone; and
- Developing a fast-track process for projects in areas with available interconnection headroom, which would encourage rapid deployment in regions that have interconnection headroom, as assessed by proactive modeling.

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[32] CAISO. 2024. Tariff Amendment to Comply with Order No. 2023. Docket No. ER24-2042-000. Available at: https://www.caiso.com/documents/may16-2024-compliancefiling-ferc-orderno-2023-er24-2042.pdf

[33] SPP. 2024. Orders Nos. 2023 and 2023-A Compliance Filing. Docket No. ER24-2026-000. Available at: https://www.spp.org/documents/71631/20240516_order%20nos.%202023%20and%202023-a%20compliance%20filing_er24-2026-000.pdf

[34] FERC. 2024. “Building for the Future Through Electric Regional Transmission Planning and Cost Allocation.” Available at: https://www.ferc.gov/news-events/news/fact-sheet-building-future-through-electric-regional-transmission-planning-and#:~:text=FERC's%20new%20transmission%20and%20cost,projects%20from%20which%20they%20benefit.

In addition to the PJM interconnection queue, there are other supply-side constraints that are either currently limiting or have the potential to limit new resource additions. These include local permitting processes, potential proposed changes to tariffs and clean energy tax credits, and global supply chain constraints. While solving the interconnection queue will not resolve all supply-side constraints, it will remove a critical bottleneck to protecting ratepayers from large cost increases. Policy interventions in these other areas, such as Pennsylvania's recently proposed Lightning Plan that includes siting reforms, will also be necessary to fully realize the benefits of a reformed queue.

APPENDIX A. CAPACITY EXPANSION MODELING METHODS AND ASSUMPTIONS

Developed by Yes Energy, EnCompass is a single, fully-integrated power system platform that allows for utility-scale generation planning and operations analysis.[35] EnCompass is an optimization model that covers all facets of power system planning, including the following:

- Short-term scheduling, including detailed unit commitment and economic dispatch
- Mid-term energy budgeting analysis, including maintenance scheduling and risk analysis
- Long-term integrated resource planning, including capital project optimization and environmental compliance
- Market price forecasting for energy, ancillary services, capacity, and environmental programs

EnCompass provides unit-specific, detailed forecasts of the composition, operations, and costs of the regional generation fleet given the assumptions described in this document. Synapse has populated the model using the *EnCompass National Database*, created by Horizons Energy. Horizons Energy benchmarked its comprehensive dataset across the 21 North American Electric Reliability Corporation (NERC) Assessment Areas, and it incorporates market rules and transmission constructs across 76 distinct zonal pricing points. Synapse uses EnCompass to first benchmark historical years, and then optimize the generation mix in PJM, NYISO, and ISO New England and to estimate the costs of a changing energy system over time.

Table 8 describes input assumptions that are held constant in our Encompass modeling across both scenarios.

Table 8. Input assumptions that are held constant in both scenarios

Input category	Assumption
Policies	
States' RPS and clean energy policies	All states receive existing renewable portfolio standards and clean energy policies.
REC availability	All RECs consumed in PJM are produced in PJM.
RGGI	We assume VA and PA are either active RGGI states or implement RGGI-like programs beginning in 2026.
Inflation Reduction Act tax credits	Model may build wind or solar plants that utilize either the investment or production tax credits. Storage facilities receive the investment tax credit. We do not plan to model nuclear tax credits (45U) and instead assume that these tax credits are sufficient to prevent the retirement of all existing nuclear plants.

[35] More information on EnCompass and the Horizons dataset can be found at https://www.yesenergy.com/encompass-power-system-planning-software.

Input category	Assumption
	We do not model additional funding provided by the IRA explicitly, and instead assume that IRA funding enables the level of electrification we are modeling.
New Resources	
Build dates	All resources are allowed to build endogenously starting in 2027. Section 1.2 describes annual resource build constraints.
Planned and under construction units	All resources identified as planned or under construction in 2024–2026 in EIA 860 are modeled as coming online.
Conventional gas combined-cycle and gas turbine	EPA's 111 rule for new gas plants is not modeled.
Adv. nuclear reactors / SMRs	Not included in model.
Hourly renewable dispatch shapes 8760	2013 weather year data shapes from Horizon's National Database. This weather year is consistent with the conventional load shape data year (which also uses 2013).
Utility-scale solar, onshore wind, and offshore wind	Cost trajectories are based on NREL Annual Technology Baseline 2024, Moderate trajectory. We also include a +25% cost adder for solar and onshore wind to reflect current supply chain challenges. We include all known, named offshore wind projects that have commercial operation dates in both scenarios.
Wind and solar potentials, cost adders, and capacity factors	Location-specific cost-adders are based on data from U.S. EPA's IPM modeling.[36] Wind and solar capacity factors are based on data from U.S. EPA's IPM modeling.
Utility-scale battery storage	4-, 6-, 8-hour storage allowed beginning 2024. Prices are based on NREL 2024 Annual Technology Baseline, moderate trajectory.
Long-duration storage	100-hour battery costs from Form Energy.[37]
Distributed solar	Follows PJM 2025 Load Forecast. *(9.7 GW in 2024, 25 GW by 2033 total for the PJM region)*
Existing Resources	
Fossil retirement specifications	All fossil plants are allowed to choose to retire beginning 2027. All resources with currently announced retirements must retire by their announced retirement date at the latest (these dates are based on the latest EIA data).
Nuclear retirement specifications	All existing nuclear plants without retirement dates are assumed to continue operating for this study period. We assume tax credits from the IRA will be sufficient to keep these nuclear plants online.
U.S. EPA air regulations	Various coal, gas, and oil plants are assumed to be affected by finalized EPA rules including Good Neighbor MATS, ELGs, and PM NAAQS. Plants receive controls and associated costs based on EPA specifications, existing controls, ages, announced retirement dates, and plant characteristics. EPA's 111 rule is not included.
Topology	
Modeled regions	Our capacity expansion model includes PJM, NYISO, ISO New England. Results are only reported for PJM. We modeled each of these regions with load zones that can

