The impact of offshore wind in meeting coastal and inland load growth in PJM

June 17, 2026

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Executive Summary

The problem

PJM is facing twin reliability and affordability challenges — as demand grows five times faster than its historical rate,[1,2] driven by data centers, semiconductor fabrication and assembly plants, and industrial electrification. Even as demand is growing, new supply additions have nearly stalled: less than 20 megawatts (MW)[3] of new natural gas entered service in 2024–2025 while 1,700 MW retired,[4] and capacity prices have surged to record highs as the market signals scarcity. PJM is now facing substantive capacity shortfalls, driving spikes in capacity prices and elevated reliability risks.[5] Without corrective action, PJM may be forced to interrupt and curtail power going to new, incremental load. Alternatively, large load customers may cancel or delay projects (i.e., delay the interconnection of new factories or data centers to the grid) entirely due to the inability to access reliable and affordable power.

Surging demand for data center capacity as well as electrification of industry, transportation, and heating is driving load growth not seen in decades.

Demand growth, next 10 yrs	New gas added in 2024–25	Projected shortfall by 2033
3.6%/yr vs 0.69%/yr historically	**<20 MW** while 1,700 MW retired	**7.8 GW PJM-wide** 4.3 GW in Dominion

The demand surge is driven by AI data centers, semiconductor fabrication, and industrial electrification — industries that need *reliable and affordable* power to remain viable. If there is not enough generation, it may slow or block new industrial connections.

At the same time, the grid's riskiest hours are shifting toward winter

87% of PJM's reliability risk now falls in winter months — a dramatic shift from its historical summer-peaking profile. Winter stress events are typically longer and deeper than summer events and can result in rapid adverse health outcomes. Two recent storms show what this looks like in practice.

Winter Storm Elliott — Dec 2022	Winter Storm Fern — Jan-Feb 2026
At its worst, **47 GW went offline at once** — 24% of the entire fleet — mostly because gas couldn't flow when buildings needed heat and generators needed fuel at the same time.	8 consecutive days above 130 GW of load. Outages were better managed than Elliott but still required emergency EPA waivers to keep oil units running beyond their permit limits.

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1 CRA analysis.

2 PJM Interconnection, LLC, *2026 Load Forecast Report* (Audubon, PA: PJM Interconnection, LLC, January 14, 2026), https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.

3 Hitachi Energy, *Energy Market Insights Software Solution (Velocity Suite)* (energy analytics and market data platform), accessed December 2025, https://www.hitachienergy.com/us/en/products-and-solutions/energy-portfolio-management/energy-analytics-software-solutions/energy-market-insights-software-solution.

4 Ibid.

5 PJM Interconnection, LLC, *2027/2028 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, December 17, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2027-2028/2027-2028-bra-report.pdf.

The cost of inaction

Capacity shortfalls of this magnitude will require regulators to take urgent action — such as fast-tracking new resources, forcing services to be interruptible, or curtailing load. Curtailing load could have negative impacts given that load growth is overwhelmingly driven by strategic sectors — industrial growth and onshoring, data centers, semiconductor chip manufacturing, and EV battery manufacturing — as well as decarbonization of heating, industry, and transportation due to a combination of decarbonization, cost savings, and consumer preference. Without abundant, reliable, and affordable electrical generation and transmission, these strategic sectors may not fully materialize, which could result in adverse impacts across a range of factors including:[6,7,8,9,10,11,12,13, 14]

[6] Cybersecurity and Infrastructure Security Agency. (n.d.). Critical Manufacturing Sector. U.S. Department of Homeland Security. Retrieved January 19, 2026, from https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/criticalinfrastructure-sectors/critical-manufacturing-sector.

[7] "Trump Plans Executive Orders to Power AI Growth in Race with China," Reuters, June 27, 2025, https://www.reuters.com/legal/government/trump-plans-executive-orders-power-ai-growth-race-with-china-2025-06-27/.

[8] National Institute of Standards and Technology, The CHIPS Program Office Vision for Success: Two Years Later, (Gaithersburg, MD: NIST, 2025), https://www.nist.gov/document/chips-america-vision-success-two-year-report.

[9] National Institute of Standards and Technology, The CHIPS Program Office Vision for Success: Two Years Later, (Gaithersburg, MD: NIST, 2025), https://www.nist.gov/document/chips-america-vision-success-two-year-report.

[10] Uptime Institute, 2024 Data Center Resiliency Survey—Executive Summary, (Fort Collins, CO: Uptime Institute, 2024), https://datacenter.uptimeinstitute.com/rs/71−RIA145/images/2024.Resiliency.Survey.ExecSum.pdf?version=0&mkt_tok=NzExLVJJQS0xNDUAAAGSPCeKfdv0kYTrLS-6.

[11] Intel Corporation, *"Intel in Ohio: You Were Built For This,"* Intel, accessed February 20, 2026, https://www.intel.com/content/www/us/en/corporate-responsibility/intel-in-ohio.html

[12] Joint Legislative Audit and Review Commission. *Data Centers in* Virginia. 2024. https://jlarc.virginia.gov/pdfs/reports/Rpt598.pdf.

[13] Cybersecurity and Infrastructure Security Agency. "Critical Infrastructure Sectors." U.S. Department of Homeland Security. Accessed April 30, 2026. https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors. [cisa.gov]

[14] Cohen, Gabriel. "Mapped: The States With the Most U.S. Military Bases." Visual Capitalist, March 8, 2026. https://www.visualcapitalist.com/mapped-number-of-military-bases-by-state/

Economic development and onshoring: New large loads and stabilizing domestic manufacturing drive economic growth — each GW of Virginia data centers generates ~$1.8B in economic benefits, while Intel's Ohio One project is anticipated to create tens of thousands of jobs and add ~$2.8B annually to Ohio's GDP.

Critical infrastructure and military readiness: Electricity is critical infrastructure, and outages would disrupt essential services—hospitals, government operations, and daily life. PJM serves multiple major military installations and federal hubs. Virginia, Maryland, and Ohio respectively host 23, 13, and 8 military installations.

Smart manufacturing and decarbonization: Electrification is critical to decreasing emissions and meeting policy targets. Electrifying industry — like the port electrification project in New Jersey — can also reduce costs while unlocking greater automation and complexity in manufacturing processes.

National Security: Domestic data centers and semiconductor manufacturing reduce reliance on foreign-controlled infrastructure and supply chains. The CHIPS Act recognized this risk directly—over 90% of advanced chips are currently produced in Taiwan, creating critical vulnerabilities in defense systems, AI development, and communications technology that onshoring aims to address.

What offshore wind (OSW) can do

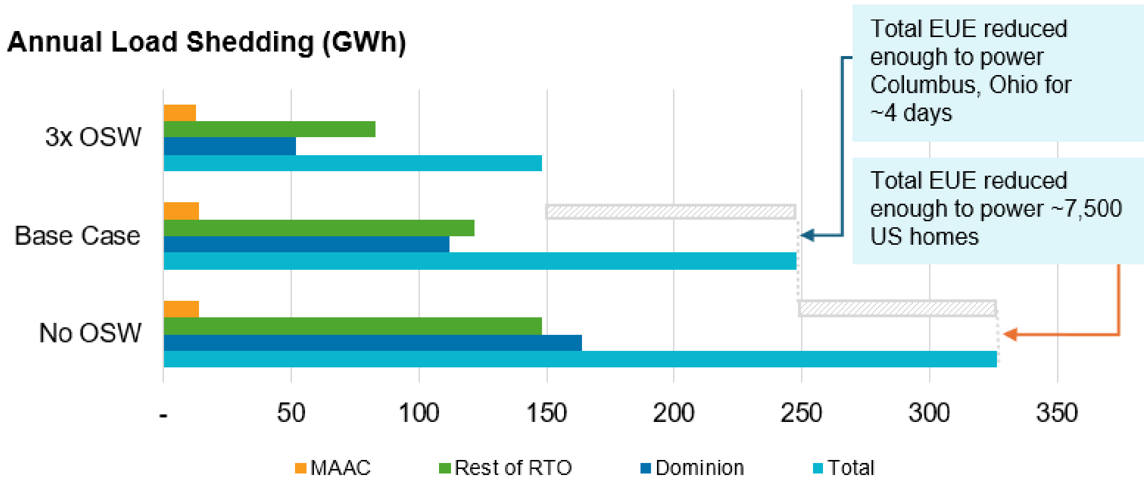
OSW is an emerging technology in PJM — today, only a single project is generating power or under advanced development, the 2.6 gigawatt (GW) Coastal Virginia Offshore Wind project (CVOW). Our analysis finds that OSW has the potential to play a material role in addressing PJM's emerging reliability gap, when paired with broader portfolio investment. Under our Base Case — which assumes **CVOW remains operational plus an additional 2 GW of Maryland** development by 2033, alongside current trajectories for all other resources — PJM still falls 7.8 GW short of its capacity target and faces 248 GWh of **expected unserved energy (EUE)**[15] annually, equivalent to cutting power to roughly 23,600 homes for an entire year.[16] These events would not be driven by small-scale outages all year, but show up as large-scale grid stress events affecting thousands of homes and businesses across PJM footprint. Against this backdrop, we

15 **Expected unserved energy** is the average amount of total load shedding in a given year due to insufficient or undeliverable power generation. It does not consider transmission and distribution outages. Alternative metrics, including loss of load expectation, loss of load probability, and others are all suitable for evaluating resource adequacy. EUE was selected due to its ability to capture magnitude and duration of events and its interpretability. Other metrics, like System Average Interruption Frequency Index, are most commonly used for distribution reliability and not typically used to measure shortfalls due to insufficient generation.

16 U.S. Energy Information Administration, "Residential Electric Bills in Hawaii and Connecticut Are Twice Those in New Mexico, Utah," *Today in Energy*, May 12, 2025, https://www.eia.gov/todayinenergy/detail.php?id=65244.

evaluate the impact of OSW. We find that OSW can play a role, but it cannot close the emerging shortfall in PJM alone.

OSW Reduces – but does not eliminate – PJM Reliability Risk



936 MW of load unlocked by CVOW equivalent to a small nuclear reactor or large gas plant

Failing to bring OSW increases risks by 31% and reliability costs by ~$1.95B reliability per year

64% direct benefit to coastal regions benefitting Dominion the most, but providing material benefits inland

Fully resolving PJM's shortfall would require approximately 24.4 GW of additional installed OSW — over nine projects the size of CVOW.[17] A complete solution requires natural gas, storage, transmission expansion, and demand-side flexibility working alongside OSW. In this broader portfolio, OSW has the potential to play a complementary, not substitutive, role with wider grid investments.[18]

As expected, offshore wind delivers its largest and most direct benefits to the Dominion zone. Because it interconnects directly into this already highly stressed part of PJM, any new generating resource plays a disproportionate role in reducing reliability risk. But the benefits are not limited to coastal regions. Because of how PJM's capacity market is structured and the physical interconnection of the grid, OSW investments on the Atlantic coast have measurable implications

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[17] Note, this estimate assumes that the ELCC of OSW would not decline substantially by adding more wind. If it did, the installed capacity could increase.

[18] Stover, Oliver, Dean Koujak, and Jesse Dakss. "Synergies between Offshore Wind and Natural Gas." Charles River Associates, January 29, 2026. https://www.crai.com/insights-events/publications/synergies-between-offshore-wind-and-natural-gas/.

for grid reliability across the full footprint, including inland states. These benefits are driven by the following dynamics:

- PJM spreads capacity credits across all zones: When OSW earns accredited capacity on the coast, that credit counts toward the system-wide reliability requirement that every zone shares. **Coastal generation reduces the shortfall that inland utilities face too.**
- Benefits aren't just an accounting exercise. **Each MW of OSW reduces physical reliability risk.** Removing OSW from the portfolio would increase load-shedding events (forced outages due to insufficient generation) by 31%, while tripling OSW capacity would cut these events by 40% by adding new fuel-free generation. The majority of these benefits flow to Dominion but they support load growth and mitigate the risk of load shedding across the entire footprint.
- Alignment with hard-to-solve hours: Atlantic OSW has its greatest generation during winter months, which are periods of critical emerging winter grid stress when natural gas fuel systems are under stress and solar generation is limited. **Given these dynamics, OSW has a generation profile that aligns with these emerging grid stress hours. However, while OSW's contribution is lower in the summer months, our modelling shows that it continues to have contribution in reducing risks in the summer, particularly during evening hours after the sun has set and batteries have discharged.**
- New generation is needed to support policymakers' goals for economic growth and sustain US global leadership: Load growth in PJM — concentrated in economically and strategically important sectors — is outpacing the grid's ability to add supply. By adding net new energy and capacity, **OSW, along with other energy resources, can help prevent projects from being delayed, cancelled, or shifted outside the PJM footprint.** While quantifying the full economic upside is outside the scope of this paper, public data suggest the potential is substantial — on the order of billions of dollars in economic growth, thousands of jobs created, improved military readiness, increased manufacturing complexity, and stronger geopolitical leadership. Some benefits could accrue elsewhere if projects were relocated outside PJM; however, the associated state and local economic development would shift with them. Other benefits are inherently PJM-local, such as electrifying existing industrial and military sites to support decarbonization or automation and depend on access to reliable and affordable power within the PJM footprint.
- New generation is not a zero-sum game: While OSW's reduction in load shedding risk is strongest near its interconnection point on the coasts, **any new generation anywhere in PJM reduces grid stress across the board and reduces PJM-wide capacity shortfalls.** While coastal ratepayers shoulder the development costs for OSW and are commensurately rewarded with more benefits, the reliability benefits flow to everyone — underscoring the original and ongoing value proposition of integrated electricity markets.
- Inland states face elevated winter stress: Many parts of inland states like Ohio, Kentucky, and West Virginia see their highest electricity demand in winter months or similar levels of demand in winter as summer (which is PJM's historical peak demand and period of

greatest grid stress). OSW generates most strongly in winter, so its output aligns directly with when these states need reliability support most. Removing OSW from the portfolio would increase the risk of load shedding. Failing to develop OSW would raise load shedding risk in the inland portions of PJM by 21%; tripling it cuts risk by 32%.

- **OSW could free up scarce gas turbines for inland use:** Resources which can be reliably counted on during grid stress events,[19] particularly natural gas, will likely be critical to closing capacity shortfalls and resolving emerging reliability risks. However, natural gas turbine supply chains are under significant stress — lead times are long and manufacturers are near capacity.[20] This is placing real pressure on decision makers as they seek to find solutions to close emerging gaps. In this environment, each MW of OSW capacity, or alternative accredited capacity like storage, allocated toward coastal reliability needs reduces the volume of gas turbine capacity that must be sourced for the same purpose, partially alleviating pressure on constrained supply chains. This does not eliminate the need for gas and wider grid investment, but it does mean that a more geographically and technologically diversified investment strategy may stretch available supply chains' capacity further across the full PJM and national footprint.

Summary: PJM faces a 7.8 GW capacity shortfall by 2033, driven by load growth five times the historical rate and slower-than-expected interconnection of new resources. OSW can play a role in reducing this gap — tripling investment cuts load shedding risk by 40%. These benefits flow across the entire PJM footprint and are positioned to support load growth and resulting economic and strategic benefits across the footprint. The direct contributions to reducing reliability risks accrue in coastal states but are also shared across the entire PJM footprint, as OSW adds fuel-free generation during key winter stress periods particularly concentrated in inland states. OSW may also ease pressure on constrained natural gas supply chains by providing an additional capacity pathway that does not compete for the same equipment. OSW alone cannot close the emerging capacity gap in PJM. Fully closing the shortfall would require over nine CVOW-sized projects, an investment larger than can be achieved in the next decade. As such, a balanced portfolio across generation, transmission, and demand-side resources will be needed to fully address emerging gaps.

[19] Referring to resources with relatively high effective load carrying capability (ELCC) values.

[20] Ibid.

Introduction

Twenty-seven miles off the coast of Virginia lies the nation's largest offshore wind (OSW) project. Dominion Virginia's 2.6 GW Coastal Virginia Offshore Wind project[21] began delivering power in March 2026,[22] arriving at a moment when Virginia's grid is under real pressure.[23] Northern Virginia hosts the largest data center market in the world, and the growth of artificial intelligence and cloud computing has made the Commonwealth one of the fastest-growing electricity systems in the country.[24] As such, it is facing increasing strain on its electricity systems, particularly as load growth is outstripping the ability of the grid to keep up with new infrastructure investments.[25]

Virginia is not alone in experiencing substantial load growth and resulting grid strain. Virginia operates within the PJM Interconnection, the regional grid operator serving 65 million people across thirteen states and Washington DC.[26] Peak summer demand across this market is projected to grow at 3.6% annually over the next decade[27] — more than five times the historical rate[28] — driven by data center expansion, domestic semiconductor manufacturing, and the electrification of industrial processes, heating, and transportation with energy growing at an even higher rate of 5.3% per year[29] due to the growth in round-the-clock load.

The industries driving PJM's load growth carry significant economic and strategic weight. Data centers, semiconductor fabrication facilities, and advanced manufacturers require power that is reliable, affordable, and available at scale — and long-term location decisions are being made based on whether that power will be available. Other actors are also seeking electricity that is increasingly clean. Without access to this reliable, affordable, and increasingly clean power, some projects may be delayed, scaled down, moved to another geographic region, or canceled. As such, a grid that cannot meet these needs does not just create reliability problems; it could constrain the economic development and strategic goals of states and local governments within PJM, along with federal goals associated with these projects. States and municipalities may lose

21 Dominion Energy. "Coastal Virginia Offshore Wind." Accessed April 9, 2026. https://coastalvawind.com/.

22 DiGangi, Diana. "Coastal Virginia Offshore Wind Begins Delivering Power." *Utility Dive*, March 23, 2026. https://www.utilitydive.com/news/coastal-virginia-offshore-wind-begins-delivering-power/815874/.

23 U.S. Department of Energy. *Evaluating the Reliability and Security of the United States Electric Grid.* Washington, DC: U.S. Department of Energy, July 7, 2025. https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20(FINAL%20JULY%207).pdf.

24 CBRE. *North America Data Center Trends H2 2025.* CBRE Research, February 2026. https://www.cbre.com/insights/books/north-america-data-center-trends-h2-2025.

25 U.S. Department of Energy. *Evaluating the Reliability and Security of the United States Electric Grid.* Washington, DC: U.S. Department of Energy, July 7, 2025. https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20(FINAL%20JULY%207).pdf.

26 PJM Interconnection, LLC. "PJM At a Glance". Audubon, PA: PJM Interconnection, 2025. https://www.pjm.com/-/media/DotCom/about-pjm/newsroom/fact-sheets/pjm-at-a-glance.pdf.

27 PJM Interconnection, LLC, *2026 Load Forecast Report* (Audubon, PA: PJM Interconnection, LLC, January 14, 2026), https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.

28 CRA analysis

29 PJM Interconnection, LLC, *2026 Load Forecast Report* (Audubon, PA: PJM Interconnection, LLC, January 14, 2026), https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.

potential for economic development and investment in essential sectors, such as transit hubs or smart manufacturing, which are fundamental to long-term economic strategies. Additionally, they may encounter obstacles in achieving decarbonization objectives.

Historically, PJM was able to maintain its overall reliability. From 2012 to 2022, PJM retired 47.2 GW of mostly coal and older gas capacity,[30] but this was largely offset by 35.3 GW of new combined-cycle gas generation,[31] and load growth was relatively low. However, in recent years, load growth has trended upward while new generator additions have slowed. Interconnection backlogs and supply chain pressures — particularly for natural gas turbines and electrical transformers — have extended development timelines and constrained new entry. Less than 20 MW of new natural gas capacity entered service in 2024–2025 while 1,700 MW retired.[32] This has resulted in a 6.6 GW shortfall in PJM's most recent capacity auction,[33] the mechanism used to match electricity demand with the least-cost supply mix needed to maintain the reliability of the system. That shortfall is most acute in Virginia, where limits on both local generation and transmission imports leave the region particularly exposed. This has serious implications for grid reliability and affordability. This shortfall means that the PJM market has higher risk of having to perform load shedding — intentionally disconnecting load due to insufficient supply — while customers are facing increases in prices.

Stakeholders across the PJM footprint are working to fill this gap with investments in onshore wind, solar, storage, natural gas, and demand-side management. OSW, in the form of CVOW, is also playing a role. By interconnecting within PJM's highly constrained Dominion zone and delivering large-scale, fuel-free energy and capacity, CVOW makes a meaningful contribution to local reliability needs while alleviating pressure on constrained natural gas supply infrastructure. For example, in its most recent IRP,[34] Dominion Virginia charted plans to build electricity generation across all technology types to their practical build limits — the largest amount deemed realistic by the utility— while also relying on capacity purchases to meet PJM targets. This means that CVOW is not being used as an alternative resource; rather, it is a core component of Dominion Virginia's plan to meet its share of new generation needs, while also counting on the

[30] PJM Interconnection, LLC, *PJM Details Resource Retirements, Replacements and Risks* (Audubon, PA: PJM Interconnection, LLC, February 24, 2023), https://insidelines.pjm.com/pjm-details-resource-retirements-replacements-and-risks/.

[31] Hitachi Energy, *Energy Market Insights Software Solution (Velocity Suite)* (energy analytics and market data platform), accessed December 2025, https://www.hitachienergy.com/us/en/products-and-solutions/energy-portfolio-management/energy-analytics-software-solutions/energy-market-insights-software-solution.

[32] Ibid.

[33] PJM Interconnection, LLC, *2027/2028 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, December 17, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2027-2028/2027-2028-bra-report.pdf.

[34] Virginia Electric and Power Company (Dominion Energy). *2024 Integrated Resource Plan.* Filed with the State Corporation Commission of Virginia, Case No. PUR-2024-00184, October 15, 2024. https://www.dominionenergy.com/-/media/content/about/our-company/irp/pdfs/2024-irp-w_o-appendices.pdf.

wider PJM market to meet its resource adequacy needs.[35] Beyond CVOW's resource adequacy role, Dominion is simultaneously relying on it to meet the Commonwealth's decarbonization commitments.[36]

Given these dynamics, OSW's contribution to coastal resource adequacy, particularly in Virginia, is reasonably well understood. However, less attention has been paid to its impact across the broader PJM footprint, including inland states that bear no direct development costs for OSW, outside of some transmission costs, but may benefit from the ability to continue to invest in OSW in the PJM market. Further, there have been limited studies to examine how OSW investments beyond CVOW may impact the grid in coming years.

This study aims to fill these gaps by examining OSW's role in addressing these emerging grid pressures, both in Virginia and across the broader PJM footprint. Using PJM's capacity market construct and independent loss of load modeling, we quantify OSW's contribution to reliability under conditions projected for 2033 — a year in which PJM faces sizable capacity shortfalls absent corrective action and sufficiently far into the future to contemplate additional OSW projects coming onto the system. The goal is to provide a clear assessment of what OSW can and cannot deliver, and how it fits within the broader portfolio of resources needed to maintain reliability while supporting continued load growth and success of the underlying strategic economic sectors. Quantifying the exact economic impact of these large load projects is outside the scope of this study, but we rely on several public data sources to provide insights into the scale of impact driven by these projects.

Deep dive: Emerging stress in PJM

PJM has historically operated with healthy reserve margins, supported by modest demand growth and steady additions of new natural gas and renewable generation. That balance is shifting materially.

Impacts of tightening supply-demand balance

The shifting balance between electricity demand and electricity supply, described above, is already visible in PJM's capacity market – the financial market used to incentivize and reward electricity generators for meeting electricity demand in the periods of grid stress. The market is a crucial tool for PJM to maintain resource adequacy of the grid. Resource adequacy focuses on

35 Stover, Oliver, Dean Koujak, and Jesse Dakss. "Synergies between Offshore Wind and Natural Gas." Charles River Associates, January 29, 2026. https://www.crai.com/insights-events/publications/synergies-between-offshore-wind-and-natural-gas/.

36 Stover, Oliver, Dean Koujak, and Jesse Dakss. "The Contribution of Offshore Wind to Grid Reliability & Resource Adequacy." Charles River Associates, November 6, 2025. https://www.crai.com/insights-events/publications/the-contribution-of-offshore-wind-to-grid-reliability-resource-adequacy/.

having enough and the right type of electricity generation to ensure the grid can deliver sufficient power to meet all end-use demand across all weather conditions.[37]

Figure 1 shows that PJM's electricity market prices have increased significantly in the past three auctions. The last two auctions reached the maximum prices permitted to maintain affordability — without these caps, prices would have been even higher.[38,39] Despite these elevated prices, PJM was unable to procure enough power to meet demand, falling short by 6.6 GW (approximately 4.2% of the requirement).[40] Due to this shortfall, PJM is now facing risks of insufficient generation to meet customer demand during grid stress events. These adverse outcomes are the result of net new generation failing to keep pace with load growth. To address this issue, PJM is implementing swift measures, such as conducting an emergency auction to secure additional resources and reform market designs.[41] Nevertheless, the current trajectory raises concerns regarding the reliability and affordability of power in the nation's largest electricity market. PJM is on a trajectory to continue to see elevated market prices and reliability risks unless new resources are connected onto the system or load growth is slowed.