[36] Documentation on EPA's IPM modeling is available here: https://www.epa.gov/power-sector-modeling/documentation-2023-reference-case.

[37] Form Energy. 2023. "The value of multi-day energy storage in New England." Available at: https://formenergy.com/insights/the-value-of-multi-day-energy-storage-in-new-england/.

Input category	Assumption
	transfer power within itself and to each other. Connections to other regions are modeled exogenously.
Existing transmission	Interzonal transmission capacity based on the latest available data published by PJM and other ISOs. We do not model intrazonal transmission
New transmission	New interzonal transmission can be built starting in 2027 in Expanded Queue Reform scenario. No new transmission in Status Quo scenario. Transmission costs are based on data published by NREL in a 2022 analysis.[38]
Capacity market parameters	
Capacity accreditations	Accredited at levels recently announced by PJM in January 2024 Docket No. ER24-99.
Demand curves and reserve margins	Based on PJM's planning parameters for the 2025/2026 capacity market auction. Capacity price caps from PJM's settlement with Pennsylvania are used for the 2026/2027 and 2027/2028 auctions.
Fuel prices	
Natural gas	Near-term Henry Hub prices based on NYMEX data; longer-term prices based on data from EIA's Annual Energy Outlook 2023 Reference Case (AEO). Basis adders are developed using Horizons NDB data.
Oil	Based on data from EIA's AEO 2023.
Coal	Based on data from EIA's AEO 2023.
Modeling settings	
EnCompass capacity expansion modeling horizon	2025–2040.
Temporal detail	Each month is modeled with a typical on-peak and a typical off-peak day. Each day is subdivided into 6 time-intervals.
Optimization periods	We used four-year optimization periods.

[38] National Renewable Energy Laboratory. 2022. "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035." Available at https://www.nrel.gov/docs/fy22osti/81644.pdf.

APPENDIX B. BILL ANALYSIS METHODS

Our state-specific bill impact modeling uses data from our EnCompass modeling, as well as publicly available data published by EIA. It includes the following assumptions:

- Forward-going costs for energy, capacity, new transmission, and RECs are projected using the EnCompass model.
- Non-market costs (e.g., costs of distribution, utility return on equity, and legacy plant costs) are derived from historical data. Specifically, using recent historical data, we subcontract wholesale energy costs (as projected by EnCompass for historical years) from statewide revenues for each PJM state, as collected by EIA in Form 860. The remaining quantity is assumed to be related to cost components not modeled in EnCompass, such as costs of distribution, utility return on equity, and legacy plant costs. We then assume these costs remain constant in real dollar terms in all future years. In future years, this constant component is added to the changing energy, capacity, new transmission, and REC costs to estimate total systemwide costs.
- Historical RGGI auction data informs the historical RGGI costs. Future RGGI allowances are calculated from data from the 2024 auction. The proportion of each state's RGGI allowance is held constant for the future study years. State RGGI revenues are subtracted from the bill impacts to account for revenue recirculation.
- Systemwide costs are allocated across two sectors: residential and C&I. Costs are allocated based on recent historical cost allocation, per data published by EIA 860. We assume this cost allocation would change slightly over time, in order to reflect a shift towards large load customers (e.g., data centers).
- We divide allocated costs by projected customer counts for each customer sector. Customer counts are based on recent historical data published by EIA 860 and are assumed to change in the future in line with load additions.

We performed this set of steps for each modeled scenario, for each state, for each customer category, and for each year.

APPENDIX C. JOB IMPACT ANALYSIS METHODS

Our job impact analyses combines cost data generated via our capacity-expansion modeling with job-per-million-dollar-spent factors generated from the IMPLAN model (and other inputs) to generate estimates of job changes over time. Our analyses are predicated on the following assumptions and methodologies:

- We calculate job impacts based on two primary inputs: the amount of money spent on a particular activity in a given year, and the jobs associated with spending money on that activity (a "job factor").
- All job factors used in our analysis are based on static snapshots of PJM's economy as it existed in the recent past. The makeup of PJM's economy may change in the future, with corresponding impacts on jobs. For example, if certain states in PJM became a hub for solar or battery manufacturing, net impacts to jobs could be even more positive than are currently calculated.
- Our analysis includes calculations of direct, indirect, and induced jobs. In other words, our analysis includes job impacts at the resources or facilities themselves, upstream impacts related to development of components for the resources or facilities, and other ripple effects in the economy related to respending energy bill savings and other effects.
- Our analysis is developed using state level job factors, which only account for in-state job impacts. As a result, it underestimates the total number of jobs that may be created throughout the PJM region. Likewise, our analysis focuses on impacts in the PJM region only. It does not account for positive or negative impacts that may accrue outside of PJM.