37 Resource adequacy focuses on the electricity generation, with consideration of transmission constraints. Transmission and distribution outages are considered in other types of assessments.

38 PJM Interconnection, LLC, *2026/2027 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, July 22, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2026-2027/2026-2027-bra-report.pdf.

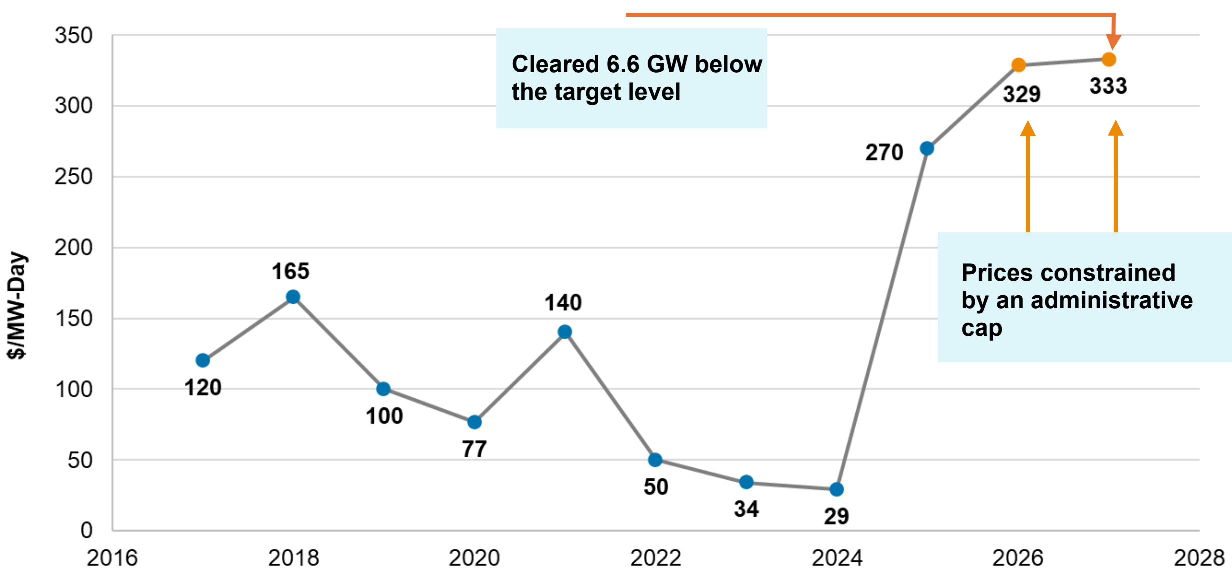
39 PJM Interconnection, LLC, *2027/2028 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, December 17, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2027-2028/2027-2028-bra-report.pdf.

40 Ibid.

41 PJM Interconnection. "Reliability Backstop Design Working Paper." Reliability Backstop Procurement Workshop, February 18, 2026. https://www.pjm.com/−/media/DotCom/committees−groups/workshops/rbpw/2026/20260218/20260218−item-03---pjm-reliability-backstop-design-working-paper.pdf.

Figure 1: PJM Capacity Prices[42,43]

Capacity prices are spiking across the country, indicating tightening supply demand balance and elevated grid risk



What is a capacity price?

Capacity markets incentivize generators for meeting resource adequacy targets. Critically, they do not guarantee that sufficient generation is brought onto the grid. **Capacity prices spike when markets are tight.**

What are the implications for reliability?

Even as prices are higher when markets are tight, reliability degrades because the system has less of a safety margin across the electrical generation and storage fleet to meet customer's demand for electricity across all types of grid and weather conditions.

[42] PJM. *2026/2027 Base Residual Auction Report*. July 22, 2025. For public use. PJM. Accessed August 18, 2025. https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2026-2027/2026-2027-bra-report.pdf.

[43] PJM Interconnection, LLC, *2027/2028 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, December 17, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2027-2028/2027-2028-bra-report.pdf.

A shift toward winter risk

Alongside the tightening supply-demand balance, PJM is facing a shift in when reliability risks are most acute. Historically, the grid's most stressed moments occurred during summer heat waves, when air conditioning demand peaks. That pattern is changing. In PJM's recent loss of load analysis, winter months accounted for **87% of reliability risk**[44,45] — a departure from historical norms driven by rising winter demand and the limited contribution of solar and battery storage during evening and overnight hours.[46] While this shift to winter risk is widely accepted, the exact speed and timing the shift is impacted by modeling assumptions.[47]

This shift has important implications for resource planning. Technologies that perform well in summer — particularly solar — contribute less during the hours when the grid is now most at risk. While investments that mitigate cold-weather outages will likely play a role in delaying or reducing this shift to winter risk, the grid will likely need new resources that can reliably perform during these modeled emerging grid stress events, cold winter evenings and overnight periods.

What winter stress looks like in practice

Two recent events illustrate the evolving nature of winter reliability risk in PJM.

Winter Storm Elliott in December 2022 produced a simultaneous loss of roughly 47 GW of generation — approximately 24% of PJM's entire fleet[48] — at the moment of highest demand. The

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44 PJM Interconnection, LLC, *ELCC Education:* Presentation to the ELCC Stakeholder Task Force, December 5, 2024, https://www.pjm.com/-/media/DotCom/committees-groups/task-forces/elccstf/2024/20241205/20241205-item-07---informational-only-posting---data-transparency---elcc-education-from-special-planning-committee-sessions-on-february-16-and-21-2024.pdf.

45 Note, in its modeling, PJM caps thermal generation at summer ratings, which accounts for a substantive portion of this winter risk. However, in the authors' view the shift toward increasing winter risk is credible, as highlighted by recent winter weather events, but that the speed and magnitude of the shift is heavily influenced by the thermal cap. PJM Interconnection, L.L.C., and Energy and Environmental Economics, Inc. 2025. *PJM ELCC / RRS Model Evaluation Report.* December 9, 2025. https://www.pjm.com/-/media/DotCom/committees-groups/task-forces/elccstf/2025/20251209/20251209-item-02---pjm-elcc-rrs-model-evaluation---e3-report.pdf.

46 Oliver Stover, Jesse Dakss, Dean Koujak, Ryan Chigogo, Abdul Mohammed, Ryan Israel, Charles Merrick, and Chloe Romero Guliak, *The Contribution of Offshore Wind to Grid Reliability & Resource Adequacy* (Boston: Charles River Associates, November 6, 2025), https://media.crai.com/wp-content/uploads/2025/11/05132542/CRA-Report-Offshore-Winds-Contribution-to-Grid-Reliability-Resource-Adequacy-November-2025.pdf.

47 Note, in its modeling, PJM caps thermal generation at summer ratings, which accounts for a substantive portion of this winter risk. However, in the authors' view the shift toward increasing winter risk is credible, as highlighted by recent winter weather events, but that the speed and magnitude of the shift is heavily influenced by the thermal cap. PJM Interconnection, L.L.C., and Energy and Environmental Economics, Inc. 2025. *PJM ELCC / RRS Model Evaluation Report.* December 9, 2025. https://www.pjm.com/-/media/DotCom/committees-groups/task-forces/elccstf/2025/20251209/20251209-item-02---pjm-elcc-rrs-model-evaluation---e3-report.pdf.

47 PJM Interconnection, Winter Storm Elliott Event Analysis and Recommendation Report (special grid reliability and emergency operations analysis), accessed February 2026, https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/20230717-winter-storm-Elliott-event-analysis-and-recommendation-report.pdf.

48 Ibid.

primary drivers were natural gas fuel constraints and cold-related equipment failures across thermal generators.

Winter Storm Fern in January and February 2026 presented a different but equally revealing challenge: not a single peak stress event, but eight consecutive days of sustained load above 130 GW, with generation outages averaging 18–19 GW throughout.[49] Improved cold-weather preparations relative to Elliott kept outages lower,[50] but the event still required emergency federal authorization for 15 oil units to operate beyond their permitted limits for more than 1,000 hours and demonstrated that cold-weather outages remain a durable phenomenon.[51]

These events highlight the defining characteristics of winter reliability risk in PJM: correlated stress across thermal generators, fuel supply constraints that affect gas availability at periods when load is already high, and multi-day stress periods that test the durability of fuel supply infrastructure and the overall electricity grid, with particular stress on storage resources.

Key takeaways: PJM is transitioning from a period of structural generation surplus to one of emerging scarcity. Capacity prices have already hit administrative ceilings in two consecutive auctions — and PJM's own analysis suggests the true market-clearing price would have been nearly double the cap, yet still attracted less than 800 MW of new supply against a 6.6 GW shortfall. Reliability risk is increasingly shifting toward winter months, when solar and storage contribute least and thermal generators are most vulnerable to correlated cold-weather outages and fuel supply constraints. Recent events — Elliott in 2022 and Fern in 2026 — illustrate that this risk is not theoretical.

The economic and strategic stakes of reliable power

Reliability shortfalls on the PJM grid are not an abstract technical concern. The industries driving load growth across the region are economically and strategically significant, and their continued investment depends on access to power that is reliable, affordable, and available at scale. Some stakeholders also have decarbonization targets that create a preference for increasingly clean power.

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[49] American Public Power Association. "PJM, MISO, ERCOT, NYISO and SPP Detail Plans to Respond to Winter Storm Fern." January 23, 2026. https://www.publicpower.org/periodical/article/pjm-miso-ercot-nyiso-and-spp-detail-plans-respond-winter-storm-fern.

[50] PJM Interconnection, L.L.C. *PJM Board Response to RESA Letter Regarding Conservative Operations.* Valley Forge, PA: PJM Interconnection, March 10, 2026. https://www.pjm.com/-/media/DotCom/about-pjm/who-we-are/public-disclosures/2026/20260310-pjm-board-response-to-resa-letter-re-conservative-operations.pdf.

[51] Ibid.

The criticality of reliable electricity

Reliable power is critical to national, social, economic, and military well-being. Power outages disrupt day-to-day life, economic activities, and in extreme cases can harm human health.[52] Electricity is critical infrastructure in its own right,[53] but its importance is magnified by how it underpins other essential systems. Reliable power is a prerequisite for continuity of government services, communications networks, water and wastewater treatment, and hospital operations. It is also a foundational enabler of military readiness. Even beyond direct military activities, power outages disrupt military personnel's day-to-day lives and harm readiness. In one study, electrical power outages disrupted daycare facilities, causing military personnel to pivot toward family-care activities.[54] These findings highlight that power outages ripple into a number of key sectors. These factors are true across the nation, but particularly evident in the PJM footprint given that it is home to major federal and defense assets and a large legacy industrial base.[55,56]

The industries at risk

Large load growth in PJM is increasingly driven by three categories of demand: data centers supporting artificial intelligence and cloud computing, domestic manufacturing investment in strategic sectors such as semiconductor fabrication, and electrification of legacy industrial processes. These sectors are energy-intensive and often have decarbonization goals due to state or company mandates or consumer preference. As such, many are factoring in the ability to access reliable, affordable, and increasingly clean power in their investment decision making. Without this line of sight to power, developers may choose or be forced to delay, downsize, cancel, or relocate investments. This could result in economic and strategic ripple effects across the PJM footprint, given the potential large state and local impact from these investments.

Northern Virginia illustrates the scale of this dynamic. The region is the largest data center market in the world, and continued expansion depends on the ability to connect new loads in the Dominion zone[57] without curtailment or delay.[58] A 2024 analysis estimated that data center

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52 Cybersecurity and Infrastructure Security Agency. "Critical Infrastructure Sectors." U.S. Department of Homeland Security. Accessed April 30, 2026. https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors. [cisa.gov]

53 International Energy Agency (IEA). "Electricity Security Matters More Than Ever." In *Power Systems in Transition*. Paris: IEA, 2020. https://www.iea.org/reports/power-systems-in-transition/electricity-security-matters-more-than-ever.

54 Foy, Kylie. "Power-Outage Exercises Strengthen Resilience of U.S. Military Bases." MIT Lincoln Laboratory, September 10, 2025. https://www.ll.mit.edu/news/power-outage-exercises-strengthen-resilience-us-military-bases.

55 Cohen, Gabriel. "Mapped: The States With the Most U.S. Military Bases." Visual Capitalist, March 8, 2026. https://www.visualcapitalist.com/mapped-number-of-military-bases-by-state/

56 Venditti, Bruno. "Mapped: U.S. Manufacturing Jobs by State." Visual Capitalist, June 6, 2025. https://www.visualcapitalist.com/u-s-manufacturing-by-state-who-gains-most-from-made-in-america/.

57 Recognizing that Dominion Virginia as well as a number of cooperative and municipal electrical service providers operation in the Dominion zone.

58 CBRE. *North America Data Center Trends H2 2025.* CBRE Research, February 2026. https://www.cbre.com/insights/books/north-america-data-center-trends-h2-2025.

capacity in Virginia generates approximately $1.8 billion in annual economic value per GW of data center capacity.[59] Each GW of demand that PJM cannot reliably serve represents a corresponding constraint on further investment and economic activity from this sector.

Economic stakes of insufficient generation

Virginia Data Centers	Intel Ohio One semiconductor fab
$1.8B	**$2.8B**
estimated annual economic value per GW of data center capacity	projected annual contribution to Ohio's economy, plus tens of thousands of jobs

These investments are contingent on the availability of reliable, affordable electricity at scale. As PJM's reserve margins tighten, the ability to reliably interconnect large loads without curtailment becomes a material constraint on whether they proceed as planned.

States across the PJM footprint are experiencing similar demand growth, driven by the expansion of strategic industries and emerging economic sectors. In Ohio, Intel's semiconductor fabrication facility in Licking County is projected to contribute over $2.8 billion annually to Ohio's economy and support tens of thousands of jobs once and if it becomes fully operational. Similarly, in West Virginia, FORM Energy announced it will invest up to $760 million to develop a new manufacturing facility for iron-air batteries, creating up to 750 full-time jobs.[60] Facilities of these kinds require power that meets stringent reliability standards and depend on affordable electricity to maintain commercial viability.[61] Supply uncertainty and affordability pressures could translate into investment uncertainty at the facility level, preventing future economic growth in the states from these projects.

Electrifying legacy manufacturing and transportation sectors along with onshoring domestic manufacturing capabilities represents another facet of this challenge. For example, Stellantis announced a $13 Billion investment across Illinois, Ohio, Michigan, and Indiana to increase

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59 Joint Legislative Audit and Review Commission. *Data Centers in* Virginia. 2024. https://jlarc.virginia.gov/pdfs/reports/Rpt598.pdf.

60 Form Energy. "West Virginia Governor Jim Justice Announces Form Energy Will Site First American Battery Manufacturing Plant in Weirton, Creating Hundreds of Jobs." Press release, December 22, 2022. https://formenergy.com/west-virginia-governor-jim-justice-announces-form-energy-will-site-first-american-battery-manufacturing-plant-in-weirton-creating-hundreds-of-jobs/.

61 Intel Corporation, *"Intel in Ohio: You Were Built For This,"* Intel, accessed February 20, 2026, https://www.intel.com/content/www/us/en/corporate-responsibility/intel-in-ohio.html

domestic manufacturing capacity by 50% while creating 5,000 new jobs.[62] This represents an expansion of Stellantis's existing domestic manufacturing capacity, including restarting idled sites.

Electricity represents a major cost for manufacturing sites. As such, these projects will likely be more economically viable if they can continue to access reliable and affordable power. Stellantis also indicates a preference for increasingly clean power.[63] Similarly, the Port of New York and New Jersey — the busiest port on the East Coast — is undergoing a major electrification effort, with terminal operators and port authorities investing in electric cargo handling equipment, shore power infrastructure, and zero-emission vehicles to meet policy-driven decarbonization targets and consumer preferences for lower carbon transportation.[64,65,66] These investments are likely contingent on grid reliability and the availability of affordable, firm power. Further, as a project primarily motivated by decarbonization, its success in achieving the goals underlying the project also relies on access to increasingly clean electricity. Delays or shortfalls in generation capacity risk or increased reliance on high emitting, expensive generators due to grid tightness[67] could undermine both the environmental goals and the economic dynamics driving this electrification effort.

What curtailing load growth would mean

If PJM cannot procure sufficient capacity to serve emerging load, PJM decision makers, and regulators for PJM states, face a limited set of options: slow or block new industrial interconnections, require large customers to accept interruptible service (likely by pairing large load investment with behind-the-meter generation), tolerate reliability below its target standard, or take other actions to mitigate reliability risks. The acceptance of a degradation of service for some or all customers has been contemplated as potential outcome by PJM in a recent white paper.[68]

62 Stellantis. "Stellantis to Invest $13 Billion to Grow in the United States." Press release, October 14, 2025. https://www.stellantis.com/en/news/press-releases/2025/october/stellantis-to-invest-13-billion-to-grow-in-the-united-states.

63 DTE Energy. "Stellantis Partners with DTE Energy to Add 400 Megawatts of New Solar Projects in Michigan Through DTE's MIGreenPower Program." Press release, December 12, 2022. https://www.dteenergy.com/us/en/newsroom/2022/Stellantis-partners-with-DTE-Energy-to-add-400-megawatts-of-new-solar-projects-in-Michigan-through-DTE-s-MIGreenPower-program.html. [dteenergy.com]

64 U.S. Environmental Protection Agency. "EPA Announces Historic $400M Clean Ports Investment in New Jersey." October 30, 2024. https://www.epa.gov/newsreleases/epa-announces-historic-400m-clean-ports-investment-new-jersey.

65 *Offshore Energy*. "Port of New York, New Jersey Unveils Net-Zero Roadmap." September 21, 2023. https://www.offshore-energy.biz/port-of-new-york-new-jersey-unveils-net-zero-roadmap/.

66 South Jersey Port Corporation. "South Jersey Ports Expands Green Fleet with Electric and Hybrid Vehicles." April 14, 2025. https://www.southjerseyport.com/south-jersey-ports-expands-green-fleet-with-electric-and-hybrid-vehicles/.

67 Stover, Oliver, Jesse Dakss, Dean Koujak, Abdul Mohammed, Chloe Romero Guliak, and Ryan Chigogo. "Impacts of Offshore Wind on Reliability and Affordability in ISO-NE and NYISO." Charles River Associates, December 2, 2025. https://www.crai.com/insights-events/publications/impacts-of-offshore-wind-on-reliability-and-affordability-in-iso-ne-and-nyiso/.

68 PJM Interconnection. 2026. Powering Reliability Through Market Design. May 6, 2026. https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2026/20260506-powering-reliability-through-market-design.pdf

Each of these outcomes carries consequences that extend beyond the electricity sector. Some of these sectors may be able to pivot to footprints outside of PJM, while others are already married to the PJM footprint.

Various policymakers and legislators have identified these sectors driving the load growth as national priorities for a number of reasons. As discussed above, they have been identified as drivers of state and local economic growth, sources of new jobs, and avenues for meeting state and company decarbonization targets. Their impact can move beyond simple economic benefits. Onshoring critical supply chains has been identified as imperative to national security. For example, Congress passed the CHIPS and Science Act with bipartisan support specifically because over 90% of advanced chips are currently produced abroad, creating risks for procuring these critical components if a global conflict were to occur.[69]

While transitioning to increasingly clean electricity is key to decarbonization, these sectors themselves play a role in meeting emissions reductions targets. Multiple investments in clean technology manufacturing are underway in the PJM footprint, including Stellantis's EV facilities across the Midwest, Form Energy's commercial-scale iron-air battery facility in Weirton, West Virginia,[70] and Honda's EV hub in central Ohio.[71] Investments in the range of clean technologies are a key enabler of achieving state and city decarbonization targets. Further, due to their energy-intensive nature,[72] they likely need affordable electricity to remain commercially viable.

Lastly, keeping critical supply chains and technological capacity in the United States has been identified as a priority for maintaining American leadership in AI,[73] clean manufacturing[74], and the industries of the future.[75] Underpinning these objectives is the ability of the grid to deliver reliable, affordable, and increasingly clean electricity to these strategic sectors. The supply tightness and rising capacity prices facing PJM place pressure on the region's ability to meet the electricity needs of these strategic sectors.

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69 Council on Foreign Relations. "What Is the CHIPS Act?" April 29, 2024. https://www.cfr.org/in-brief/what-chips-act.

70 Form Energy. "Form Factory 1." Accessed April 9, 2026. https://formenergy.com/form-factory-1/.

71 Honda. "Honda EV Hub Prepares for New Level of Flexible Production in Reimagined Manufacturing Environment." February 4, 2025. https://hondanews.com/en-US/releases/honda-ev-hub-prepares-for-new-level-of-flexible-production-in-reimagined-manufacturing-environment.

72 Degen, Florian, et al. "Energy Consumption of Current and Future Production of Lithium-Ion and Post Lithium-Ion Battery Cells." *Nature Energy* 8 (2023): 1284–1295. https://www.nature.com/articles/s41560-023-01355-z.

73 The White House. *Winning the Race: America's AI Action Plan.* July 2025. https://www.whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf.

74 U.S. Department of Energy. *2021–2024 Four-Year Review of Supply Chains for the Advanced Batteries Sector.* December 2024. https://www.energy.gov/sites/default/files/2024-12/20212024-Four%20Year%20Review%20of%20Supply%20Chains%20for%20the%20Advanced%20Batteries%20Sector.pdf.

75 Center for Strategic and International Studies. "Strategic Equilibrium: The United States' Manufacturing Resurgence and the Role of Natural Gas in a Carbon-Competitive World." January 31, 2025. https://www.csis.org/analysis/strategic-equilibrium-united-states-manufacturing-resurgence-and-role-natural-gas-carbon.

Key takeaways: The industries driving PJM's load growth — data centers, semiconductor fabrication, and advanced manufacturing — carry significant economic and strategic weight for states across the region and at the federal level. Their continued investment depends on a grid that can reliably serve large, concentrated loads with affordable and increasingly clean electricity. Capacity shortfalls do not just raise electricity prices, increase load shedding risk, and drive-up emissions; they could slow or curtail the economic development and policy objectives associated with investment in these industries.

The potential role of OSW in PJM

Mid-Atlantic OSW demonstrates strong alignment with PJM's emerging risk profile. OSW generates most strongly during winter months and evening hours. This means its output is correlated with extreme cold weather events, a period of increasing grid stress.[76] During both Winter Storm Elliott and Winter Storm Fern, wind generation remained consistently available during high-load periods, in contrast to the correlated thermal outages and fuel supply constraints that defined both events. As a fuel-free resource, OSW also increases grid fuel diversity, hedging against the supply disruptions seen in Elliott and the high gas prices seen in Fern.[77] This shift toward winter stress is driven, in part, by PJM's modeling assumptions — particularly the treatment of cold-weather outages, some of which may be partially or fully mitigated through grid-hardening investments.[78]

This performance is reflected in PJM's capacity accreditation framework, where OSW received relatively high Effective Load Carrying Capability (ELCC) values in recent auctions, exceeding the values assigned to many storage and some thermal technologies in the near-term. An ELCC is a measure of the portion of a resource that can be reliably counted on during grid stress events and counted toward meeting capacity needs. These values are shown below in Figure 2.

OSW presently receives a relatively high rating, outstripping both gas combustion turbines that do not have dual fuel capabilities and four-hour batteries. This is because OSW can contribute during the emerging grid stress hours – very cold mornings and evenings – when natural gas systems are the most stressed in PJM's modeling. However, these ELCCs are projected to decline over

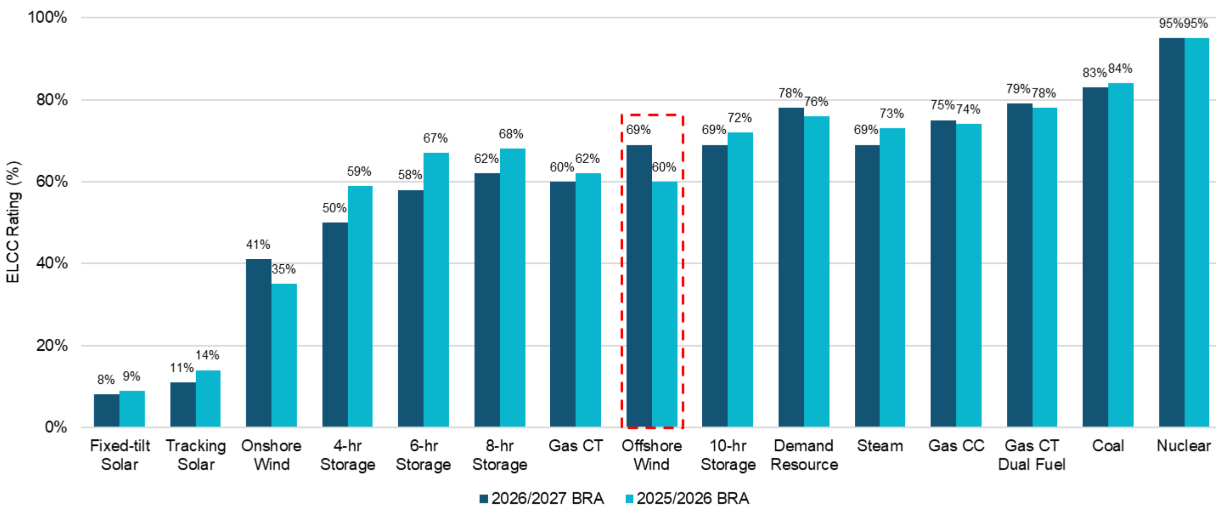
76 Stover, Oliver, Dean Koujak, and Jesse Dakss. "The Contribution of Offshore Wind to Grid Reliability & Resource Adequacy." Charles River Associates, November 6, 2025. https://www.crai.com/insights-events/publications/the-contribution-of-offshore-wind-to-grid-reliability-resource-adequacy/.

77 PJM Interconnection, Winter Storm Elliott: Event Analysis and Recommendation Report (special grid reliability and emergency operations analysis), accessed February 2026, https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/20230717-winter-storm-Elliott-event-analysis-and-recommendation-report.pdf.

78 PJM Interconnection, L.L.C., and Energy and Environmental Economics, Inc. 2025. *PJM ELCC / RRS Model Evaluation Report.* December 9, 2025. https://www.pjm.com/-/media/DotCom/committees-groups/task-forces/elccstf/2025/20251209/20251209-item-02---pjm-elcc-rrs-model-evaluation---e3-report.pdf.

time as the penetration of both offshore and onshore wind grows.[79] This is a critical dynamic as grid planners find the right balance of resources over time. If the shift to winter stress is slower than expected, or mitigated by hardening fuel systems, OSW's ELCC may decline because Atlantic OSW has a lower generation during the summer months, but may still play a substantive role in grid reliability given its ability to fill in nighttime hours, after the sun has set.

Figure 2: PJM ELCC Ratings[80,81]



What is an ELCC?

An ELCC is a 0 to 100% measure of how much a resource can be "counted" on during the periods of greatest grid stress. A higher number indicates a resource is more likely to be available during the hours when the risk of load shedding is highest.

Presently, CVOW remains the only project delivering power in PJM. Other PJM states have also demonstrated interest in OSW, but at the time of writing, progress has slowed as projects face regulatory and market uncertainties. Maryland has set an 8.5 GW offshore wind goal,[82] but development faces federal reconsideration of key approvals.[83] Delaware has multiple projects

79 PJM, "*2025 PJM Effective Load Carrying Capability and Reserve Requirement Study (ELCC/RRS) PJM Resource Adequacy Planning.*" October 22, 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/2025-pjm-elcc-rrs.pdf.

80 PJM Interconnection, LLC. *ELCC Class Ratings for the 2025/2026 Third Incremental Auction*. For Public Use. 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/2025-26-3ia-elcc-class-ratings.pdf.

81 PJM Interconnection, LLC. *ELCC Class Ratings for the 2026/2027 Base Residual Auction*. For Public Use. 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/2026-27-bra-elcc-class-ratings.pdf.

82 Public Service Commission of Maryland, *Promoting Offshore Wind Energy Resources Act of 2023 (POWER Act) Status Update Report* (Annapolis, MD: Public Service Commission of Maryland, July 1, 2024), https://www.psc.state.md.us/wp-content/uploads/OSW_POWER_Act_Status_Update_Report_2024.pdf.

83 DiGangi, Diana. "Trump Administration to Revoke Approval for 2.2-GW Maryland Offshore Wind." *Utility Dive*, August 27, 2025. https://www.utilitydive.com/news/trump-maryland-offshore-wind-revoke-approval-ocean-city/758717/.

under development. The state is targeting 1.2 GW of OSW under SB 265,[84] with SB 159[85] enshrining the ability to build a critical substation in Sussex County. New Jersey previously aimed for 11 GW by 2040 (via a 2022 executive order[86]), but its OSW program has since suffered major setbacks. Several planned New Jersey projects were canceled or paused in 2023–2025 due to financing and permitting challenges, leaving the Atlantic Shores South Project 1 (1.5 GW)[87] as the leading remaining development – itself facing significant headwinds.[88,89] The state also built the New Jersey Wind Port to support OSW construction,[90] yet progress has slowed with market uncertainty and the Governor is exploring alternative uses of the site.[91]

Key takeaways: The wind off the Atlantic coast has properties that align with emerging grid stress in PJM, which is reflected in the relatively high ELCC values assigned to this technology, particularly in the near-term. However, its ELCC may decline, based on the amount of risk in summer versus winter months and interactions with other technologies. Across PJM, OSW is in various stages of development. A single project in Virginia, the 2.6 GW CVOW project, is currently providing energy and capacity in the most stressed part of PJM. While a diverse pipeline exists across states in the footprint, many projects face headwinds given the current regulatory environment.

Methodology

Next, we present a numerical assessment of OSW's potential impact. Our study moves beyond ELCC forecasts and the traditional emphasis on coastal regions to more fully evaluate OSW's contribution across the broader PJM footprint. We focus on 2033 — a year in which PJM faces

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84 Delaware General Assembly. *Senate Bill 265, 152nd General Assembly (2023–2024): An Act to Amend Titles 17, 26, and 29 of the Delaware Code Relating to the Delaware Energy Solutions Act of 2024*. Primary Sponsor: Hansen. Signed by Governor, September 5, 2024. https://legis.delaware.gov/BillDetail/141232.

85 Delaware General Assembly. *Senate Bill 159, 153rd General Assembly (2025): An Act to Amend Title 26 of the Delaware Code Relating to Public Utilities*. Primary Sponsor: Hansen. Signed by Governor, June 30, 2025; effective January 31, 2026. https://legis.delaware.gov/BillDetail/142363.

86 Jared Anderson, "New Jersey Expands Offshore Wind Power Capacity Goal to 11 GW by 2040," *S&P Global Energy*, September 23, 2022,https://www.spglobal.com/energy/en/news-research/latest-news/electric-power/092322-new-jersey-expands-offshore-wind-power-capacity-goal-to-11-gw-by-2040.

87 Sandi Briner, "Atlantic Shores Statement on New Jersey's Fourth Offshore Wind Solicitation," *Atlantic Shores Offshore Wind (Press Release)*, Atlantic City, NJ, February 4, 2025, https://www.atlanticshoreswind.com/atlantic-shores-statement-on-new-jerseys-fourth-offshore-wind-solicitation/.

88 Adnan Memija, "Shell Ends Atlantic Shores Offshore Wind Involvement in US," *OffshoreWind.biz*, November 3, 2025, https://www.offshorewind.biz/2025/11/03/shell-ends-atlantic-shores-offshore-wind-involvement-in-us/.

89 Jarrett Renshaw (Reuters), "Trump Says NJ Offshore Wind Halt Will Be Permanent," *Baird Maritime*, October 25, 2025, https://www.bairdmaritime.com/offshore/renewables/offshore-wind/trump-says-nj-offshore-wind-halt-will-be-permanent.

90 State of New Jersey, *New Jersey Offshore Wind Energy Timeline* (Trenton, NJ: State of New Jersey, accessed 2026), https://www.nj.gov/offshorewind/about/timeline/.

91 Adrijana Buljan, "New Jersey Exploring Alternative Uses for Its Offshore Wind Port," *OffshoreWind.biz*, February 18, 2025, https://www.offshorewind.biz/2025/02/18/new-jersey-exploring-alternative-uses-for-its-offshore-wind-port/.

material capacity shortfalls under current market trajectories and sufficiently in the future that further OSW projects could be developed — and proceed in two steps.

First, we construct a forward-looking view of PJM's resource mix in 2033, incorporating expected retirements, projects currently in the interconnection queue, announced additions from utility integrated resource plans, and a Base Case for OSW development that includes CVOW and 2 GW of Maryland development.[92] This portfolio falls materially short of PJM's target reserve margin — consistent with shortfalls identified in recent capacity auctions — and serves as the baseline against which OSW's incremental contribution is measured.

Second, we assess OSW's impact using two complementary tools. Capacity market modeling translates the resource mix into capacity market outcomes under PJM's market rules, quantifying how much of the emerging shortfall OSW closes at varying penetration levels. This enables us to understand the magnitude of new generation resources needed to meet capacity targets and return capacity prices to historical levels. Loss of load modeling then evaluates OSW's effect on physical reliability outcomes — the probability, magnitude, and duration of outage events — across the Dominion region, the broader Mid-Atlantic region (MAAC), and inland portions of the RTO (Rest of RTO). We assess these three geographic regions to examine whether OSW's benefits extend beyond the coast. A map of these regions given in Figure 3.

From these simulations, we estimate the economic impact of outages using a value of lost load (VOLL) of $25,000/MWh.[93,94] VOLL is an estimate of the price a customer would be willing to pay to prevent a disruption, and its value varies across studies. Given that VOLL is an estimate, reliability costs should also be treated as indicative estimates for scale of impact.

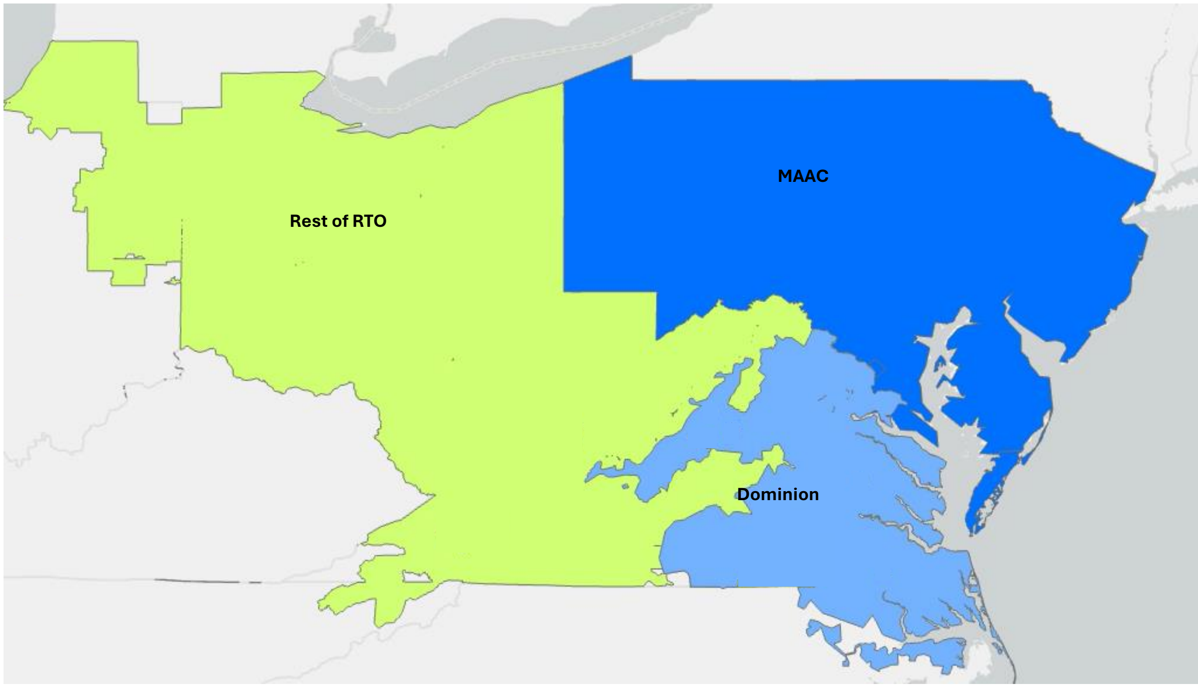
A full description of data sources, modeling assumptions, and results is provided in the appendix.

92 Our model places the OSW in Maryland, but initial modeling showed similar results even in the OSW was located in New Jersey due to the strong interconnection of zones of PJM within the MAAC region.

93 Thomas Schröder and Wilhelm Kuckshinrichs, "Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review," Frontiers in Energy Research 3 (December 24, 2015), https://www.frontiersin.org/articles/10.3389/fenrg.2015.00055/full.

94 Michael J. Sullivan, Robert T. McDermott, and Shmuel S. Oren, "The Value of Lost Load (VoLL) for Electricity Supply Reliability: An Econometric Analysis of U.S. Outage Cost Data," Utilities Policy 78 (December 2022), https://doi.org/10.1016/j.jup.2022.101403.

Figure 3: Definition of PJM locations



Results

This section provides a summary of results. More detailed results can be found in the Appendix.

The baseline: A grid running short

Under current market trajectories, PJM faces a 7.8 GW capacity shortfall by 2033 — roughly 23% of the size of New York state's peak demand.[95] The shortfall is most acute in the Dominion zone, where transmission constraints prevent the zone from fully accessing capacity available elsewhere in PJM, producing a local deficit of 4.3 GW. Without corrective action, PJM would face 248 GWh of expected unserved energy annually — enough to cut power to approximately 23,600 homes for an entire year and incur $6.2B in reliability costs per year. This reflects not a single catastrophic event but the cumulative cost of a grid operating persistently below its reliability standard. In part due to different assumptions, we find that risk persists in both summer and winter months, rather than primarily being concentrated in winter.

95 New York Independent System Operator (NYISO). "Electric Grid Prepared to Meet 2025 Summer Demand." Press Release, May 13, 2025. https://www.nyiso.com/-/press-release-electric-grid-prepared-to-meet-2025-summer-demand.

What OSW contributes

OSW can help reduce these shortfalls. While only a portion of the total generator's installed capacity 'counts' toward meeting capacity needs, these additions can still substantively close emerging shortfalls due to the scale of OSW projects. At PJM's projected accreditation rate, every MW of offshore wind installed closes 0.36 MW of the capacity gap — in both Dominion and across the RTO as a whole in 2033. This assumes a future ELCC rating of 32%,[96] and converting unforced capacity into equivalent load demand (see appendix). While this is lower than thermal resources in this year, it is higher than other resources. Further, the ability to add projects at a large scale enables individual OSW projects to play a non-trivial role. For example, a project the size of CVOW enables 936 MW of new load via 832 MW of unforced capacity, equivalent to the size of a small nuclear plant or large gas plant. Note, amount of load supported is greater than the unforced capacity when accounting for PJM's treatment of its reserve margin and forecast pool requirement. Further details can be found in the appendix.

Additionally, our modeling demonstrates that the reliability benefits are not limited to capacity accounting and continue even if the risk is not overwhelming concentrated in winter months. Loss of load modeling — which evaluates physical outage risk across thousands of simulated operating conditions — confirms that OSW reduces the probability and magnitude of outage events across the full PJM footprint. In the appendix, we report modeling results at a range of levels of OSW development. In the main body, we report modeling outcomes at the following scenarios:

- **Base Case:** A base outlook for all technologies. This assumes CVOW remains operational plus an additional 2 GW of Maryland development by 2033, alongside current trajectories for all other resources.
- **Failing to Develop OSW Case:** A base outlook for all technologies excluding OSW. As compared to the base case, no OSW resources are included.
- **Tripling Investment Case:** A base outlook for all technologies with accelerated OSW. This assumes that OSW investment triples with respect to the base case.

Each MW of OSW reduces expected unserved energy by approximately 12.8 MWh RTO-wide. A project the size of CVOW could reduce EUE risk by 33 GWh, enough electricity to power 3,100 average American homes for a year[97] and providing reliability benefits of $832M per year.

OSW's investments bring fuel-free generation during the hard-to-solve winter hours while playing a smaller but non-trivial role in solving summer risk. In addition, OSW makes day-to-day contribution to driving electricity prices and emissions down. For example, CVOW is projected to

[96] PJM Interconnection. "Discussion of Preliminary ELCC Class Ratings for Period 2027/2028 through 2035/2036." PJM Interconnection, 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/discussion-of-preliminary-elcc-class-ratings-for-period-2027-2035.pdf.

[97] U.S. Energy Information Administration, "Electricity Use in Homes," *Use of Energy Explained*, last modified December 18, 2023, accessed May 5, 2026, https://www.eia.gov/energyexplained/use-of-energy/electricity-use-in-homes.php.

generate enough electricity day-to-day to meet the needs of 660,000 average American homes.[98] OSW plays its greatest role in winter and evening hours – aligning with winter grid stress[99] hours and creating synergies with other technologies,[100] while playing a smaller, but continued role during traditional hours of stress in summer afternoons when its generation output is lower.

7.8 GW	936 MW	$320,000
RTO-wide shortfall	Load unlocked by a CVOW-size project	Reliability benefits per MW of OSW

The Dominion story

The Dominion zone captures the largest reliability benefits from OSW investment for two compounding reasons. First, its baseline risk is the highest in PJM with stress in both summer and winter months — a function of rapid load growth, limited local generation, and transmission constraints that prevent the zone from importing sufficient capacity during peak stress periods. Second, OSW connects directly into this constrained zone, providing capacity that cannot be substituted through imports from elsewhere in the grid.

Due to the dynamics of the PJM capacity market construct, capacity is shared across the footprint, but constraints are enforced in some zones to maintain sufficient local generation to meet local reliability needs. Dominion is one of these zones. As a result, every new megawatt of generation, including OSW, supports growth across the entire PJM footprint, but has the greatest impact if development occurs in Dominion.

This insight is further supported by loss of load modeling. In the Failure to Develop Case, Dominion Virginia would increase load shedding risk in the zone by 46% relative to the Base Case. In the Tripling Investment Case, load shedding risk would be reduced by 54% relative to the Base Case. For a project the size of CVOW, this could result in economic benefits on the scale of $1.68B of additional economic growth per year by supporting the energy and capacity needs of new data centers without harming reliability of the grid, if we assume that the trends observed in the JLARC report continue into the future. This metric is computed by scaling the per GW economic benefits reported in the JLARC report. Note, this is a simplified estimate

98 Dominion Energy. "The Project." Coastal Virginia Offshore Wind. Accessed April 13, 2026. https://coastalvawind.com/about/the-project.

99 Stover, Oliver, Jesse Dakss, Dean Koujak, Ryan Chigogo, Abdul Mohammed, Ryan Israel, Charles Merrick, and Chloe Romero Guliak. *The Contribution of Offshore Wind to Grid Reliability & Resource Adequacy*. Boston, MA: Charles River Associates, November 6, 2025. https://media.crai.com/wp-content/uploads/2025/11/05132542/CRA-Report-Offshore-Winds-Contribution-to-Grid-Reliability-Resource-Adequacy-November-2025.pdf.

100 Stover, Oliver, Jesse Dakss, Dean Koujak, Ryan Chigogo, Abdul Mohammed, and Ryan Israel. "Synergies Between Offshore Wind and Natural Gas." White paper, Charles River Associates, January 29, 2026. https://www.crai.com/insights-events/publications/synergies-between-offshore-wind-and-natural-gas/

based on other economic studies but illustrates the order of magnitude economic impact of these types of projects.

46% increase in load shedding risk in Failure to Develop Case relative to the Base Case

54% decrease in load shedding risk in Tripling Investment Case relative to the Base Case

The inland story

The reliability benefits of OSW are not confined to the coast. Because PJM distributes capacity credits uniformly across its footprint, OSW developed in Virginia reduces the capacity shortfall facing utilities in Ohio, West Virginia, and Kentucky just as it does in the Dominion zone.

As in Dominion, the alignment runs deeper than capacity credit accounting. Coastal OSW contributes to reliability inland. Every new MW of generation in the system helps prevent load shedding and minimizes the need to import generation to meet demand in high stress coastal zones. During periods of grid stress, this prevents inland regions from competing with Dominion for power, since Dominion is able to access local generation from OSW. This is particularly relevant during winter stress events. Some parts of the inland states face their highest reliability stress in winter months — driven by elevated heating demand — precisely when OSW generates most strongly. In the **Failure to Develop Case**, load shedding risk would increase by 21% relative to **the Base Case**; **the Tripling Investment Case** investment would reduce load shedding risk by 32% relative to the **Base Case**.

No OSW

Inland load-shedding risk **increases by 21%**

3x OSW

Inland load-shedding risk **decreases by 32%**

The need for wider infrastructure investment

Our results demonstrate that OSW can offer support in meeting capacity shortfalls and minimizing load shedding risks, but it cannot close the emerging capacity gap on its own. Fully resolving PJM's 7.8 GW RTO-wide shortfall through OSW alone would require approximately 24.4 GW of installed capacity — roughly nine projects the size of CVOW. In our view, this is beyond what can be reasonably developed by 2033, given the relatively nascent state of OSW in the United States and the fact that CVOW is the largest domestic project.

Our analysis also shows that OSW investment plays a smaller role in the MAAC region. This is because MAAC's risk is primarily concentrated during summer, when OSW's generation is lower.

During these periods, MAAC is also competing for excess generation with Dominion because our modeling distributes energy in a manner that minimizes load shedding and thus prioritizes larger outages in Dominion. In practice, OSW may be prioritized for MAAC entities first, rather than minimizing load shedding across PJM as a whole. Regardless of how energy is shared during emergency events, OSW can still play a role in driving down energy and capacity costs, reducing emissions, and increasing fuel resilience in the region.

While new OSW projects can play a material role, fully meeting PJM's reliability requirements will require contributions from natural gas, storage, transmission expansion, and demand-side flexibility. The potential value of OSW lies not in its ability to solve the problem alone, but in its ability to bring additional capacity, its alignment with the conditions under which PJM is now most at risk — winter stress events when fuel systems are under pressure – and its synergistic interactions with other technologies.

Key takeaways: OSW materially reduces capacity shortfalls and outage risk across the full PJM footprint, with the largest benefits in the Dominion zone and meaningful contributions to winter reliability and capacity benefits in inland states. A project the size of CVOW closes nearly 1 GW of PJM's capacity gap and eliminates 33 GWh with reliability benefits of $832 million per year. Fully closing the gap requires a broader portfolio — but OSW offers a potential tool as grid planners seek the best pathway to resolve emerging reliability and affordability pressures in PJM while also balancing federal, state, and local economic and policy priorities.

Conclusions

PJM is entering a period of tightening reliability margins driven by rapid load growth, slowed generator additions, and an increasing shift of system risk into the winter months. Under the 2033 resource outlook developed in this study, PJM faces 7.8 GW of RTO-wide capacity shortfalls and 4.3 GW in the Dominion zone, reflecting structural transmission constraints and rising demand. If these gaps are not addressed, PJM may be forced to slow large load interconnections or tolerate higher reliability risk — outcomes with significant economic consequences for states across the region. Virginia's data center economy, Ohio's semiconductor manufacturing investments, automotive investments across the Midwest, and the industrial electrification underway across the broader PJM footprint all depend on a grid that can reliably serve large, concentrated loads.

Our modeling shows that OSW can materially reduce these shortfalls, with its greatest potential to resolve winter and evening stress. At an assumed ELCC of 32%, each MW of OSW reduces capacity shortfalls by 0.36 MW in the Dominion zone and 0.36 MW RTO-wide. While this is lower than thermal resources, OSW's greatest value is in its ability to complement wider grid investments and enable additional resources to be added at scale. Loss of load modeling demonstrates that OSW's reliability potential is non-trivial, even if summer risk remains durable. We find that a project the size of CVOW could reduce load shedding by 33 GWh, enough electricity to power 3,100 average American homes per year while supporting economic development on the order of magnitude of $1.68B per year, if historic conditions continue.

Because PJM distributes accredited capacity uniformly across zones, OSW developed on the coast helps close shortfalls across both coastal and inland regions — including states such as Ohio, West Virginia, and Kentucky that bear no direct development costs but face real reliability and economic consequences if the gap is not closed. Loss of load modeling shows these benefits are not just due to accounting. Failing to develop OSW would drive up load shedding risks by 31% or 78 GWh, enough electricity to power ~7,400 homes, and would drive up reliability costs by $1.95B per year.

However, OSW alone cannot eliminate PJM's emerging deficits. Fully closing the RTO-wide shortfall would require approximately 24.4 GW of additional OSW — over nine projects the size of CVOW — beyond what can be delivered by 2033. Meeting reliability requirements will still require complementary investments in natural gas, storage, high-ELCC resources, and transmission expansion. In this broader portfolio, OSW plays a complementary, not substitutive, role.

Loss of load modeling further illustrates where OSW's contribution is most pronounced. The Dominion zone receives the largest reduction in load shedding risk, with each MW of OSW reducing expected unserved energy by approximately 8.2 MWh — reflecting both the zone's high baseline risk, its direct interconnection with OSW resources, and its dual summer-winter risk profile. OSW strengthens Dominion's local system and helps it bring its share of resource adequacy to the grid, while also supporting state decarbonization targets. Inland regions also benefit, particularly during winter months when system stress is highest and OSW output is strongest, reducing coastal constraints that would otherwise propagate across the system. OSW can also stretch access to scarce natural gas turbines in inland regions by effectively shifting capacity that may otherwise have been used to meet coastal load toward inland needs. MAAC sees lower direct reliability benefits due to a more summer-forward risk profile and modeling assumptions that prioritize energy toward larger shortfalls in Dominion.

This study highlights the factors grid planners must weigh as they seek the optimal portfolio to address emerging shortfalls in PJM. The role of resources such as OSW will depend not only on accredited capacity value, but also on the seasonal profile of reliability risk, infrastructure and supply-chain constraints, and the practical ability to build at scale in constrained zones such as Dominion. Future analysis should consider both the cost of OSW relative to alternative technologies, including associated transmission and/or pipeline costs, and the amount of each resource that can be realistically developed. As greater clarity emerges around load growth and regulatory reform in PJM, these considerations will help planners determine the right balance of OSW and complementary investments needed to support reliability, affordability, and other system needs.

Appendix

Methodology deep dive

This analysis proceeded in three steps. First, we developed a 2033 resource outlook to estimate PJM's baseline capacity position. Second, we quantified capacity shortfalls and the incremental accredited capacity provided by OSW across different locations, using PJM's capacity construct. Third, we evaluated OSW's impact on physical reliability outcomes using loss of load modeling, to provide further detail into OSW's impact without relying on PJM's assumptions.

Resource outlook for 2033

We constructed a forward-looking view of PJM's resource mix in 2033. This outlook reflects expected additions under current market conditions, incorporating the following components:

- Projects currently in the interconnection queue, assumed to reach commercial operation at historical completion rates;[101]
- An accelerated completion rate for natural gas and storage resources (set at twice historical levels) to reflect strong market incentives for high-ELCC resources;
- All projects included in PJM's Reliability Resource Initiative (RRI);[102]
- Announced additions in Integrated Resource Plans (IRPs) of vertically integrated utilities within PJM; and
- A base outlook for OSW projects. This base outlook includes 2.6 GW in Dominion Virginia based on the CVOW project and 2 GW in Maryland based on projects which could be developed by 2033 including the Maryland Offshore Wind project.[103]
- Additional transmission imports into the Dominion territory reflecting ongoing investments.

The resulting resource mix fell materially below PJM's target reserve margin — consistent with shortfalls identified recently by PJM.[104] This outlook is intended to track market trajectory using historical operations, rather than serving as a definitive forecast of system conditions. It is our view

[101] Joseph Rand, Nick Manderlink, Steven Zhang, Chris Talley, Will Gorman, Ryan H. Wiser, Joachim Seel, Julie Mulvaney Kemp, Seongeun Jeong, and Fredrich Kahrl, *Queued Up: 2025 Edition—Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2024* (Berkeley, CA: Lawrence Berkeley National Laboratory, December 2025), https://emp.lbl.gov/sites/default/files/2025-12/Queued%20Up%202025%20Edition%20-%2012.15.2025.pdf.

[102] PJM Inside Lines, "*PJM Chooses 51 Generation Resource Projects To Address Near-Term Electricity Demand Growth*," *PJM Inside Lines*, May 2, 2025, https://insidelines.pjm.com/pjm-chooses-51-generation-resource-projects-to-address-near-term-electricity-demand-growth/.

[103] US Wind. "MarWin Offshore Wind Project." US Wind Inc. Accessed April 10, 2026. https://uswindinc.com/marwin/.

[104] PJM Interconnection, L.L.C. (Feb 2026), *Reliability Backstop Design Working Paper,* February 18, 2026, accessible at: https://www.pjm.com/-/media/DotCom/committees-groups/workshops/rbpw/2026/20260218/20260218-item-03---pjm-reliability-backstop-design-working-paper.pdf.

that the market will face substantive tightness in the coming decade. Due to this stress, we believe that it is likely that the PJM grid will clear very close to, or below, the reserve margin needed to meet the "1-Day-in-10-Year" reliability target unless new avenues are developed to bring new generators onto the system. A number of stakeholders — including state and federal regulators,[105] utilities,[106,107] states,[108] data center developers,[109] and PJM itself[110] — are taking such actions to resolve emergency capacity shortfalls. This resource outlook therefore provides a structured baseline to quantify the emerging capacity gap under current system trends and assess how new technologies, such as OSW, may help close it while supporting load growth. In this manner, we can quantify the potential impact of additional resources in filling shortfalls of accredited capacity and demonstrate their impact in different parts of the grid.

Converting capacity gaps into load shortfalls

To assess how OSW supports PJM's reliability needs, we translated capacity gaps into equivalent load shortfalls — the amount of demand that cannot be reliably served if existing resource trends continue.

PJM's capacity market provides a transparent indicator of whether the system is "long" or "short" relative to the reliability requirement. When the system clears short, PJM may need to curtail load to maintain target reliability levels.

This analysis was performed using CRA's capacity model, CapacityX, which converts the installed capacity mix into capacity market outcomes, based on PJM's Capacity Market Construct.[111] This model converts the aggregate capacity gap into an estimate of the load that cannot be reliably served under business-as-usual conditions. To evaluate the impact of OSW across the PJM footprint, we perform this analysis for Dominion and RTO-wide in a manner consistent with PJM's

[105] U.S. Department of Energy, "Statement of Principles Regarding PJM," January 15, 2026, https://www.energy.gov/documents/statement-principles-regarding-pjm.

[106] Exelon Corporation, "Exelon Delivers Q2 2025 Results, Reaffirms Full-Year Outlook," July 31, 2025, https://www.exeloncorp.com/grid/exelon-delivers-q2-2025-results,-reaffirms-full-year-outlook.

[107] FirstEnergy Corp., "New Generation Facilities Proposed by FirstEnergy to Spark Job Growth and Economic Opportunity in West Virginia," November 2025, https://www.firstenergycorp.com/newsroom/news_articles/new-generation-facilities-proposed-by-fe-to-spark-job-growth-econ-opp-in-wv.html.

[108] Pennsylvania Public Utility Commission, "PUC Advances Plan to Balance Data Center Growth and Consumer Protection," November 6, 2025, https://www.puc.pa.gov/press-release/2025/puc-advances-plan-to-balance-data-center-growth-and-consumer-protection-11062025.

[109] The White House, "President Trump Secures Historic Commitment to Keep Electricity Costs Down Amid Data Center Boom," March 5, 2026, https://www.whitehouse.gov/articles/2026/03/president-trump-secures-historic-commitment-to-keep-electricity-costs-down-amid-data-center-boom.

[110] PJM Interconnection, "PJM Board Supports Action in Support of Urgent Grid Reliability Needs," *PJM Inside Lines*, February 5, 2025, https://insidelines.pjm.com/pjm-board-supports-action-in-support-of-urgent-grid-reliability-needs.

[111] PJM Interconnection, L.L.C., *Manual 18: PJM Capacity Market*, June 2024, https://www.pjm.com/-/media/DotCom/documents/manuals/m18.ashx.

capacity market rules.[112] This rule-based approach establishes a transparent baseline for assessing how OSW may support load growth, and resulting economic development, across the PJM footprint within PJM's capacity construct.

In this analysis, we assumed the ELCC of the OSW resources is 32%, based on the outlook produced by PJM in October 2025.[113] Because PJM projects that ELCC values for wind decline at higher penetration levels, this assumption is influential; however, if wind additions lag expectations, ELCC values may decline more slowly.

Using the 2033 portfolio, we calculate the capacity deficit relative to PJM's planning reserve margin. We then assess OSW's contribution by re-estimating the shortfall at OSW penetration levels ranging from 0% to 300% of the base case, assuming a 32% ELCC.[114] This approach provides a direct measure of how much closer the system moves toward meeting its capacity target — and therefore how much additional load can be reliably served — for each MW of OSW added.

Loss of load modeling

In addition to the capacity-based assessment, we conduct loss of load modeling to capture how OSW affects physical reliability outcomes under a wide range of operating conditions. This analysis is also independent of PJM's ELCC assumptions.

This analysis uses CRA's AdequacyX,[115] a Monte-Carlo simulation tool that quantifies the probability, magnitude, and duration of load shedding events. Unlike capacity-market modeling, AdequacyX does not rely on ELCC assumptions, allowing a neutral evaluation of OSW's physical contribution across PJM.

For each modeled portfolio, we compute:

- **Expected Unserved Energy (EUE)** – the average GWh of unmet demand due to insufficient or undeliverable generation.

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[112] PJM Interconnection, "PJM Board Supports Action in Support of Urgent Grid Reliability Needs," *PJM Inside Lines*, February 5, 2025, https://insidelines.pjm.com/pjm-board-supports-action-in-support-of-urgent-grid-reliability-needs.

[113] PJM, "*2025 PJM Effective Load Carrying Capability and Reserve Requirement Study (ELCC/RRS) PJM Resource Adequacy Planning.*" October 22, 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/2025-pjm-elcc-rrs.pdf.

[114] PJM, "*2025 PJM Effective Load Carrying Capability and Reserve Requirement Study (ELCC/RRS) PJM Resource Adequacy Planning.*" October 22, 2025. https://www.pjm.com/-/media/DotCom/planning/res-adeq/elcc/2025-pjm-elcc-rrs.pdf.

[115] Charles River Associates (CRA), *Introducing CRA AdequacyX: CRA's Resource Adequacy Model* (white paper, October 2024), https://media.crai.com/wp-content/uploads/2024/10/17133654/Introducing-CRA-AdequacyX-whitepaper-October2024.pdf.

- **Normalized EUE (N-EUE)** – EUE expressed as a share of annual energy sales (in parts per million). Typical benchmarks around 10–20 ppm.[116]
- **Reliability costs** – The product of EUE and VOLL, assumed to be $25,000/MWh.[117,118]
- **Survival curves**, which show the full probability distribution of potential outage outcomes.

We perform this analysis for Dominion, MAAC, and the Rest of RTO (sometimes referred to as inland to highlight its distance from coastal regions with OSW), evaluating OSW penetration levels ranging from 0% to 300% of the base case. This allows us to compare OSW's impact across constrained coastal zones and inland regions with different seasonal risk profiles.

By combining capacity-market modeling with loss of load simulations, we capture both accredited capacity impacts and physical reliability improvements, providing a comprehensive assessment of OSW's contribution across PJM.

[116] Because the target for resource adequacy is very high due to the critical nature of electricity to public safety and economic development, N-EUE targets are very small. As such, this metric is typically reported in ppm format. This means the raw share of unserved energy is multiplied by one million.

[117] Thomas Schröder and Wilhelm Kuckshinrichs, "Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review," Frontiers in Energy Research 3 (December 24, 2015), https://www.frontiersin.org/articles/10.3389/fenrg.2015.00055/full.

[118] Michael J. Sullivan, Robert T. McDermott, and Shmuel S. Oren, "The Value of Lost Load (VoLL) for Electricity Supply Reliability: An Econometric Analysis of U.S. Outage Cost Data," Utilities Policy 78 (December 2022), https://doi.org/10.1016/j.jup.2022.101403.

Detailed results

Capacity shortfalls

We found that PJM faces material capacity shortfalls under business-as-usual conditions in 2033, including approximately 4.3 GW in the Dominion Zone and 7.8 GW RTO-wide. These shortfalls were calculated after accounting for expected electricity imports and assuming that Dominion's Capacity Emergency Transfer Limit (CETL) remains at the value used in PJM's 2027/28 auction.[119] CETL represented the amount of power that can reliably flow into the zone during peak conditions, and holding it constant provides a clearer view of the capacity Dominion must supply locally.

Dominion shows zonal shortfalls because PJM classifies it as a "constrained Locational Deliverability Area (LDA)", reflecting limited transmission import capability. As a result, Dominion clears independently in capacity auctions, and PJM applies additional local reliability requirements to ensure sufficient dependable resources are available.

These conditions provided a more accurate picture of Dominion's local capacity need.

Given the magnitude of these shortfalls, load shedding events would be frequent in the absence of corrective action. To maintain reliability, stakeholders would likely need to accelerate high-ELCC resource additions, delay or stage new load interconnections, or take other emergency actions. In this analysis, we assume load is curtailed to maintain planning reserve margin compliance.

We find that OSW can partially mitigate these emerging shortfalls. For every 1 MW of OSW developed in Dominion, shortfalls decrease by 0.36 MW of ICAP in both Dominion and RTO-wide (assuming a 32% ELCC).[120] The resulting shortfalls at each OSW level are shown in Table 1.

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[119] PJM Interconnection, LLC, *2027/2028 Base Residual Auction Report* (Audubon, PA: PJM Interconnection, LLC, December 22, 2025), https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2027-2028/2027-2028-bra-report.pdf.

[120] In this analysis, we do not assume that the ELCC assigned to OSW would decline given that its relative magnitude is small relative to overall PJM system size of 276 GW and the overall wind capacity of 12 GW (including onshore and offshore wind).

Table 1: Capacity Shortfall at Varying Levels of OSW in Dominion

Level of OSW	All of RTO shortfall (unforced capacity MW)	Dominion shortfall (unforced capacity MW)
0%	9,271.66	5,100.31
50%	8,535.66	4,684.31
100%	7,799.66	4,268.31
150%	7,063.66	3,852.31
200%	6,327.66	3,436.31
250%	5,591.66	3,020.31
300%	4,855.66	2,604.31

Loss of load modeling

Next, we report the result of the loss of load modeling which assesses the load shedding risks at varying levels of penetration for OSW. The summary metrics are given in Table 2, reporting the EUE and N-EUE for each level of OSW investment across Dominion, MAAC, and the Rest of RTO. To assess the full range of load shedding risk, the survival curves for Dominion, MAAC, and the Rest of RTO are given in Figure 4, Figure 5, and Figure 6, respectively.

Table 2: Resource adequacy results

Region	Level of OSW	Expected unserved energy (GWh)	Reliability costs ($B/yr)	Normalized expected unserved energy (ppm)
Dominion	**0%**	164	4.1	14.6
	50%	135	3.38	12.4
	100%	112	2.80	10.5
	150%	93	2.33	9.1
	200%	77	1.93	8.1
	250%	63	1.58	6.8
	300%	52	1.3	6.1

MAAC	**0%**	14.0	0.35	50
	50%	14.0	0.35	50
	100%	14.0	0.35	50
	150%	14.0	0.35	50
	200%	14.0	0.35	50
	250%	14.0	0.35	50
	300%	14.0	0.35	50
Rest of RTO	**0%**	148	3.70	38
	50%	134	3.35	34
	100%	122	3.05	30
	150%	110	2.75	27
	200%	100	2.50	23
	250%	91	2.28	21
	300%	83	2.08	19

Table 3: Efficacy of OSW in reducing load shedding risk

Zone	Average EUE reduction per MW of OSW (MWh/MW)
All of RTO	12.8
Dominion	8.2
MAAC	0.01
Rest of RTO	4.69

Survival curves

In addition to reporting EUE, the results include the full distribution of annual unserved energy outcomes across all simulations using a survival curve format.

These visualizations illustrate the probability that annual unserved energy exceeds any specified threshold, providing a comprehensive view of the range and likelihood of reliability outcomes associated with each portfolio. This allows for the evaluation of tail risk outcomes.

Figure 4: Survival curve for Dominion

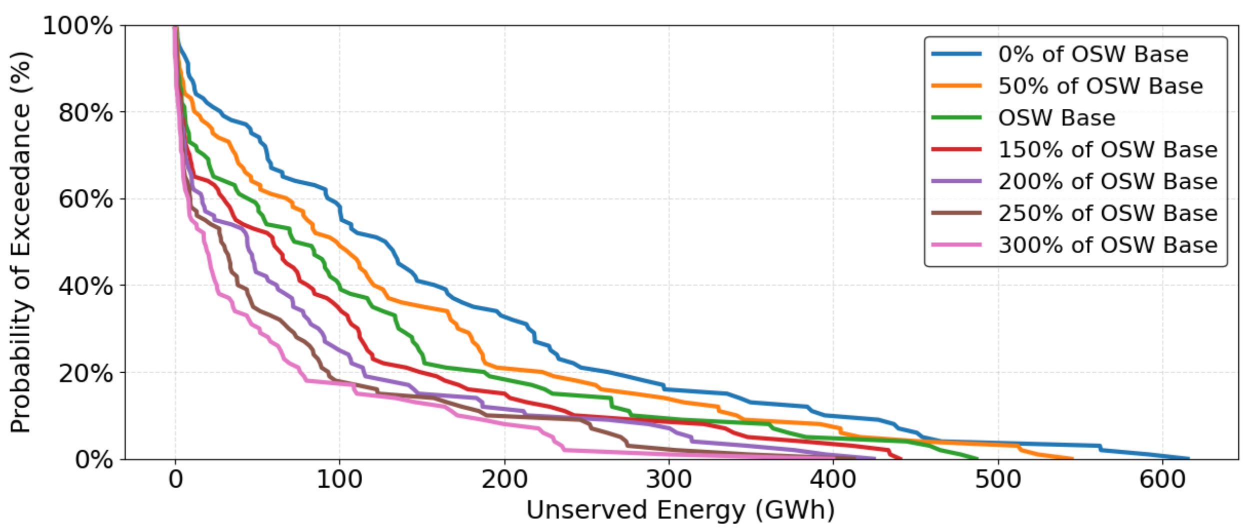


Figure 5: Survival curve for MAAC

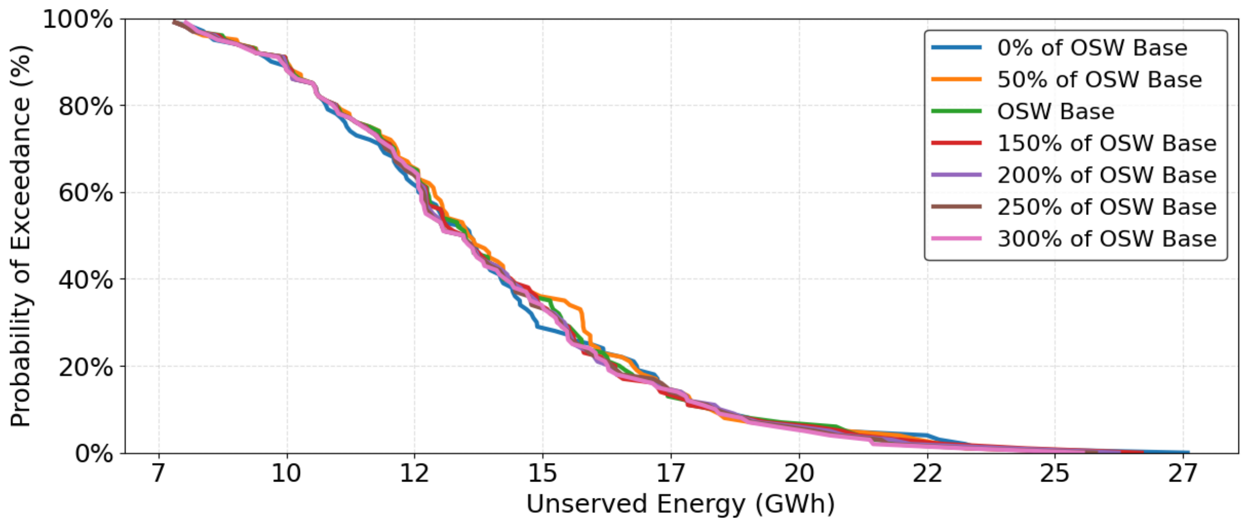
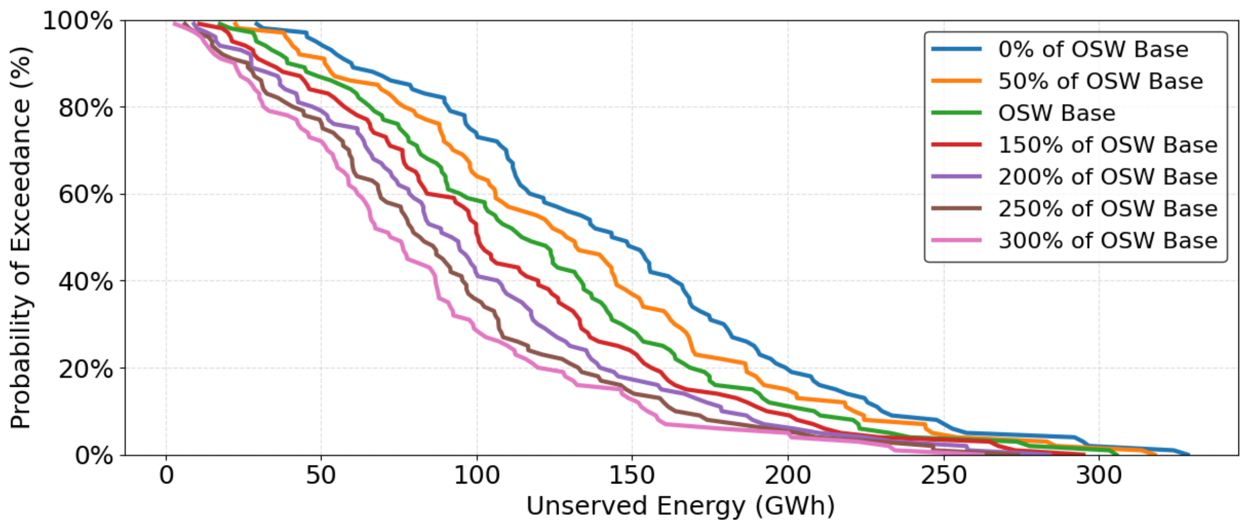


Figure 6: Survival curve for Rest of RTO



Qualitative discussion of fuel diversity

OSW is a fuel-free resource that strengthens grid fuel diversity and reduces exposure to supply disruptions during extreme winter events, such as Winter Storm Elliott and Winter Storm Fern. These benefits, however, are difficult to quantify with today's loss of load models, which largely replay historical operating conditions and do not yet include forward-looking methods for capturing electric–gas interdependence or fuel-system stress.

Although the industry recognizes the growing importance of analyzing interactions between the electric grid and gas supply,[121] comprehensive models capable of assessing multi-day fuel disruptions — like those experienced during Winter Storm Fern — are still in early stages of development. Further, some of these risks may be mitigated by hardening fuel supplies themselves, rather than installing new resources. As these tools evolve, they will be better equipped to evaluate how OSW can relieve pressure on fuel-constrained systems and contribute to winter reliability.

Definition of MAAC

The MAAC region is composed of the following PJM zones:

- Allegheny Electric Cooperative
- Baltimore Gas and Electric Company
- Delmarva Power & Light Company
- Jersey Central Power & Light Company
- Metropolitan Edison Company
- PECO Energy Company
- Pennsylvania Electric Company
- PPL Electric Utilities Corporation
- Public Service Electric and Gas Company
- Rockland Electric Company

Dominion composes its own zone. All other zones are reported in the "Rest of RTO" category.

[121] North American Electric Reliability Corporation. *Electric–Gas Interdependence.* Accessed March 17, 2026. https://www.nerc.com/initiatives/electricgas-interdependence.

PJM Energy Forecast[122]

Table 4: PJM Energy Forecast

Year	Energy Forecast (GWh)
2026	856,075
2027	898,163
2028	949,769
2029	1,000,177
2030	1,086,262
2031	1,170,946
2032	1,243,681
2033	1,299,453
2034	1,348,192
2035	1,390,749
2036	1,437,629
2037	1,479,300
2038	1,516,178
2039	1,540,586
2040	1,567,228
2041	1,580,537
2042	1,598,767
2043	1,615,986
2044	1,638,354
2045	1,649,287
2046	1,667,075

[122] PJM Interconnection, LLC, *2026 Load Forecast Report* (Audubon, PA: PJM Interconnection, LLC, January 14, 2026), https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf.