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Synergies between offshore wind and natural gas

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Executive summary

The US electric system is entering a period of rapid and unprecedented change. Electricity demand is rising sharply due to the acceleration of Artificial Intelligence (AI) data centers, semiconductor manufacturing, industrial onshoring, and the electrification of heating and transportation. As a result, the grid is transitioning toward winter peaking conditions and facing increased operational stress during extreme cold events. Across multiple regions, load growth is outpacing the speed at which new generation, fuel infrastructure, and transmission can be built. In light of these challenges and to support America's wider domestic and foreign policy goals, policy makers are taking an **energy dominance** approach to develop abundant, affordable energy while strengthening the nation's geopolitical leadership.

Against this backdrop, natural gas (NG) and offshore wind (OSW) have emerged as two of the most consequential resources for meeting near- and medium-term reliability needs. Although often framed as competing resources, **our analysis shows that NG and OSW address different dimensions of system risk and deliver the greatest reliability value when deployed together**. Their interaction is shaped by seasonal load patterns, fuel deliverability constraints, and infrastructure limits that increasingly define system performance.

This assessment draws on four complementary methods: (1) quantitative modeling to evaluate the available headroom on gas pipelines, the joint resource adequacy benefit of OSW and NG, and the impact of OSW on oil-fired generation in NYISO; (2) targeted literature review of grid-operator, regulatory, and research studies; (3) structured interviews with NG developers, OEMs, and EPCs to ground the analysis in real-world supply-chain, permitting, and construction conditions; and (4) qualitative case studies of two advanced OSW projects – Dominion's CVOW and Orsted/Skyborn Renewables' South Fork Wind – to illustrate how OSW performs in regions with gas constraints and transmission constraints. Together, these approaches provide a multi-angle evaluation of how OSW and NG jointly support America's energy goals.

The following key findings summarize the results of our analysis and highlight the implications for reliability planning and policy.

Key findings

1. Load growth is accelerating faster than net new generation.

Across multiple markets, projected demand has risen sharply, driven by data centers and industrial investments and electrification of heating and transportation. Winter load is growing the fastest due to electrification of heating – shifting reliability needs to hours when solar is unavailable, storage may be depleted, and fuel systems typically experience their greatest stress. At the same time, thermal resources have retired, and new additions have not been built quickly enough to maintain resource adequacy. Rapid load growth from data centers and other manufacturing sectors is only exacerbating this strain.

2. NG will remain essential, but fuel infrastructure limits constrain its ability to scale.

NG is the backbone of US grid reliability.[1,2] However, limited firm pipeline headroom in several regions – particularly New York and New England – limits how much additional NG generation can be added in the near- to medium-term. Modeling shows that in some corridors, winter pipeline flows already approach physical limits. Even in regions where pipelines have sufficient capacity to add new generators, interviews with developers indicate that turbine backlogs, rising capital costs, and workforce shortages slow the pace of NG generation deployment.

3. OSW provides winter-aligned, fuel-free, local generation that directly mitigates emerging reliability risks.

OSW's strongest output occurs during winter and at night – precisely when NG systems face deliverability constraints and when electrified heating drives system peaks. This alignment allows OSW to offset winter load growth and reduce stress on gas-fired generation. Case studies from South Fork Wind and Dominion's CVOW project illustrate that OSW can deliver large quantities of local energy into constrained coastal load pockets where gas infrastructure is strained.

4. Neither resource can solve emerging resource adequacy and affordability challenges alone.

The US grid is seeing load growth not seen in decades. While both resources can be brought onto the grid at scale, material supply-chain, infrastructure, and permitting challenges limit the ability to harness the full potential of both resources. At present, the scale of load growth and retirements is outpacing the rate at which new energy resources can be added.[3]

5. OSW and NG demonstrate some complementary reliability value when deployed together but also exhibit diminishing marginal benefits as capacity increases.

Hit rate[4] modeling shows that each technology becomes more effective at reducing remaining risk when the other is present due to complementary generation profiles. OSW most effectively reduces risk during winter peaks with smaller but still material contributions during the summer. NG provides firm support during low-wind periods (often in summer). However, as more capacity of either resource is added, the marginal impact declines because both ultimately address the same pool of risk hours.

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1 US Energy Information Administration. "Use of Natural Gas." *EIA — Energy Explained*. Last updated June 28, 2024. Accessed December 18, 2025. https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php

2 North American Electric Reliability Corporation. *2024–2025 Winter Reliability Assessment*. November 2024. https://www.nerc.com/globalassets/programs/rapa/ra/nerc_wra_2024.pdf

3 US Department of Energy, *Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid* (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

4 Hit rate is defined as the portion of risk reduced per megawatt of unserved energy. This is a novel concept in this paper.

6. OSW materially reduces reliance on back-up fuel oil generation.

Due to rapidly growing winter load, oil-fired generation could more than triple by the mid-2030s as winter load grows. OSW reduces the number of hours in which dual-fuel generators must burn oil – lowering costs, emissions, and mechanical wear on an aging fleet. It also preserves limited oil inventories for the highest-risk events and increases the effective reliability contribution of NG units during cold weather.

7. NG and OSW face many of the same development barriers.

Supply-chain bottlenecks, long permitting timelines, EPC capacity shortages, and rising capital costs affect both technologies. Manufacturing lines for NG turbines, OSW components, and subsea cables are operating near full utilization. The workforce needed for NG and OSW construction competes directly with labor for LNG terminals, semiconductor fabrication, and data centers. Permitting processes (federal, state, local, and judicial) create multiyear uncertainty for energy infrastructure – pipelines, NG generation, and OSW alike.

8. Shared solutions can unlock new domestic energy and capacity to support America's energy goals.

Energy priorities established by federal and state regulators focus on expanding access to abundant, affordable, and increasingly clean energy to strengthen the nation's geopolitical and technological leadership, drive economic growth, and support investments in energy-intensive industries. Addressing the barriers facing both energy sources can increase the pace and scale at which new resources are brought onto the system. Investing in both also creates a natural hedge if one faces disruptions and unlocks additional pathways to new domestic energy. Harnessing net new energy generation from all available domestic energy sources is critical to meeting the moment facing America's grid.

Takeaways

Together, these findings indicate that neither OSW nor NG alone can meet emerging reliability needs under realistic infrastructure and fuel-deliverability constraints. But each resource can meaningfully support load growth. Further, the analyses show that they offer additional benefits when paired together, particularly because their periods of strongest performance occur at different times. NG provides flexible, dispatchable capacity but may be limited in regions with constrained pipeline headroom or during periods of high winter demand. OSW provides winter-aligned, fuel-free generation that reduces pressure on gas systems, but it requires firm capacity, either energy-dense resources like NG and/or storage, to cover low-wind or summer lulls at deep penetrations of OSW.

The results also indicate that OSW and NG pair well because their operational strengths are complementary: OSW tends to produce most during winter – with lower but still material generation during summer – and nighttime periods when gas-deliverability constraints are most likely. NG provides firm output during low-wind or high-temperature hours when OSW output declines. These differing profiles allow each to address distinct sources and timing of system stress.

Further, as highlighted in the case studies, NG and OSW may be best suited for different locations and applications. NG may be best suited for areas with available fuel-system headroom and for serving continuous, high-load-factor demand, such as data centers. OSW is appropriate for coastal load pockets where fuel-deliverability limits, transmission congestion, or siting constraints make new thermal generation challenging. In these regions, OSW can help meet emerging winter load growth while broader grid or fuel-infrastructure investments progress. Given these varying profiles, each can play a distinct and complementary role in reliably meeting load growth while supporting America's energy goals.

At the same time, the Marginal Reliability Impact (MRI) results highlight competitive interactions: as more capacity of one resource is added, the marginal reliability contribution of the other declines. This occurs because both resources ultimately compete to eliminate the same remaining risk hours. This competitive interaction is true of most resources, except for solar and storage.[5] However, our results also show that if system shortfalls exist, as is projected in many systems across the country,[6,7,8] the MRI of both increases rapidly. Thus, while OSW and NG can provide benefits when deployed together, their incremental value depends on regional conditions, remaining risk hours, and the generation mix already on the system. Given the projected shortfalls facing much of the grid, every megawatt of new energy generation provides substantive reduction in risk.

Given these findings, federal and state leaders should focus on adding new megawatts, especially resources whose output aligns with the system's highest-risk hours, and prioritize solutions that strengthen overall resource adequacy and resilience, rather than framing OSW and NG as competing choices. A portfolio approach that leverages the complementary strengths of all resources, including NG and OSW, will be the most effective path to meeting the nation's reliability, security, and economic objectives in the face of rapid load growth.

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5 Energy and Environmental Economics, Inc., Reliability Planning in the Era of Decarbonization: Practical Application of Effective Load Carrying Capability in Resource Adequacy (San Francisco: E3, August 2020), https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf.

6 US Department of Energy, *Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid* (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

7 PJM Interconnection, *Energy Transition in PJM: Resource Retirements, Replacements, and Risks*, Valley Forge, PA: PJM, August 2023, Retrieved from the PJM website: *Energy Transition in PJM: Resource Retirements, Replacements, and Risks* (2023), https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx.

8 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.* Charles River Associates, November 2025.

Introduction

The sharp rise in electricity demand confronting the US grid underscores a structural challenge: the speed at which new generation and infrastructure can be deployed may fall short of the pace of load growth.[9] Permitting timelines for all resource types have lengthened,[10] interconnection backlogs continue to grow,[11] and key supply-chain components such as gas turbines, transformers, and breakers now face multi-year manufacturing queues. The result is a widening gap between the system we have and the system we need – one that materially elevates reliability risk for customers and industries that depend on highly reliable electricity.[12,13,14] At the same time, electricity is becoming more expensive, particularly in New England, the Mid-Atlantic, and California.[15]

Compounding these challenges, America's existing NG infrastructure is under stress in some regions of the country due to aging existing infrastructure and growing demand coupled with slower-than-desired investment. Repeated assessments by NERC[16], ISO-NE[17], and the NPCC[18] have warned that some parts of the NG system are increasingly constrained during extreme cold. While some parts of the country have abundant headroom to add new resources, other pipelines operate at or near maximum throughput on the coldest days, leaving limited capacity

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9 US Department of Energy, *Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid* (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

10 Utility Dive. 2024. "Congressional Action on Energy Permitting Remains Stuck, but States, Developers Are Finding Solutions." *Utility Dive*, February 27, 2024. https://www.utilitydive.com/news/federal-energy-permitting-reform-doe-ferc-congress/705818/

11 Bolinger, M., Seel, J., & Wiser, R. *Queued Up: 2024 Edition*, Berkeley, CA: Lawrence Berkeley National Laboratory, April 2024, Retrieved from the Lawrence Berkeley National Laboratory website https://emp.lbl.gov/sites/default/files/2024-04/Queued%20Up%202024%20Edition_1.pdf.

12 US Department of Energy, *Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid* (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

13 PJM Interconnection, *Energy Transition in PJM: Resource Retirements, Replacements, and Risks*, Valley Forge, PA: PJM, August 2023, Retrieved from the PJM website: *Energy Transition in PJM: Resource Retirements, Replacements, and Risks* (2023), https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx.

14 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.* Charles River Associates, November 2025.

15 Levinson, Michelle, and Ian Goldsmith. 2025. "What's Driving US Electricity Prices?" *World Resources Institute*, December 15, 2025. https://www.wri.org/insights/whats-driving-us-electricity-prices

16 Cooperative.com, *NERC Warns of Electricity Shortages in Winter Reliability Assessment*, 2023, https://www.cooperative.com/news/Pages/NERC-Warns-of-Electricity-Shortages-in-Winter-Reliability-Assessment.aspx.

17 US Energy Information Administration (EIA), "New England utility closes import-dependent gas-fired power plant, keeps LNG import option*," Today in Energy—IN BRIEF ANALYSIS,* https://www.eia.gov/todayinenergy/detail.php?id=62404.

18 Levitan & Associates, Inc, *Northeast Gas/Electric System Study—Prepared for Northeast Power Coordinating Council—PUBLIC VERSION*, Northeast Power Coordinating Council (NPCC), January 21, 2025, https://cdn.prod.website-files.com/67229043316834b1a60feba3/678fee912264907c381a0f68_NPCC%20Northeast%20Gas%20Electric%20System%20Study.pdf.

to add critically needed, new gas-fired generators. Additionally, limited fuel supply places stress on existing gas-fired generation. When heating demand surges, dual-fuel units are forced to switch to costly distillate fuels, and in extreme cases, fuel shortages have contributed to emergency load shedding events on the electricity grid.[19] Investments in gas infrastructure are planned and ongoing to support growing demand and mitigate these risks,[20,21] but they will take time to materialize, given the complexity of developing new energy infrastructure.

In light of these challenges, grid planners and regulators face urgent questions:

- **How to position the electricity grid, and wider energy infrastructure ecosystem, to reliably and affordably meet rapid load growth;**
- **How to strengthen America's geopolitical position by providing abundant, reliable, affordable, and increasingly clean domestic energy; and**
- **How to achieve these goals despite infrastructure, permitting, and supply-chain constraints that limit the speed and scale of new additions.**

This white paper examines how **offshore wind (OSW)** and **natural gas (NG)** can jointly help grid planners and regulators address these challenges. Although often discussed as competing options, the two resources exhibit strong functional complementarities across seasons, operating conditions, deployment timelines, and infrastructure needs. OSW produces its highest output during the exact conditions when the gas system is most stressed. NG, in turn, provides flexible, dispatchable capacity to balance wind variability and support reliability during low-wind periods. Together, they form a portfolio that is more resilient, more fuel-secure, and more capable of supporting the emerging AI-driven economy and America's policy goals than either resource alone.

Research questions

This white paper seeks to explore several questions related to the joint role of OSW and NG in supporting America's energy goals. These questions include the following:

- How can OSW and NG jointly contribute to system reliability and affordability under today's infrastructure constraints and rising electricity demand?

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19 New York Independent System Operator. *2024 Reliability Needs Assessment (RNA): A Report from the New York Independent System Operator.* November 19 2024. https://www.nyiso.com/documents/20142/2248793/2024-RNA-Report.pdf

20 *"US Midstream Report: Natural Gas Pipeline Growth Drives 2025 Optimism,"* Pipe Exchange, July 2, 2025, https://pipexch.com/u-s-midstream-report-natural-gas-pipeline-growth-drives-2025-optimism/

21 Brian Watson and Casey Wolf, *"New Era of Growth for US Liquefied Natural Gas Exports,"* Invesco, October 22, 2025, https://www.invesco.com/us/en/insights/new-era-of-growth-for-us-liquefied-natural-gas-exports.html

- What specific synergies or competitive interactions emerge when these technologies are developed together, and what lessons or reforms could support the development of both resources?
- What challenges confront these technologies today?

To answer these questions, we use four complementary approaches:

- **Numerical modeling** of fuel-deliverability limits, back-up fuel displacement, and marginal reliability impacts (MRI) to quantitatively examine the joint role of OSW and NG in solving emerging resource adequacy gaps;
- **Literature review** to understand the challenges slowing infrastructure investment across the country; and
- **Qualitative case studies** of operating and near-operational OSW projects to examine their impact on the grid and role in wider infrastructure investments; and
- **Stakeholder engagement** with developers, OEMs, EPCs, and operators in the NG space to evaluate headwinds facing current supply-chain and permitting conditions for new NG resources.

Together, these analyses provide a grounded, data-driven perspective on how OSW and NG interact under conditions of fast load growth, constrained infrastructure, and changing reliability requirements.

Evolving reliability needs and policy drivers

For context, this section provides a brief overview of key topics that impact OSW and NG development including resource adequacy, energy dominance, and headwinds facing NG and OSW development.

Resource adequacy

Resource adequacy refers to having sufficient and appropriately located electricity generation to meet demand under all plausible weather and grid conditions.[22]

[22] National Renewable Energy Laboratory, *Explained: Fundamentals of Power Grid Reliability and Clean Electricity*, Golden, CO: National Renewable Energy Laboratory, January 2024, NREL/FS-6A40-85880, https://www.nrel.gov/docs/fy24osti/85880.pdf.

Load is growing at a pace not seen in decades, driven by the explosive expansion of hyperscale data centers,[23] a resurgence of energy-intensive sectors of domestic manufacturing,[24,25] and growth in other energy-intensive industries.[26] These industries have been recognized as critical to the nation's economic competitiveness and geopolitical strength.[27] Federal policymakers have explicitly recognized AI data centers as critical defense facilities and have strongly promoted domestic investment in these industries to ensure the US prevails in the global AI race.[28]

Similarly, onshoring of manufacturing, particularly for products like semiconductors, is viewed as essential to national security and a driver of high-wage job creation.[29] These industries are uniquely energy intensive. As such, they will require abundant reliable and affordable power to meet industrial customers' stringent uptime requirements[30] and prevent costly disruptions to manufacturing processes.[31]

In addition to the growth in energy-intensive industries, load is rising due to electrification. Transportation, existing industrial processes, and building heating applications are increasingly shifting to electricity as a fuel source driven by cost savings, decarbonization efforts, and state policies.[32] Collectively, these factors are driving up demand forecasts for electricity across the country at a pace not seen in decades. National load growth due to data center development alone has been estimated as high as 109 GW (S&P) or as low as 33 GW (Lawrence Berkeley

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23 S&P Global. *"Data Center Grid Power Demand to Rise 22 % in 2025, Nearly Triple by 2030."* S&P Global, October 14, 2025. Accessed December 28, 2025. https://www.spglobal.com/energy/en/news-research/latest-news/electric-power/101425-data-center-grid-power-demand-to-rise-22-in-2025-nearly-triple-by-2030

24 Grand View Research. 2025. "US Steel Market Size & Outlook, 2024–2030." *Grand View Research*. Accessed December 28, 2025. https://www.grandviewresearch.com/horizon/outlook/steel-market/united-states

25 Semiconductor Industry Association (SIA). *"America Projected to Triple Semiconductor Manufacturing Capacity by 2032, the Largest Rate of Growth in the World."* Semiconductor Industry Association, accessed December 28, 2025. https://www.semiconductors.org/america-projected-to-triple-semiconductor-manufacturing-capacity-by-2032-the-largest-rate-of-growth-in-the-world/

26 Electric Reliability Council of Texas (ERCOT). *2025 Long-Term Load Forecast Report*. April 8, 2025. Accessed December 28, 2025. https://www.ercot.com/files/docs/2025/04/08/ERCOT-2025-Long-Term-Load-Forecast-Report.pdf

27 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/critical-infrastructure-sectors/critical-manufacturing-sector

28 "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/.

29 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.

30 Uptime Institute, *2024 Data Center Resiliency Survey—Executive Summary*, (Fort Collins, CO: Uptime Institute, 2024), https://datacenter.uptimeinstitute.com/rs/711-RIA-145/images/2024.Resiliency.Survey.ExecSum.pdf?version=0&mkt_tok=NzExLVJJQS0xNDUAAAGSPCeKfdv0kYTrLS-6.

31 The Brattle Group, *Value of Lost Load Study for the ERCOT Region*, prepared for the Electric Reliability Council of Texas, Inc., Project No. 55837, (Cambridge, MA: The Brattle Group, September 2024), https://www.brattle.com/wp-content/uploads/2024/09/Value-of-Lost-Load-Study-for-the-ERCOT-Region.pdf.

32 Lalit Batra et al., *"Rising Current: America's Growing Electricity Demand,"* ICF, May 28, 2025, https://www.icf.com/insights/energy/impact-rapid-demand-growth-us

National Laboratory's Low case) over the next decade.[33] For reference, the peak demand in the lower 48 States is 759 GW.[34] Further, the pace of forecasts has trended up in recent years. For example, the PJM forecast for the year 2030 increased by 16 GW (9.5%) between the 2024 and 2025 forecast vintages.[35]

Against this backdrop, the grid is struggling to maintain resource adequacy. A large amount of firm thermal generation is retiring due to age, economics, state decarbonization goals, and increasing consumer preference for low-carbon electricity.[36,37,38] Entry of new capacity is constrained by supply chain challenges and interconnection backlogs.[39] Moreover, much of the new capacity consists of non-dispatchable resources (solar and wind), energy-limited resources (storage), or just-in-time fuel resources (NG).[40] Together, these shifts are yielding a grid with lower reserve margins and risks spread across a broader range of hours.[41] Even with delayed retirements of dispatchable resources, many markets are already showing signs of strain:

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33 US Department of Energy, *Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid* (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

34 US Energy Information Administration. "*Electricity Demand in the Lower 48 Sets a New Record on July 29, 2025.*" August 6, 2025. https://www.eia.gov/todayinenergy/detail.php?id=65864.

35 PJM Interconnection, *2025 Long-Term Load Forecast Report*, Valley Forge, PA: PJM, January 2025, Retrieved from PJM website, https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2025-load-report.pdf.

36 Clean Energy Buyers Association, *CEBA Report: Corporate Demand Drives Clean Energy*, October 1, 2025, https://cebuyers.org/wp-content/uploads/2025/09/CEBA-Report-Corporate-Demand-Drives-Clean-Energy.pdf

37 PJM Interconnection, *Energy Transition in PJM: Resource Retirements, Replacements, and Risks*, Valley Forge, PA: PJM, August 2023, Retrieved from the PJM website: *Energy Transition in PJM: Resource Retirements, Replacements, and Risks* (2023), https://www.pjm.com/-/media/DotCom/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx.

38 Jenny Heeter, Lauren Knapp, Eric O'Shaughnessy, Sarah Mills, and John DeCicco, *"Will Consumers Really Pay for Green Electricity? Comparing Stated and Revealed Preferences for Residential Programs in the United States," Energy Research and Social Science* 65 (2020), https://research-hub.nrel.gov/en/publications/will-consumers-really-pay-for-green-electricity-comparing-stated-/

39 Bolinger, M., Seel, J., & Wiser, R. *Queued Up: 2024 Edition*, Berkeley, CA: Lawrence Berkeley National Laboratory, April 2024, Retrieved from the Lawrence Berkeley National Laboratory website https://emp.lbl.gov/sites/default/files/2024-04/Queued%20Up%202024%20Edition_1.pdf.

40 Ibid.

41 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.* Charles River Associates, November 2025.

capacity prices have surged to record levels in PJM[42] and MISO[43] and reliability studies are raising concerns from industry and government leaders.[44,45]

In addition to broader challenges, the times at which the grid is stressed is changing. Electrification of space heating is driving rapid winter load growth, while cold weather places stress on NG systems, which continue to supply most of the dispatchable fleet. Even in markets where peak demand still occurs in the summer, operators are increasingly concerned about winter performance, with some now describing their systems as **summer peaking but winter-constrained**. Other systems are even projecting to become **winter peaking**. Across much of the country, winter mornings and evenings are emerging as the periods of greatest stress – times when solar output is minimal, heating demand is elevated, and storage resources may already be depleted.

Energy dominance

In light of these challenges, various federal and state regulators have introduced the concept of **energy dominance** as a lens for evaluating domestic energy priorities. This policy aims to maximize domestic energy production and infrastructure investments to ensure national security, economic competitiveness, and supply chain resilience.[46] The core goals of this policy have bipartisan support across federal, state, and industry leadership.[47,48]

Recent global and domestic events have underscored the impact of energy security and reliability. The war in Ukraine disrupted global fuel markets. Supply chain shocks exposed weak points in critical industries. American companies and policymakers are also focused on onshoring energy-intensive sectors. These developments underscore how geopolitical instability and supply vulnerabilities can directly impact US economic competitiveness and national

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42 This auction was held for the June 1, 2026 through May 30, 2027 delivery period, PJM Interconnection, *2025–2026 Base Residual Auction Report*, 2025, https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2025-2026/2025-2026-base-residual-auction-report.pdf.

43 Midcontinent Independent System Operator (MISO), “MISO’s Planning Resource Auction Indicates Sufficient Resources,” *MISO News Center*, April 28, 2025, https://www.misoenergy.org/meet-miso/media-center/2025---news-releases/misos-planning-resource-auction-indicates-sufficient-resources/.

44 S. Department of Energy, 2025, *Report on Evaluating US Grid Reliability and Security*, DOE final report, July 7, 2025, Washington, DC: US Department of Energy.

45 Federal Energy Regulatory Commission, “FERC to Host Commissioner-Led Technical Conference on Resource Adequacy,” *News Release*, February 20, 2025, Washington, DC https://www.ferc.gov/news-events/news/ferc-host-commissioner-led-technical-conference-resource-adequacy.

46 Executive Order 14213*, Establishing the National Energy Dominance Council | the American Presidency Project,* Ucsb.edu, February 14, 2025, https://www.presidency.ucsb.edu/documents/executive-order-14213-establishing-the-national-energy-dominance-council.

47 Congressman Chuck Fleischmann, *US Representative: Our Bipartisan Commitment to Energy Dominance*, April 24, 2025, https://fleischmann.house.gov/media/in-the-news/us-representative-our-bipartisan-commitment-to-energy-dominance.

48 Bipartisan Policy Center, *Energy*, 2024, https://bipartisanpolicy.org/policy-area/energy/.

security, strengthening the rationale for policies that prioritize domestic energy capacity and self-sufficiency.[49,50]

At its core, energy dominance is built on four policy pillars:[51]

Energy affordability: Expand efficient, cost-competitive production to stabilize prices and reduce inflation.

Energy independence and security: Leverage abundant domestic resources, regardless of fuel source, to reduce reliance on foreign energy imports and position the US as a stable global supplier.

Reliability and resilience: Deliver uninterrupted power using a diverse mix of baseload and renewable generation to fuel American economic activity and everyday life. Erosion in grid reliability threatens national security, public health, economic competitiveness, and – at its worst – human life. Highly reliable electricity delivery is also critical to incentivizing domestic investment in energy-intensive industries such as artificial intelligence, semiconductors,[52] and other strategic sectors.[53,54,55]

Economic growth and leadership: Harness domestic energy production as a driver of job creation, industrial revitalization, and technological innovation. Position the US to lead not only in energy production but in critical sectors such as data centers, artificial intelligence, semiconductor manufacturing, and electric vehicle production. By leveraging abundant resources, the US can attract and expand these critical industries, support onshoring of strategic supply chains, and maintain technological and economic competitiveness.[56]

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49 Dan Eberhart, *Ukraine War Illustrates Importance of American Energy Dominance*, Forbes, February 24, 2023, https://www.forbes.com/sites/daneberhart/2023/02/24/ukraine-war-illustrates-importance-of-american-energy-dominance/

50 US Department of Energy, *Investing in American Energy: Continued Progress through Policy*, 2025, https://www.energy.gov/sites/default/files/2025-01/Investing_in_American_Energy_2024_010925-FINAL.pdf

51 The White House, "Establishing the National Energy Dominance Council," *Presidential Actions—Executive Orders*, February 14, 2025, https://www.whitehouse.gov/presidential-actions/2025/02/establishing-the-national-energy-dominance-council/.

52 Semiconductor Industry Association, 2025 State of the US Semiconductor Industry, accessed July 10, 2025, https://www.semiconductors.org/wp-content/uploads/2025/07/SIA-State-of-the-Industry-Report-2025.pdf.

53 Atlas Public Policy, Tracking the State of US EV Manufacturing, 2025, accessed January 2025, https://atlaspolicy.com/wp-content/uploads/2025/01/Tracking-the-State-of-U.S.-EV-Manufacturing.pdf.

54 The White House, *Made in America Agenda Delivers Manufacturing Boom* (2025), accessed August 13, 2025, https://www.whitehouse.gov/articles/2025/08/made-in-america-agenda-delivers-manufacturing-boom/.

55 US Congress Joint Economic Committee, Fact Sheet: The Manufacturing Renaissance That Will Drive the Economy of the Future (April 24, 2024), (Washington, DC: Joint Economic Committee, 2024), https://www.jec.senate.gov/public/index.cfm/democrats/2024/4/fact-sheet-the-manufacturing-renaissance-that-will-drive-the-economy-of-the-future.

56 The White House, National Energy Dominance Council Paves Way for Unleashing American Energy, February 20, 2025, https://www.whitehouse.gov/articles/2025/02/national-energy-dominance-council-paves-way-for-unleashing-american-energy/.

While the current energy dominance policy is often described as embracing an "all-of-the above-approach," its implementation has been varied, with notable political and market divides between support for NG and renewables, particularly OSW. However, both can play important roles in meeting American domestic energy objectives – contributing to affordability, reliability, economic growth, and strategic resilience – and can complement one another when developed in tandem. Both technologies, however, face material development challenges in the coming years.

Barriers to NG and OSW supporting near-term reliability

As the largest source of electricity generation[57] in the US, NG is the current backbone of American grid reliability and is projected to continue to play a meaningful reliability role in the future.[58] However, due to the pace, location, and seasonality of current load growth, NG investments alone will likely be insufficient to reliably meet ongoing load growth. Several key aspects of NG development have raised concerns from system operators and regulators including:

- **Supply chain limits:** Industry analysts estimate that global manufacturing capacity will be operating close to 90% utilization in 2025, leaving little flexibility to accommodate new orders.[59] This has led to significant backlogs in gas turbine orders, with deliveries now extending into 2029 and beyond. Gas turbine manufacturers, including GE Vernova and Siemens, have acknowledged that even expanded production capacity cannot keep pace with demand.[60]

- **Escalating costs:** The cost of building a NG power plant has spiked in recent years. For example, NextEra Energy's CEO noted that a combined-cycle facility built in 2022 cost approximately $785 per kilowatt, while building the same facility in 2024 would exceed $2,400 per kilowatt – a threefold increase in just two years.[61] Adding to this trend, a recently completed Black Hills Corporation gas power plant cost $2,830 per kilowatt.[62] In 2022, the industry average for the same turbines was just $722 per kilowatt, highlighting the

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57 US Energy Information Administration (EIA). "What Is US Electricity Generation by Energy Source?" Frequently Asked Questions. Accessed September 24, 2025. https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

58 US Energy Information Administration (EIA). "What Is US Electricity Generation by Energy Source?" Frequently Asked Questions. Accessed September 24, 2025. https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

59 Mackenzie, Wood. 2025. "Wood Mackenzie." Woodmac.com. May 14, 2025. https://www.woodmac.com/press-releases/despite-surging-power-demand-gas-fired-power-faces-manufacturing-constraints-that-could-limit-near-term-growth/.

60 Sophie. 2025. "Costs to Build Gas Plants Triple, Says CEO of NextEra Energy." Gas Outlook. March 25, 2025. https://gasoutlook.com/analysis/costs-to-build-gas-plants-triple-says-ceo-of-nextera-energy/.

61 Nicholas Cunningham, "Costs to Build Gas Plants Triple, Says CEO of NextEra Energy," *Gas Outlook*, March 25, 2025, https://gasoutlook.com/analysis/costs-to-build-gas-plants-triple-says-ceo-of-nextera-energy/.

62 Zada Jones, "Groundbreaking of New Power Plant in Rapid City," *KOTA TERRITORY*, August 14, 2025, https://www.kotatv.com/2025/08/14/groundbreaking-new-power-plant-rapid-city/.

magnitude of cost escalation in only three years.[63] These high capital costs will drive electricity prices higher and could further delay the deployment of needed capacity.

- **Competing industrial demand:** Turbine manufacturing currently faces growing demand from power and non-power sectors. Compounding this, capacity is limited, with backlogs extending to 2029.[64] The same factories and skilled labor that produce gas turbines for power generation also serve aerospace, shipbuilding, and other industrial sectors. These industries compete for the same casting facilities, critical supply chain components such as alloys and forgings, and specialized labor.

- **Fully subscribed NG pipelines, particularly in the Northeast:** Despite abundant domestic gas reserves in places like the Appalachian shale fields, there is limited ability to transport the fuel to some parts of the country due to pipeline capacity constraints, particularly New York and New England.[65] Several Massachusetts utilities have imposed moratoria on new gas hookups.[66] Additionally, NERC's Director has warned that there is insufficient gas pipelines to serve all existing electric generation in some regions of the Northeast.[67]

- **Cold-weather outages:** Gas fuel supplies remain susceptible to freezing during extreme cold. Winter Storms Uri (2021) and Elliott (2022) caused wellhead and pipeline freeze-offs that curtailed generation and led to widespread outages. While hardening efforts have improved recent performance,[68] these events underscore the risk of correlated outages when relying on a single fuel source for electricity generation.

- **Permitting delays and policy uncertainty:** Efforts to expand NG pipelines to relieve constraints have been delayed or cancelled due to permitting challenges and policy uncertainty. NG pipeline projects must navigate a web of overlapping federal, state, and local requirements. These layers of oversight, combined with risks of litigation and

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63 Kevin Clark, "Construction Costs for US Gas Generation Fell in 2022, While Solar and Wind Construction Costs Rose Slightly," *Power Engineering*, November 5, 2024, https://www.power-eng.com/business/construction-costs-for-u-s-gas-generation-fell-in-2022-while-solar-and-wind-construction-costs-rose-slightly/.

64 Wood Mackenzie, 2025, ""Despite surging power demand, gas-fired power faces manufacturing constraints that could limit near-term growth," *NEWS RELEASE*, May 14, 2025, https://www.woodmac.com/press-releases/despite-surging-power-demand-gas-fired-power-faces-manufacturing-constraints-that-could-limit-near-term-growth/.

65 AEA. 2024. "Northeastern Energy Corridor: Development, Regulation, and Threats to Expansion." American Energy Alliance. November 22, 2024. https://www.americanenergyalliance.org/2024/11/northeastern-energy-corridor-development-regulation-and-threats-to-expansion/.

66 Young, Colin A. 2019. "Natural Gas Hookups off Limits in More Mass. Towns." WWLP. February 19, 2019. https://www.wwlp.com/news/natural-gas-hookups-off-limits-in-more-mass-towns.

67 "NERC Warns of Electricity Shortages in Winter Reliability Assessment." 2023. Cooperative.com. 2023. https://www.cooperative.com/news/Pages/NERC-Warns-of-Electricity-Shortages-in-Winter-Reliability-Assessment.aspx.

68 North American Electric Reliability Corporation. 2024. *2024–2025 Winter Reliability Assessment*. November. https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2024.pdf

stakeholder opposition, have made permitting both costly, unpredictable, and slow.[69] Even when projects receive federal approval, state denials or litigation can stall project development. Several proposed projects such as the Constitution Pipeline, Northeast Supply Enhancement (NESE) project, and Mountain Valley (MVP), aimed at expanding existing capacity were either delayed or canceled due to legal, regulatory, and community opposition.[70] Further detail on these projects is provided below in Table 1.

Table 1: Overview of Pipelines under Development

MVP	Constitution
Background: 304-mile pipeline from West Virginia to Virginia, with a planned Southgate extension into North Carolina.[71,72] **Challenges:** Faced multiyear legal challenges and permit reversals; ultimately placed in service in 2024 only after congressional intervention through the Fiscal Responsibility Act.[73] **Impact:** Costs increased from $3.5 billion to $7.8 billion, and the in-service date occurred roughly six years later than the original 2018 target.[74,75]	**Background:** Designed to transport natural gas from the Marcellus region in Pennsylvania to New York to relieve supply constraints. **Challenges:** Denial of key state water permits and strong community and environmental opposition led to years of delays and regulatory uncertainty.[76] **Impact:** Project canceled in 2020; recent efforts to revive the project continue to face significant state and environmental opposition.[77]

69 Reuters. 2021. "Factbox: US Oil and Natgas Pipelines Delayed by Legal and Regulatory Battles." Reuters. February 2021. https://www.reuters.com/article/us-usa-canada-pipelines-factbox/factbox-u-s-oil-and-natgas-pipelines-delayed-by-legal-and-regulatory-battles-idUSKBN2A11EI.

70 "Williams to Revive Constitution, NESE Pipelines in Joint Effort with Regulators." 2025. Pgjonline.com. 2025. https://pgjonline.com/news/2025/may/williams-to-revive-constitution-nese-pipelines-in-joint-effort-with-regulators.

71 MVP Southgate, *MVP Southgate—Project Overview*, accessed August 20, 2025, https://www.mvpsouthgate.com/overview/.

72 Robert Bradley, Jr. "Mountain Valley Pipeline: 94 Percent Complete, FERC 6 Percent Incomplete," *Master Resource*, June 30, 2022, https://www.masterresource.org/federal-energy-regulatory-commission-ferc/mountain-valley-pipeline-status.

73 Catherine Morehouse, "FERC gives green light to start up mountain valley pipeline," *POLITICO*, June 11, 2024, https://www.politico.com/news/2024/06/11/ferc-greenlights-mountain-valley-pipeline-startup-00162827.

74 Reuters, *US Mountain Valley natural gas pipeline begins operations*, June 14, 2024, https://www.reuters.com/business/energy/us-mountain-valley-natural-gas-pipeline-begins-operations-2024-06-14/.

75 Corey Paul, "Mountain Valley Pipeline wants permit extension until 2026 to finish last elements," *S&P Global Commodity Insights,* 2022, https://www.spglobal.com/commodity-insights/en/news-research/latest-news/natural-gas/062722-mountain-valley-pipeline-wants-permit-extension-until-2026-to-finish-last-elements.

76 "Williams Cancels N.Y. Constitution Pipeline," 2020, Pgjonline.com, 2020, https://pgjonline.com/news/2020/02-february/williams-cancels-ny-constitution-pipeline.

77 Scott Disavino, 2025, "Williams working with federal, state regulators to revive Pennsylvania-New York Natgas pipes," *Reuters*, May 29, 2025, https://www.reuters.com/business/energy/williams-working-with-federal-state-regulators-revive-pennsylvania-new-york-2025-05-29/.

Northeast Supply Enhancement (NESE)	Atlantic Coast Pipeline (ACP)
Background: Proposed expansion of existing pipeline capacity across Pennsylvania, New Jersey, and New York, adding ~400,000 dekatherms/day of capacity.[78] **Challenges:** New York and New Jersey denied Clean Water Act permits due to water quality and coastal ecosystem concerns; environmental groups mounted sustained opposition.[79] **Impact:** Project canceled in 2024; developer seeking revival in 2025 and received key approvals from New York State Department of Environmental Conservation,[80] but the project continues to face major regulatory and legal barriers.[81,82]	**Background:** Proposed 600-mile pipeline to transport gas from West Virginia to North Carolina. **Challenges:** Multiple legal challenges regarding environmental impacts and routing; a 2020 court ruling created new uncertainty around waterbody crossing permits. **Impact:** Costs rose from ~$5B to over ~$8B; project canceled in 2020. Restoration and environmental remediation expected to continue through 2025.[83]

Offshore wind

Unlike NG, OSW is still emerging in the US. However, it is a mature technology internationally. Europe began developing OSW in the early 1990s[84] and has reached nearly 37 GW[85] of installed capacity as of 2024.

78 Williams Companies, *Northeast Supply Enhancement*, July 2, 2025, https://www.williams.com/expansion-project/northeast-supply-enhancement/.

79 Scott Disavino, 2025, "Williams working with federal, state regulators to revive Pennsylvania-New York Natgas pipes," *Reuters*, May 29, 2025, https://www.reuters.com/business/energy/williams-working-with-federal-state-regulators-revive-pennsylvania-new-york-2025-05-29/.

80 New York State Department of Environmental Conservation. 2025. *NESE Article 15 Permit and Water Quality Certification*. November 7, 2025. https://dec.ny.gov/sites/default/files/2025-11/nesewqcandart15permit.pdf

81 Suzanne Mattei, "Williams throws in towel on NESE pipeline project," *Institute for Energy Economics and Financial Analysis (IEEFA)*, May 14, 2024, https://ieefa.org/resources/williams-throws-towel-nese-pipeline-project.

82 "Williams to Revive Constitution, NESE Pipelines in Joint Effort with Regulators," 2025, *Pipeline & Gas Journal*, 2025, https://pgjonline.com/news/2025/may/williams-to-revive-constitution-nese-pipelines-in-joint-effort-with-regulators.

83 "Dominion Energy and Duke Energy Cancel the Atlantic Coast Pipeline," *Duke Energy—News Center*, 2020, https://news.duke-energy.com/releases/dominion-energy-and-duke-energy-cancel-the-atlantic-coast-pipeline.

84 WindEurope. "History of Europe's Wind Industry." *WindEurope*. Accessed November 26, 2025. https://windeurope.org/about-wind/history/

85 Clean Energy Wire. "European Wind Power Capacity Grows but Expansion Rate Slightly Down in 2024." *Clean Energy Wire*, February 28, 2025. https://www.cleanenergywire.org/news/european-wind-power-capacity-grows-expansion-rate-slightly-down-2024

The US has a substantive pipeline of OSW, with multiple projects that have recently come online or are projected to interconnect in the near-term. Between 2023 and 2024, the American OSW pipeline expanded by 53%, reaching more than 80 GW, including 174 MW operating and ~80 GW in planning or development stage (see *Table 2*).[86]

Table 2: OSW project pipeline status

Status	Capacity 2023 (MW)	Change from 2023 (MW)	Capacity 2024 (MW)	Notes
Operating	42	132	174	South Fork Wind (132 MW) came online, joining Block Island (30 MW) and CVOW Pilot (12 MW).
Under Construction	932	3,165	4,097	Vineyard Wind 1 (806 MW), Revolution Wind (704 MW), and CVOW Commercial (2,587 MW).
Financial Close	0	0	0	No projects reached financial close in the period.
Approved	1,100	2,278	3,378	Empire Wind 1, Sunrise Wind, and New England Wind 1 & 2[87] received BOEM approval.
Permitting	20,978	-1,184	19,793	Some projects lost offtake agreements and shifted back to earlier stages.
Site Control	24,596	-1,725	22,870	Includes developers holding leases but not yet in permitting.
Planning	5,039	25,172	30,211	Driven by new lease areas in Gulf of Maine, Central Atlantic, Oregon, and Gulf of Mexico.
Total	**52,687**	**27,836**	**80,523**	**US offshore wind pipeline grew 53% year-over-year.**

86 NREL, *OFFSHORE WIND MARKET REPORT 2024 EDITION*, 2024. https://www.nrel.gov/docs/fy24osti/90525.pdf.

87 The approval for these Empire Wind 1 faces permitting uncertainty due to ongoing litigation.

Like NG, OSW faces challenges that make it difficult to achieve large-scale deployment on the US grid and for OSW to provide a meaningful contribution to reliability and affordability. These include:

- **Market and policy uncertainty:** OSW has faced reversals in state and federal policy. Recent stop-work orders, permit reversals,[88] and leasing freezes[89] cast doubt on projects that had been considered near-certain. Challenges facing the industry, including recent changes in federal policy and overall market uncertainty, have led to the cancellation of Ørsted's Wind 1 project and the Atlantic Shores Wind project. As a result, billions of dollars in contracts for wind-support vessels were withdrawn.[90,91] Firms that had committed to investments in American OSW and associated infrastructure have canceled plans because of these federal policy reversals.
- **Limited ports and shipyards:** Only a handful of US ports are capable of serving as marshaling terminals. Planned upgrades, such as the New Bedford Marine Commerce Terminal (Massachusetts) and the Arthur Kill Terminal (New York), are progressing, but delays in these port upgrades limits staging capacity.[92] Some ports and shipyards are postponing or canceling planned investments and upgrades, shrinking shipbuilding and component capacity.[93] The New Jersey Wind Port (New Jersey), originally launched in 2020 as the first greenfield wind port in the United States, was planned to support OSW staging. However, the project is now set to be repurposed.[94]
- **Lack of Jones Act compliant Wind Turbine Installation Vessels (WTIVs):** Presently, the US currently has one Jones Act-compliant WTIV – the Charybdis – which was built by Dominion Energy to support its OSW development. Constructing this vessel required a significant investment of approximately $715 million.[95] If a Jones Act-compliant vessel is not

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88 Ørsted A/S. *"Revolution Wind Receives Offshore Stop-Work Order from US Department of the Interior's Bureau of Ocean Energy Management."* Company announcement, August 22, 2025. https://orsted.com/en/company-announcement-list/2025/08/revolution-wind-receives-offshore-stop-work-order--145387701

89 The White House, "Temporary Withdrawal of All Areas on the Outer Continental Shelf from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects," *Presidential Actions—Executive Orders*, January 20, 2025, https://www.whitehouse.gov/presidential-actions/2025/01/temporary-withdrawal-of-all-areas-on-the-outer-continental-shelf-from-offshore-wind-leasing-and-review-of-the-federal-governments-leasing-and-permitting-practices-for-wind-projects/.

90 "Home Page - New Jersey Wind Port," 2024, *New Jersey Wind Port*, October 17, 2024, https://njwindport.njeda.gov/.

91 Nichola Groom, 2025, "Focus: Trump Hostility to US Offshore Wind Reverberates through Supply Chain," *Reuters*, February 14, 2025, https://www.reuters.com/business/energy/trump-hostility-us-offshore-wind-reverberates-through-supply-chain-2025-02-13/.

92 US Department of Energy (DOE), "Offshore Wind Market Report: 2023 Edition," *Wind Energy Technologies Office*, n.d., https://www.energy.gov/eere/wind/articles/offshore-wind-market-report-2023-edition.

93 Ibid.

94 OffshoreWIND.biz. "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/.

95 Tim Ferry, 2025, "US 'Monster' Installation Vessel Heads into Sea-Trials and Service," *Rechargenews.com*, 2025, https://www.rechargenews.com/policy/us-monster-installation-vessel-heads-into-sea-trials-and-service/2-1-1853407.

available, developers must rely on foreign WTIVs anchored offshore while shuttling equipment from US ports using smaller domestic vessels.[96] This practice complicates logistics, increases costs, raises schedule risks, and exposes projects to high global demand for these installation vessels. Further, investment in Jones Act-compliant WTIVs has been canceled due to uncertainty. For example, in October 2025, Maersk terminated a roughly $475 million contract for a nearly complete Jones Act-compliant WTIV that was being built to serve the *Empire Wind* project.[97]

- **Permitting complexity:** On average, federal permitting alone takes four to six years – far longer than other mature OSW markets, such as Europe, where projects often complete permitting in one to two years. American developers must also navigate complex federal, state, local, and tribal requirements. Approvals are required from the Bureau of Ocean Energy Management (BOEM), Environmental Protection Agency (EPA), US Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), and state Coastal Zone Management offices.

Methodology

This section outlines the methodology used to evaluate synergies between these technologies in supporting America's energy goals.

5.1 Quantitative modeling

This subsection describes the three quantitative analyses used to quantify interactions between OSW and NG: (1) fuel deliverability limits, (2) marginal reliability impacts, and (3) reliance on oil-fired backup generation.

5.1.1 Quantitative analysis #1: Fuel deliverability limits

First, we assessed **maximum available winter headroom** in key gas-constrained regions in the United States. This analysis provides a quantitative estimate of how much new NG generation could be supported by existing pipeline capacity during peak winter conditions.

We performed this analysis using RBAC's Gas Competition Pipeline Model (GPCM)[98] and EIA data. We analyzed historical pipeline inflow and outflow data from the EIA and pipeline capacity

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96 Mark Shenk, 2024, "Launch of US Wind Installation Vessel Masks Critical Shortage," *Reuters*, June 13, 2024, https://www.reuters.com/business/energy/launch-us-wind-installation-vessel-masks-critical-shortage-2024-06-13/.

97 Nichola Groom, *"Maersk Cancels $475 Million Contract for US-Bound Offshore Wind Vessel,"* Reuters, October 10, 2025, https://www.reuters.com/sustainability/climate-energy/maersk-terminates-475-million-contract-offshore-wind-vessel-2025-10-10/

98 RBAC's Gas Competition Pipeline Model (GPCM) is a nodal natural gas pipeline model which captures historical gas supply, demand, and pipeline flows as well as predicting future flows based upon user inputs.

between states.[99] This data was then paired with regional customer demand provided by RBAC to determine the maximum pipeline capacity available to electric utilities.[100]

Using GPCM, we translated these fuel margins into potential electric-generation capability, based on the heat rate of a representative peaking unit (10,000 Btu/kWh). This produced a daily estimate of the maximum electricity that could be produced from remaining winter gas headroom. We also account for headroom that is freed due to the electrification of heating.

5.1.2 Quantitative analysis #2: Marginal reliability impact and hit rate

To evaluate the reliability contribution of each technology, we examine the MRI of NG and OSW in NYISO. MRI measures how much a resource reduces expected unserved energy (EUE) when 1 MW of additional capacity of that resource is added. EUE is a core metric used in resource adequacy modeling to quantify shortfalls. MRI can be interpreted as the incremental reduction in those shortfalls provided by the next MW of a given technology. Grid planners aim to keep EUE levels low while balancing other targets like affordability and reliability.

We compute MRI as:

$$MRI = \frac{EUE_i - EUE_{i+1}}{ICAP_{i+1} - ICAP_i}$$

The formula computes the reduction in EUE (risk reduction) divided by the increase in installed capacity. A higher MRI means each additional megawatt of the resource provides a greater reliability benefit. This formulation allows for consistent, cross-technology comparison and highlights how effectively each marginal MW reduces risk and interacts with the broader generation mix.

Because our goal is to measure risk reduction, not to assign accredited capacity values, we do not normalize MRI to a perfect generator or calibrate the system to a target reliability threshold. These steps, common in ELCC and accreditation studies, are intentionally omitted because they can obscure seasonal reliability patterns and dilute underlying technology differences. Our goal is to explore the reliability impact of new resources, particularly if the market has less resources than its target reserve margins, as occurred recently in the PJM capacity auction.[101]

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99 EIA Natural Gas: Pipelines: US state-to-state capacity, Jan 2025. https://www.eia.gov/naturalgas/data.php

100 RBAC: GPCM Database 2025 Q2; https://rbac.com/gpcm-base-case-natural-gas-forecast-briefing/

101 Herman K. Trabish, *"PJM's Interconnection Queue Data Shows Growing Impact of Massive Data Center Loads," Utility Dive*, August 26, 2025. Accessed December 28, 2025. https://www.utilitydive.com/news/pjm-interconnection-capacity-auction-data-center/808264/

We also compute a hit rate which measures how often a technology produces during hours when the system is at risk. This is a novel metric introduced in this work. It is designed to measure the alignment of a resource with remaining risk hours. This is calculated as:

$$HRI = \frac{MRI}{EUE_i}$$

MRI measures how effective a resource is at reducing risk. To achieve a high MRI value several factors must exist: 1) there must be underlying risk in the system, and 2) the resource must be effective during events when load shedding occurs. Similarly, for the hit rate to be high, the generation profile of the resource must align with the periods of remaining risk. This is similar in sprit to the concept of an ELCC but intentionally does not include steps to assume a market achieves its reliability target.

Measuring the efficacy of technologies at reducing risks and capturing interactions between technologies has been an important area of study. Most studies have focused on evaluating technologies like solar and storage.[102] However, to our knowledge, no study has examined the joint reliability contributions and interactions between OSW and NG. We aim to fill this gap to evaluate the interactions between these two technologies and their relative efficacy at reducing risk.

Simulation approach

To perform this analysis, we employ **loss of load modeling** using *AdequacyX,*[103] a Monte Carlo-based simulation tool that quantifies the probability, magnitude, and duration of load-shedding events. Loss of load modeling is a probabilistic approach used to estimate the likelihood and severity of situations where electricity demand exceeds available supply. It accounts for uncertainties in load, generation, and outages to quantify reliability risk.

AdequacyX simulates correlated system “shocks” in load, renewable generation, and thermal outages, explicitly capturing how electrification of heating and transportation reshapes hourly load shapes and increases risk during the coldest hours. The structure of AdequacyX is shown in Figure 1. From the loss of load modeling, we can quantify the resource adequacy of the grid mix by measuring the **expected unserved energy** (EUE).

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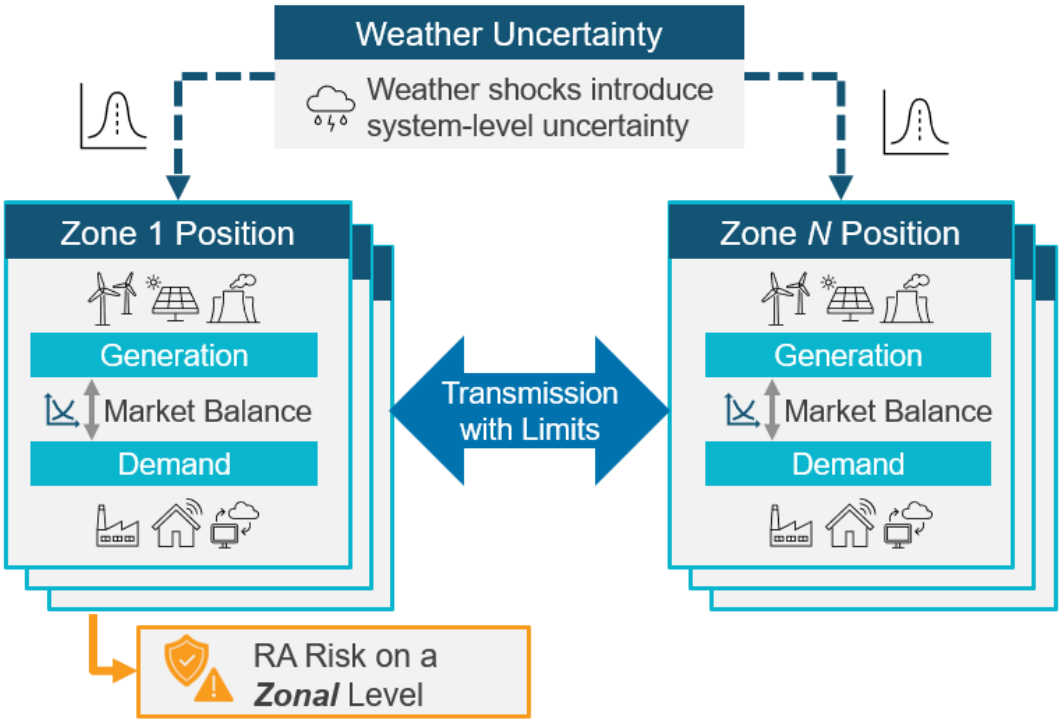
102 Energy and Environmental Economics, Inc., Reliability Planning in the Era of Decarbonization: Practical Application of Effective Load Carrying Capability in Resource Adequacy (San Francisco: E3, August 2020), https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf.

103 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.

Figure 1: Structure of AdequacyX



Study design

We perform this study to examine the role of OSW and NG in maintaining resource adequacy in NYISO. We focus on a single zone – Zone J (NYC) – given this is one of the zones of highest risk. We also use a single study year, 2032, because NYISO has identified this year as having elevated reliability risks.[104]

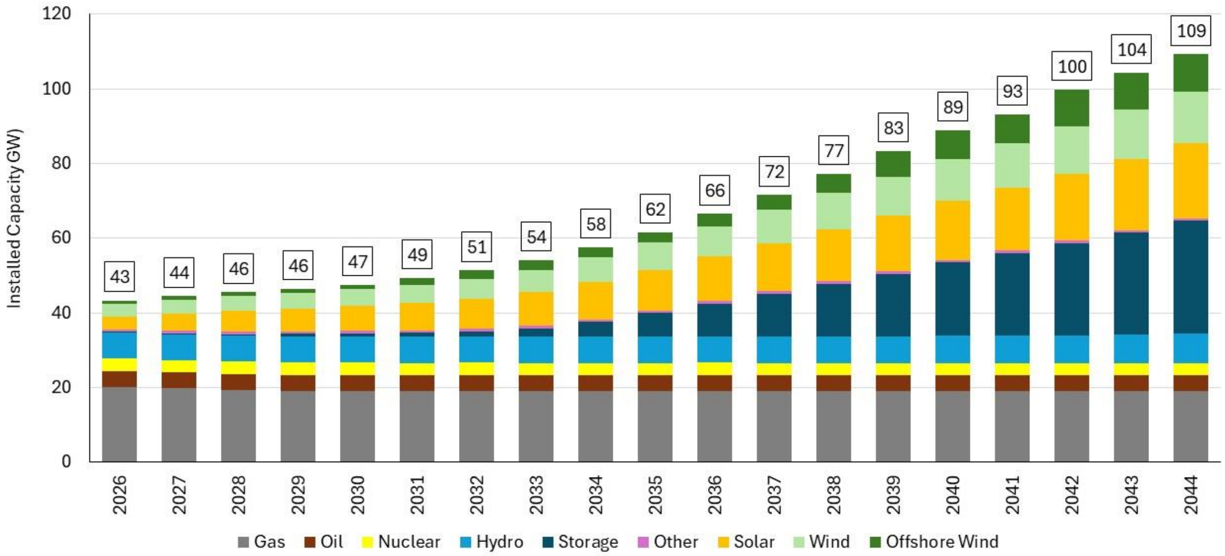
We adopt the generation outlook produced by the Authors in a previous work.[105] This outlook, shown in Figure 2, includes 2,234 MW of OSW and 18,971 MW of NG. It largely aligns with NYISO's 2023 System & Resource Outlook.[106]

104 New York Independent System Operator. *2024 Reliability Needs Assessment (RNA): A Report from the New York Independent System Operator*. November 19 2024. https://www.nyiso.com/documents/20142/2248793/2024-RNA-Report.pdf

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

106 NYISO. (2023). *2023–2042 System Resource Outlook*. Retrieved from https://www.nyiso.com/documents/20142/46037414/2023-2042-System-Resource-Outlook.pdf

Figure 2: Base case generator resource forecast for NYISO



Electrification of heating and transportation is projected to drive sustained load growth, especially during nighttime and cold-weather hours. We model these shifts using synthetic load data calibrated to NYISO's Gold Book projections, ensuring that total annual energy, seasonal load shapes, and median annual peaks align with published forecasts. Between 2032 and 2036, average January load growth exceeds July growth by 3.6 times, with the largest relative increases in the shoulder months – periods that have historically supported generator maintenance.[107]

We perform assessments for varying levels of OSW. The base case outlook assumes 2,234 MW of OSW and 18,971 MW of NG in the study year. Using these starting points, we vary each resource across four levels (the base value, minus 500 MW, minus 750 MW, and minus 1,000 MW), resulting in 16 total combinations. This approach allows us to test how reliability risk responds to incremental changes in OSW and NG capacity and to identify whether their contributions interact in complementary or diminishing ways.

The permutations used in our modeling runs are provided below in Table 3.

107 NYISO (New York Independent System Operator), 2025 Gold Book: Public (Albany, NY: NYISO, 2025), https://www.nyiso.com/documents/20142/2226333/2025-Gold-Book-Public.pdf.

Table 3: MRI study scenario

NG	OSW
18,971 MW (-0 MW)	2,234 MW (-0 MW)
18,971 MW (-0 MW)	1,734 MW (-500 MW)
18,971 MW (-0 MW)	1,484 MW (-750 MW)
18,971 MW (-0 MW)	1,234 MW (-1,000 MW)
18,471 MW (-500 MW)	2,234 MW (-0 MW)
18,471 MW (-500 MW)	1,734 MW (-500 MW)
18,471 MW (-500 MW)	1,484 MW (-750 MW)
18,471 MW (-500 MW)	1,234 MW (-1,000 MW)
18,221 MW (-750 MW)	2,234 MW (-0 MW)
18,221 MW (-750 MW)	1,734 MW (-500 MW)
18,221 MW (-750 MW)	1,484 MW (-750 MW)
18,221 MW (-750 MW)	1,234 MW (-1,000 MW)
17,971 MW (-1,000 MW)	2,234 MW (-0 MW)
17,971 MW (-1,000 MW)	1,734 MW (-500 MW)
17,971 MW (-1,000 MW)	1,484 MW (-750 MW)
17,971 MW (-1,000 MW)	1,234 MW (-1,000 MW)

5.1.3 Quantitative analysis #3: Oil-fired generation in NYISO

This third analysis evaluates how OSW affects reliance on oil-fired backup generation in downstate New York during winter peaks — conditions where NG fuel deliverability is most constrained.

Many gas-fired units in NYISO lack firm NG supply during extreme cold periods because pipeline infrastructure is constrained, and demand for NG fuel to support residential building heating is prioritized. To satisfy capacity obligations under these conditions, a meaningful subset of these generators are dual-fuel capable and can operate on distillate fuels stored on-site during periods when access to NG is limited.[108]

Despite benefits of improved reliability, operating on back-up fuels (typically fuel oil) presents several challenges:

- **High cost:** Distillate fuels are significantly more expensive than NG. Operating on distillate fuels raise wholesale energy prices when oil-fired units set the marginal price.
- **Limited storage:** On-site inventories typically cover only a few days of winter peak operation, with resupply constrained by transportation and competing heating-oil demand. While refueling efforts typically occur concurrently with extreme weather events, refueling creates additional logistical burdens and poses risks if disruptions occur.[109]
- **Maintenance and emissions:** Burning oil increases maintenance requirements[110] and produces higher SO_x, NO_x, and particulate emissions. Permitting often limits annual oil-burn hours; for example, Ravenswood Generating Station in New York City is restricted to 720 hours per year under its Title V permit.[111] Further, these sites are located in high-density urban areas, which has raised concerns on the public health implications of relying on emissions-intensive fuel oil, particularly for generators close to the general public.[112]
- **Retirement risks:** NYISO's generation fleet is among the oldest in the country. NYISO has highlighted the reliability risks that would occur if a large number of generators retired. Increasing the usage of dual fuel generators – particularly when they are operating on back-up fuel – could increase their risk of retiring by increasing the stress on aging units.

Because OSW generation is typically highest during the coldest periods, when gas-fired generators face their most significant fuel-deliverability challenges, OSW could, in principle, serve some portion of winter peak load and reduce reliance on power plant back-up fuels.

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108 Analysis Group. *2023 Fuel Security Study (Final)*. New York Independent System Operator, 2023. Accessed September 29, 2025. https://www.nyiso.com/documents/20142/41258685/Analysis-Group-2023-Fuel-Security-Study-Final.pdf

109 New York Independent System Operator. (2024, November 19). *2024 Reliability Needs Assessment (RNA)*. Retrieved from https://www.nyiso.com/documents/20142/2248793/2024-RNA-Report.pdf/0fe6fd1e-0f28-0332-3e80-28bea71a2344

110 Distillate Handling, Firing," *Combined Cycle Journal*, 2Q 2012, accessed September 29, 2025, https://www.ccj-online.com/2q-2012-outage-handbook/distillate-handling-firing/.

111 New York State Department of Environmental Conservation, *Permit Review Report: Ravenswood Generating Station, Permit ID 2-6304-00024/00039, Renewal Number 2, Modification Number 2 (January 26, 2018)*, (Long Island City, NY: NYSDEC, 2018), accessed September 29, 2025, https://extapps.dec.ny.gov/data/dar/afs/permits/prr_263040002400039_r2_2.pdf

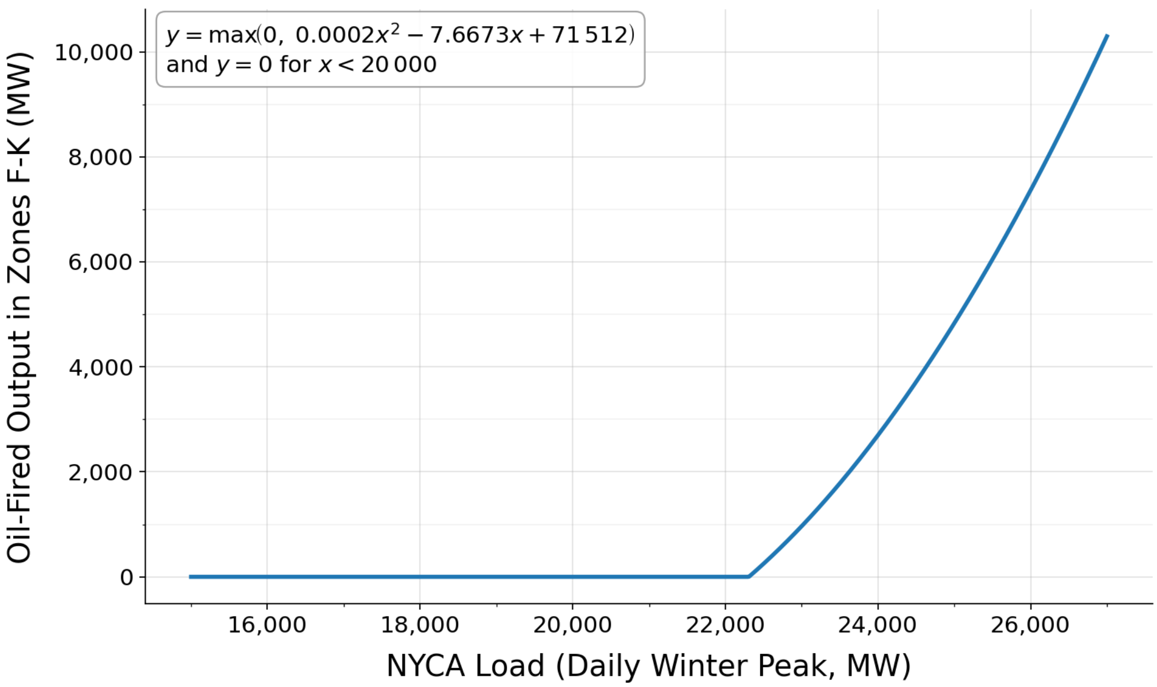
112 Law, Adam, Ali Snell, Allison Cardoso, et al. 2024. *Replacing Peaker Plants with Energy Storage in New York State*. Oakland: PSE Healthy Energy. October 9. https://www.psehealthyenergy.org/work/opportunities-for-replacing-peaker-plants-with-energy-storage-in-new-york-state/

This quantitative analysis is designed to **test whether these hypothesized benefits bear out**, and to quantify how incremental OSW additions may affect the number of hours in which dual-fuel generators are required to burn oil in downstate New York.

5.1.4 Simulation approach

To estimate the amount of oil-fired generation downstate, we employ a relationship developed by NYISO that links daily winter peak load in Zones F-K (i.e., Capital region, Hudson Valley, greater New York City area, and Long Island) to the corresponding level of oil-fired generation in those zones observed under historical stress conditions.[113, 114] This relationship is shown in Figure 3.

Figure 3: Oil Generation in NYISO Zones F-K as a function of winter daily peak load[115,116]



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113 New York State Reliability Council (NYSRC). (2025, March 5). *Fuel Availability Constraints: Modeling Phase 2* (Installed Capacity Subcommittee Meeting #301). NYISO. https://www.nysrc.org/wp-content/uploads/2025/03/Fuel-Availability-Constraints.pdf

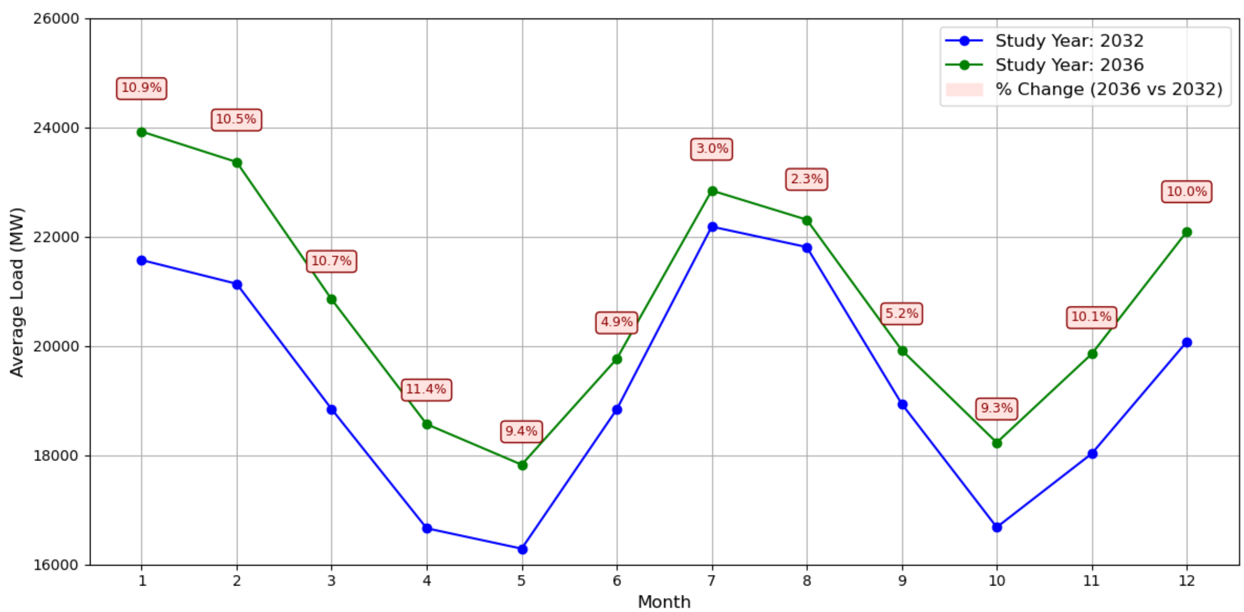
114 Note, this equation is given as y=- 0.0002 +7.6673*x-71512. However, this does not match the graphics provided in the presentation. We assume the correct equation is the inverse of that reported in the presentation: y=0.0002 -7.6673*x+71512. We also clip this value to enforce only non-negative values and only considers load values above 20,000 MW.

115 New York State Reliability Council (NYSRC). (2025, March 5). *Fuel Availability Constraints: Modeling Phase 2* (Installed Capacity Subcommittee Meeting #301). NYISO. https://www.nysrc.org/wp-content/uploads/2025/03/Fuel-Availability-Constraints.pdf

116 Note, this equation is given as y=- 0.0002 +7.6673*x-71512. However, this does not match the graphics provided in the presentation. we assume the correct equation is the inverse of that reported in the presentation: y=0.0002 -7.6673*x+71512. we also clip this value to enforce only non-negative values and only considers load values above 20,000 MW.

We simulated a range of future load conditions using the synthetic hourly load shapes generated for the AdequacyX loss of load modeling, combined with OSW generation profiles. OSW output was subtracted from hourly load in Zones F-K to create a net winter-demand profile, which was then applied to the NYISO-derived relationship to forecast oil-fired generation under future scenarios. Critically, this load shape captures the impact of electrification, which drives load growth during the coldest days. The resulting average monthly load shapes, including the load adjustments, are shown in Figure 4. As shown in this figure, winter load grows at a substantially faster rate than summer load. While this pattern is consistent with trends reported in the NYISO *Gold Book*, the hourly load shapes used in our analysis are developed using CRA's internal modeling capabilities.

Figure 4: Average monthly load shape for NYISO



Additionally, as more buildings switch from gas for building heating, water heating, and cooking to the electric fueling of these end uses, NG use from these applications will decline. This frees up some gas supply that can be used for power generation instead of heating and other end uses, partially displacing the need for oil-produced electricity during certain hours. Importantly, we do not assume that new NG plants are built in this analysis. Rather, *existing* gas units have increased access to NG fuel during cold-weather periods because a portion of gas fuel previously consumed for building heating becomes available for power generation. As such, a larger share of gas-fired generators can remain on their primary fuel source, NG, rather than switching to back-up fuels during extreme cold, high load events. We quantify this effect by calculating how much heating demand shifts to electricity and then converting the freed-up gas into additional generating capability during winter peaks (see Table 4).

Table 4: New NG fuel availability during winter peaks in NYISO Zones F-K due to electrification

Year	Increase in NG generating capability relative to 2025 on peak days (MW)
2032	2,084
2036	4,055

5.2 Stakeholder review

In addition to numerical modeling, we also conducted targeted outreach to key stakeholders in the NG and energy infrastructure sectors to ground our analysis in real-world experience. We spoke with or received written responses from five major organizations. These firms represent a cross-section of developers, equipment manufacturers, and EPCs actively involved in NG power plant development across the United States, particularly in the Northeast and Mid-Atlantic regions. From these responses, we summarized overarching themes regarding challenges facing the NG industry.

Please see the Appendix for more detail. Our outreach was aimed at understanding the evolving role of NG in supporting grid reliability and industrial growth, as well as the industry's infrastructure constraints, permitting challenges, supply chain dynamics, and perspectives on complementary resource strategies. We posed a consistent set of questions across all interviews, covering topics such as data center-driven demand, turbine availability, labor shortages, permitting timelines, and approaches to portfolio diversification.

5.3 Literature review

We conducted a targeted literature review by examining studies from grid operators, regulators, and research institutions to identify challenges that OSW and NG share across permitting, infrastructure, workforce availability, and supply-chain constraints. Governmental and energy agency data provided necessary context about demand evolution and the current state of reliability. Materials published by utilities and manufacturers provided helpful background understanding labor, equipment, and interconnection obstacles to both gas and OSW development. Finally, academic research and industry news supported our understanding of the current regulatory environment and acute issues affecting customers from data center to residential. This review also explored how improvements in one technology, such as streamlined permitting or expanded construction capacity, could reduce barriers and improve deployment timelines for the other. Our analysis also focused on the role these resources can play in meeting America's energy goals and joint challenges hindering their development.

5.4 Qualitative case studies

Lastly, we conducted diligence on two online or advanced domestic OSW projects: Dominion's Coastal Virginia Offshore Wind (CVOW) and South Fork Wind. To support the CVOW case study, we reviewed the 2024 Integrated Resource Plan produced by Dominion, the reliability outlook for PJM produced recently by the Department of Energy, and other reports describing the resource adequacy outlook in PJM. To support the South Fork Wind case study, we reviewed the request for proposal (RFP) for this project, reports from the Long Island Power Authority (LIPA), and other publicly available reporting.

Next, we discuss the findings from our analyses.

Results

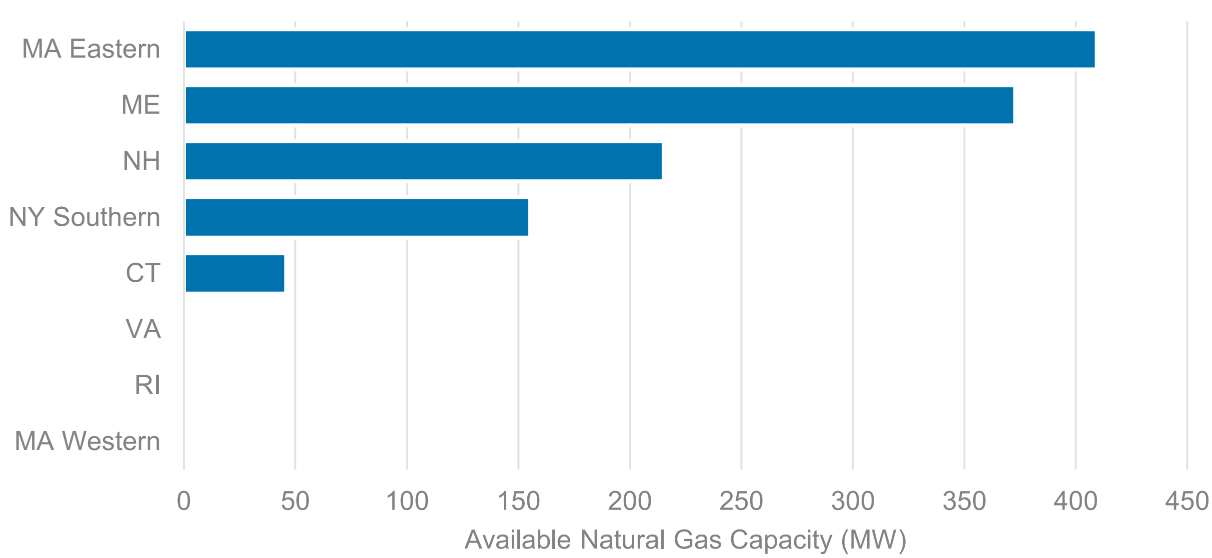
This section presents the results from each component of our analysis, including numerical modeling, qualitative case studies, and the broader literature review.

6.1 Findings: Quantitative analyses

6.1.1 Quantitative analysis #1: Build limits

First, we examine the ability to add new NG generation in New York and New England. The results are shown in Figure 5.

Figure 5: Electricity generation from NG by region



The results indicate there is limited ability to add new NG generation under firm fuel contracts in the Northeast due to constraints on the existing system. Most regions can only add a few hundred megawatts of gas generation. For reference, this is only a fraction of a typical new data center campus, which can regularly consume energy at a gigawatt scale. This constraint has serious implications for grid reliability in the Northeast. These same regions are expected to experience faster winter than summer load growth as building heating electrifies, driven by state decarbonization goals and consumer preferences.[117] This trend in winter load growth will intensify pressure on existing pipelines and local gas delivery systems. While system upgrades are likely given ongoing investment in NG in the region, they are unlikely to materialize quickly enough to meet near-term winter demand.

6.1.2 Quantitative analysis #2: MRI

This analysis evaluates the MRI of NG and OSW on the New York City region of NYISO. Results are shown below. In these tables, the OSW capacity is shown across the x-axis, and the NG capacity is shown on the y-axis. For each technology, the capacity reduction from the base is shown in parentheses. The resulting metric for the portfolio with the relevant level of NG and OSW is shown in the table. We show the MRI for NG in Table 5 and OSW in Table 7. We also show the hit rate as a part per million (ppm) in Table 6 and 8. In these tables, a higher MRI or hit rate indicates that the resource is more effective at reducing risk (MRI) or reducing remaining risk (hit rate).

Table 5: Marginal reliability impact for NG in New York City (Study Year 2032)

		OSW			
	Gas / OSW	**1,234 MW (-1,000 MW)**	**1,484 MW (-750 MW)**	**1,734 MW (-500 MW)**	**2,234 MW (-0 MW)**
GAS	**-17,971 MW (-1,000 MW)**	106	96	88	75
	18,221 MW (-750 MW)	85	78	70	59
	18,471 MW (-500 MW)	61	55	49	42
	18,971 MW (-0 MW)	**Base**	**Base**	**Base**	**Base**

117 “NERC Warns of Electricity Shortages in Winter Reliability Assessment.” 2023. Cooperative.com. 2023.

Table 6: Hit rate in parts per million for NG in New York City (Study Year 2032)

		OSW			
	Gas / OSW	**1,234 MW (-1,000 MW)**	**1,484 MW (-750 MW)**	**1,734 MW (-500 MW)**	**2,234 MW (-0 MW)**
GAS	**-17,971 MW (-1,000 MW)**	895	910	927	943
	18,221 MW (-750 MW)	925	948	958	972
	18,471 MW (-500 MW)	862	876	887	899
	18,971 MW (-0 MW)	**Base**	**Base**	**Base**	**Base**

Table 7: Marginal reliability impact for OSW in New York City (Study Year 2032)

		OSW			
	Gas / OSW	**1,234 MW (-1,000 MW)**	**1,484 MW (-750 MW)**	**1,734 MW (-500 MW)**	**2,234 MW (-0 MW)**
GAS	**-17,971 MW (-1,000 MW)**	50	42	31	**Base**
	18,221 MW (-750 MW)	40	34	25	**Base**
	18,471 MW (-500 MW)	33	26	19	**Base**
	18,971 MW (-0 MW)	21	16	11	**Base**

Table 8: Hit rate in parts per million for OSW in New York City (Study Year 2032)

		OSW			
	Gas / OSW	**1,234 MW (-1,000 MW)**	**1,484 MW (-750 MW)**	**1,734 MW (-500 MW)**	**2,234 MW (-0 MW)**
GAS	**-17,971 MW (-1,000 MW)**	423	392	327	**Base**
GAS	**18,221 MW (-750 MW)**	440	412	336	**Base**
GAS	**18,471 MW (-500 MW)**	467	424	344	**Base**
GAS	**18,971 MW (-0 MW)**	510	458	361	**Base**

Across all combinations, several consistent patterns emerge.

1. **Both NG and OSW reduce reliability risk, but NG delivers larger MRI values.**

NG provides on-demand, dispatchable generation that contributes during summer peaks, winter peaks, and low-wind hours. As a result, the MRI of NG is generally two to three times higher than the MRI of OSW in most cases.

This does not imply OSW has low value — rather, it reflects the broader set of stress conditions that NG can cover particularly as OSW reaches multiple gigawatts of investment.

2. **MRI increases as the system becomes more stressed.**

When more NG or OSW is removed from the system, overall EUE rises. In these higher-risk conditions, each added MW (of either resource) produces a larger reduction in EUE.

Conversely, as reliability improves, the marginal benefit of additional MW declines. This diminishing-return pattern appears for both technologies.

This means that adding more NG or OSW capacity is most valuable when the grid is under strain. In this scenario, each new unit helps prevent more outages. But as the system gets stronger and more reliable, adding extra capacity makes less of a difference. In the current outlook where reliability risks are material,[118] both resources have substantive reliability benefits.

[118] New York Independent System Operator. “2025 Q3 STAR Report Final.” NYISO, 2025. https://www.nyiso.com/documents/20142/39103148/2025-Q3-STAR-Report-Final.pdf.

While not explicitly studied, we are confident this trend extends to other technology types. This has important implications for grid planners: when the system has material reliability risks, all megawatts are good megawatts. This is critically important to consider when multiple regions across the country are facing credible possibilities of insufficient generation to meet reserve margin targets.[119,120]

3. NG and OSW become more effective when the other resource is present.

NG and OSW have complementary performance patterns that allow each resource to fill in gaps left by the other.

- When OSW levels are higher, NG's hit rate increases.
  Reason: OSW reduces winter and nighttime risk, allowing NG to address the remaining summer and low-wind hours more effectively.

- When NG levels are higher, OSW's hit rate increases.
  Reason: NG stabilizes periods with low wind, allowing OSW to focus on winter and fuel-constraint hours where it performs best.

To our knowledge, this is a novel insight into the relationship between NG and OSW and has important implications for pairing. This finding likely extends to other technologies that show strong seasonal synergies like solar and wind generation (both offshore and onshore).

4. OSW becomes less effective at higher penetrations.

As penetration increases, the incremental effectiveness of OSW declines. Its hit rate — the share of existing risk reduced with each additional megawatt of a resource — falls because those remaining risk hours increasingly shift to periods with lower wind output. As a result, each additional megawatt of OSW provides smaller reliability benefits.

NG also exhibits declining marginal reliability contributions, as reflected in a lower MRI at higher penetrations. However, this decline is driven primarily by a reduction in overall system risk — not by a deterioration in NG performance. Unlike OSW, NG's hit rate does not show a clear downward trend. This also has important implications for grid planners as they can seek to find the optimal level of OSW investment at a penetration where is provides direct benefits and also pair it with storage resources. Importantly, our findings show that the grid does not show material risk for overinvestment in OSW in the near- to medium-term. OSW continues to have a

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

120 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.* Charles River Associates, November 2025.

direct resource adequacy impact after multiple gigawatts of investment – a level beyond that in planned OSW projects. Further, this declining direct investment can be mitigated by pairing investment with storage resources.

5. The resources "compete" for the riskiest hours — but also complement each other.

The results show both **competitive and synergistic** effects:

- **Competitive:** As one technology grows, it eliminates the system's highest-risk hours first, leaving fewer critical hours for other resources to mitigate. This creates competitive interactions across technologies and causes MRI to decline with higher penetration. Each resource also exhibits diminishing returns within its own class, because additional megawatts increasingly mitigate remaining risk hours. These competitive interactions are not unique to NG and OSW. Once the system achieves its reliability target, EUE declines sharply, and the marginal value of further resources of any type drops toward zero.

- **Synergistic:** However, resource adequacy modeling shows, when risk exists, deploying both together causes each to be more effective. This is because each resource is more likely to be available during the remaining risk hours because each contributes best to different times of risk:

  - OSW "hits" remaining risk in winter mornings/evenings and NG-constrained hours

  - NG "hits" remaining risk in low-wind evenings, summer peaks, and net-load ramps

The hit rate analysis shows that NG and OSW mitigate different clusters of high-risk conditions, and together they provide broader coverage of the system's most severe hours. However, the MRI results indicate that planners must calibrate the balance and scale of each technology carefully. At high penetrations, either resource alone, or both in combination, can overshoot the level of investment needed to meet reliability targets, reducing marginal value. This challenge extends beyond NG and OSW to other technology types and is the key motivating principle behind electricity capacity markets. While this is an important consideration in the longer term, most markets are facing material shortfalls in the near- to medium-term.[121] As such, over-investment in either technology is unlikely. Deploying both NG and OSW together to address these emerging gaps provides a more robust strategy because each performs well under different regimes of system stress, and investment across disparate fuel sources and supply chains creates natural hedges if one of these technologies experiences a disruption in development or operation.

[121] Ibid.

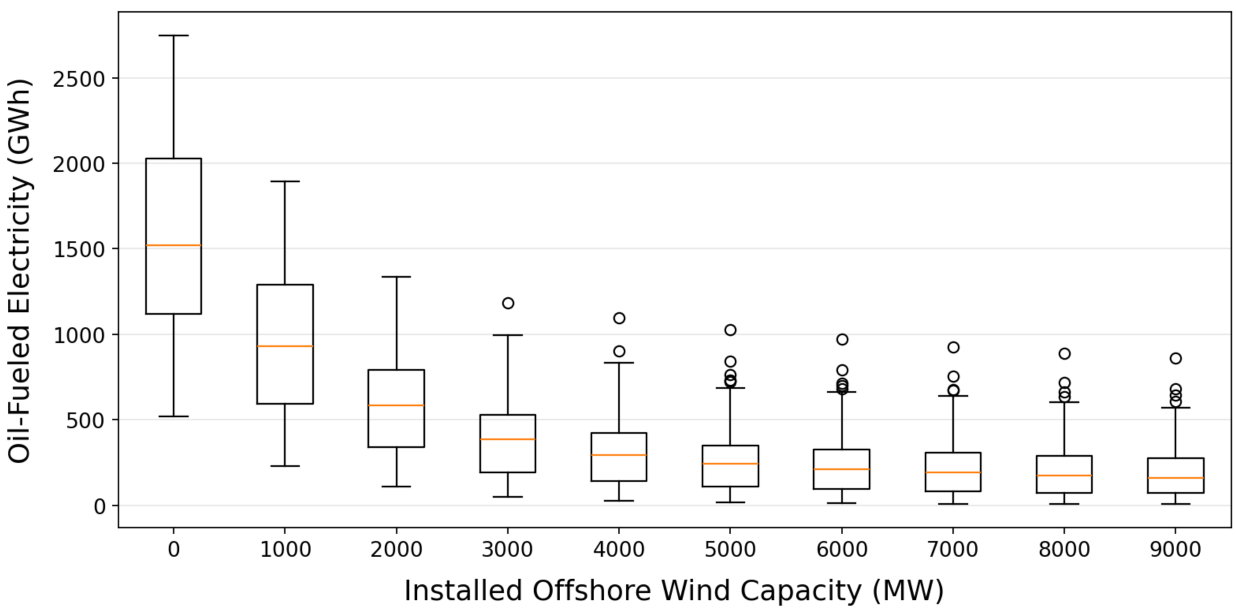
6.1.3 Quantitative analysis #3: Oil-fired generation in NYISO

This section presents the results of the third quantitative analysis, which examined the relationship between OSW generation and oil-fired operations in NYISO. Results for 2032 and 2036 are shown in Figure 6 and Figure 7, and the reduction in oil-fired generation per installed unit of OSW is summarized in Table 9.

The results show that, without new OSW, rising winter load would significantly increase reliance on oil-fired generation. In the absence of additional OSW, winter load growth leads to more periods in which gas-fired units cannot obtain sufficient NG and must rely on backup distillate fuels and use oil-only generation. Across the scenarios, oil-fired generation in Zones F–K, the most heavily populated regions of NYISO,[122] increases by more than 2.5× between the two years due to rising winter load.

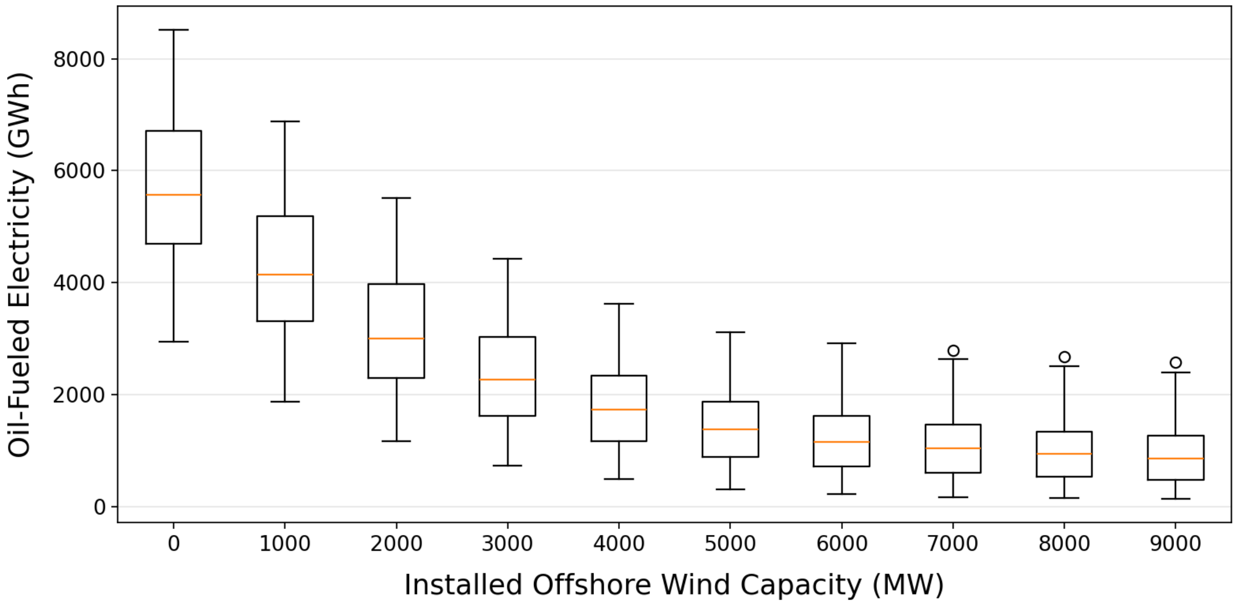
OSW additions materially reduce the number of hours in which oil is required. Because OSW output is highest during the same cold-weather periods when gas-deliverability constraints occur, even moderate levels of OSW offset a large share of the incremental winter load. As with higher levels of OSW investment, the amount of oil-fired generation required would drop sharply in both 2032 and 2036.

Figure 6: Annual electricity generated by oil in NYISO Zones F-K (2032)



[122] New York State Department of Health. *"Table 02 — Vital Statistics of New York State, 2020."* Accessed December 28, 2025. https://www.health.ny.gov/statistics/vital_statistics/2020/table02.htm

Figure 7: Annual electricity generated by oil in NYISO Zones F-K (2036)



With adequate OSW investment, the region avoids most of the oil-firing growth that would otherwise occur. In the high-OSW cases, oil use increases only slightly between 2032 and 2036 despite significant electrification-driven winter demand growth. This indicates that OSW can neutralize the additional oil-burn hours that would otherwise be required to maintain reliability. This is a critical finding for state regulators as they consider electrification for heating and transportation to achieve decarbonization. **Without bringing fuel-free generation that is aligned with the profile of growing demand (i.e., winter and evenings), electrification can result in unintended emissions and grid-stress increases.**

The magnitude of OSW's impact increases over time. OSW reduces more oil-fired generation in 2036 than in 2032 because winter load growth is larger in 2036, and the grid is more constrained during periods of extreme cold. As a result, each MW of OSW avoids more oil-fired generation in later years, as shown in Table 9. This represents an important finding: while OSW can contribute across all seasons, its greatest impact occurs in mitigating winter load growth.

The incremental value of OSW declines once OSW levels begin to saturate the highest-risk winter hours. Beyond approximately 5 GW of OSW, each additional MW yields diminishing direct reductions in oil-fired dispatch. This does not mean OSW could not provide further value; instead, it would have to pair with storage resources to further drive down fuel oil usage. This is also an important finding indicating that the risk of overinvesting in OSW is minimal: OSW continues to provide a direct contribution for this single market up to multiple gigawatts of investment.

Overall, the analysis shows that initial OSW additions deliver the largest reductions in oil firing, with subsequent additions providing complementary value, especially when paired with storage, by reducing the frequency and duration of backup-fuel operation during extreme winter conditions.

Table 9: Annual Electricity Generated by Oil in NYISO Zones F-K per OSW ICAP

Year	Annual Oil Generation Displaced Per MW of OSW at 1,000 MW of OSW	Annual Oil Generation Displaced Per MW of OSW at 3,300 MW of OSW
2032	590 MWh	180 MWh per MW
2036	1,468 MWh per MW	748 MWh per MW

6.2 Findings: Stakeholder engagement

Next, we discuss the findings from the engagement with NG EPCs. We spoke with or received written responses from five stakeholders. Their perspectives provide insight into the practical constraints facing new NG development, especially in regions with rapid load growth or fuel-deliverability limits. Several key themes emerged:

- **Surging demand for gas turbines:** Developers reported a sharp increase in requests for flexible, quick-start NG plants capable of meeting variable demand and running for extended periods, driven by hyperscaler and industrial load growth. Many are designing modular plants to meet rapid deployment needs and accommodate load swings.
- **Severe supply chain constraints:** Turbines, transformers, and breakers were consistently cited as the most constrained components, with lead times extending into 2029. Developers are securing equipment years in advance through reservation agreements to avoid delays.
- **Labor shortages and workforce strain:** All stakeholders noted difficulty sourcing skilled labor, especially electricians and field service technicians. Large-scale data center and energy projects are competing for the same limited labor pool, particularly in regions with shallow workforce availability.
- **Synergies with NG and renewables generators as customers:** Some stakeholders also reported that suppliers were concerned that demand from NG customers would decline in the longer term. This created headwinds for them to justify investments to expand their manufacturing capacity to meet near-term upticks in demand. However, when suppliers jointly supplied NG and renewable generators, they were more confident in making investments due to a more diversified and durable customer base.

- **Lengthy and complex permitting processes:** Permitting timelines – especially for interconnection – were cited as a major barrier, with delays of three to five years or more in ISO-NE, PJM, and MISO queues. Developers emphasized the importance of early engagement with permitting agencies and local communities to mitigate delays.

6.3 Findings: Qualitative case studies

This section reviews the impact of two OSW projects that have been placed in service or will be placed in service imminently.

6.3.1 Dominion's CVOW

Dominion's Coastal Virginia Offshore Wind (CVOW) project is a 2.6-GW OSW farm consisting of 176 turbines located roughly 27 miles off the Virginia Beach coast. The project was projected to be completed by the end 2026,[123] but has faced a pause in its lease due to an order for the US Department of Interior.[124] Assuming CVOW can be successfully brought online, it will be the largest OSW project in the country. At its planned output, the project is expected to generate enough electricity to serve approximately 660,000 homes, providing critical new energy generation in one of the fastest growing electrical grids in the country.[125]

The key driver of this growth is data center development in the region. Dominion Virginia powers the largest data center market globally, more than five times larger than the next largest domestic market.[126] As a result of substantial investments in this sector, PJM projects up to a 6.3% compound annual growth rate (CAGR) in peak demand in the Dominion zone over the next decade.[127] This is placing pressure on the system's ability to reliably and affordably meet growing demand – as reflected in warnings from the Department of Energy's recent reliability study,[128] sharp spikes in capacity prices PJM-wide,[129] and failure to clear sufficient generating capacity in the Dominion zone to meet its reliability requirement in the 2025/2026 PJM Capacity

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123 Dominion Energy. *Coastal Virginia Offshore Wind: The Project.* Accessed February 2025. https://coastalvawind.com/about/the-project

124 US Department of the Interior. 2025. "Trump Administration Protects US National Security by Pausing Offshore Wind Leases." Press release. Accessed December 28, 2025. https://www.doi.gov/pressreleases/trump-administration-protects-us-national-security-pausing-offshore-wind-leases

125 Ibid.

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

127 PJM Resource Adequacy Planning Department. *PJM Long-Term Load Forecast Report*. 2025. https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2025-load-report.pdf

128 US Department of Energy. *Report on Evaluating U.S. Grid Reliability and Security.* Washington, DC: US Department of Energy, July 2025.

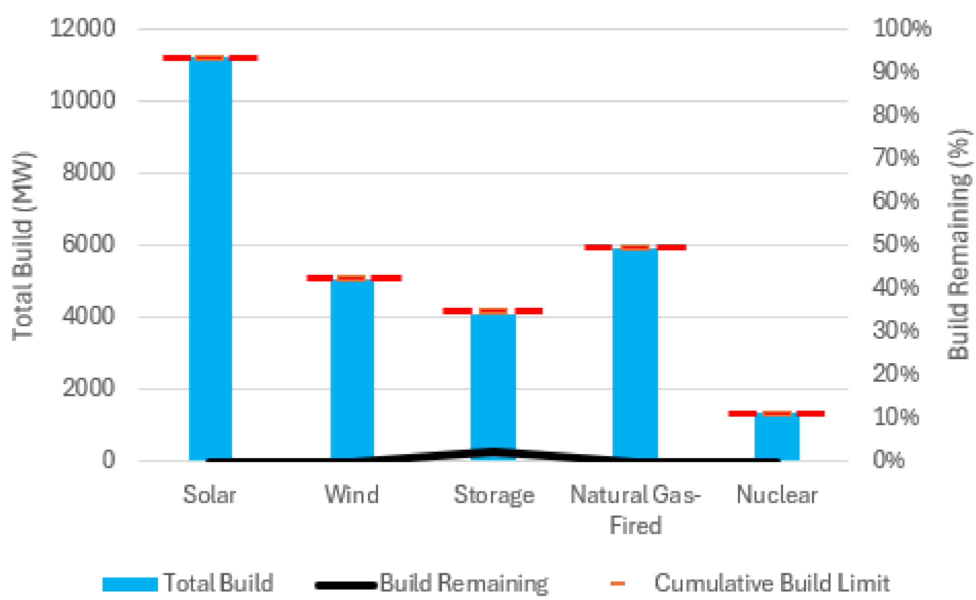
129 PJM. *2026/2027 Base Residual Auction Report*. July 22, 2025. For public use. PJM. Accessed August 18, 2025. https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2026-2027/2026-2027-bra-report.pdf.

Auction.[130] In the 2027/2028 PJM Base Residual Auction, the market failed to meet its reserve margin target by more than 6 GW of accredited capacity. Importantly, this shortfall is reported on an accredited basis, meaning that PJM requires well over 6 GW of installed capacity to mitigate this shortfall.[131]

This is further reflected in Dominion's 2025 Integrated Resource Plan, the long-term strategic planning document required by Virginia law to evaluate the need for additional generating resources. Dominion's IRP contemplates substantial investment to meet growing load demand: including 5.9 GW of NG, 12 GW of solar, 1.3 GW of small modular nuclear reactors, 4.1 GW of energy storage, 60 MW of onshore wind, and 2.6 GW OSW in addition to its ongoing 2.6 GW CVOW project.

Most critically, as shown in Figure 8, Dominion proposes to develop all resources at their maximum annual build limits, with the exception of solar distributed energy resources (DERs) and storage resources which have limited room for additional growth. These build limits represent the amount of each generation type that Dominion considers feasible to construct in a given year, based on practical constraints such as land, workforce, capital, and supply chain capacity.

Figure 8: 2024 Dominion integrated resource plan for 2029-2039



130 PJM. *2025/2026 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/2025-2026/2025-2026-base-residual-auction-report.pdf.

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

By relying on existing technologies alone – principally solar, storage, NG – Dominion would be unable to maintain reliability under this rapid pace of load growth. Even with the meaningful buildout charted in Dominion's IRP, which includes additions of OSW and next-generation nuclear technology, Dominion still anticipates a material shortfall of firm capacity, requiring up to 3.3 GW of annual capacity purchases from the PJM market or bilateral contracts. Without additional phases of CVOW, that requirement could rise to approximately 4 GW, a 20% increase above Dominion's stated planning cap.[132]

A capacity purchase means Dominion must procure the capacity needed to meet its resource adequacy requirement from third-party suppliers. This reliance on external markets introduces significant uncertainty: there is no guarantee that the physical resources needed to back those capacity commitments will materialize. This dynamic was evident in the 2026/2027 PJM Base Residual Auction, where the PJM cleared over 6 GW below its reserve margin targets, despite historically high capacity prices, indicating insufficient physical supply to meet the zone's needs.[133]

These dynamics underscore the challenges of meeting modern load growth, driven by electrification, data centers, and industrial reshoring, with legacy technologies alone. Even building all legacy resources to their maximum capacity, they may be unable to keep pace with load growth. **OSW – working in concert with NG – represents a promising additional pathway for reliability and affordability**. In this context, it is not a replacement for NG; rather it is an auxiliary energy and capacity avenue. Without it, Dominion's system would face a widening reliability gap and rising dependence on external capacity purchases.

6.3.2 South Fork Wind

South Fork Wind (South Fork) demonstrates how OSW can be deployed as a complementary resource to NG to address localized reliability constraints, defer transmission investments, and bring new energy and capacity in a gas-limited region.[134]

South Fork Wind was placed into service in March 2024 and is the first utility-scale OSW project to deliver power to the American grid. It is located approximately 35 miles east of Montauk Point, New York, and consists of 15 turbines. It has a total nameplate capacity of 132 MW and generates 444 GWh annually, enough to power the region's 70,000 homes.[135] By adding a local, fuel-free resource, the project enhances reliability, reduces dependence on a

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132 Ibid.

133 Ibid.

134 This paper refers to the OSW project as 'South Fork Wind' and the region as 'South Fork region' or 'South Fork'.

135 "Welcome to South Fork Wind" n.d. Southforkwind.com. https://southforkwind.com/.

single fuel, bypasses a constrained natural gas supply, and defers the need for select local transmission investments.

South Fork Wind originated in the 2015 South Fork Request for Proposals (RFP), issued by PSEG Long Island on behalf of the Long Island Power Authority (LIPA). The RFP sought up to 169 MW to meet forecasted peak demand and defer expensive local transmission upgrades on the South Fork. The RFP specifically highlighted concerns around limited NG deliverability to the region. Only fuel-free or liquid fuel resources with an identified supply were considered in the proposal.[136]

Of the twenty-one proposals, OSW – paired with demand reduction, storage, and transmission investments[137] – ultimately offered the best combination of scale, timing, and risk profile. OSW could deliver large amount of energy directly into the transmission-constrained South Fork region load pocket during winter and overnight hours when NG pipelines are most constrained, heating demand is highest, and gas-fired units often run near capacity. Though lower than winter generation, OSW could also play a role in meeting peak summer demand. With no fuel cost, OSW also provided long-term price certainty, which hedged customers against potential spikes in NG prices. Prior to this project, the South Fork region relied almost entirely on gas-fired generation and experienced significant constraints on its systems, which created reliability and price risks from dependence on a single fuel type. LIPA explicitly cited the value of fuel diversification in its procurement materials, noting that renewable supply avoids exposure to the risk of fossil-fuel price uncertainty over the contract term.[97]

South Fork Wind complements, rather than replaces, NG in the energy mix. The South Fork region's NG plants remain essential for meeting demand during periods of low-wind and for providing dispatchable capacity to smooth variations in wind and provide reserves.[138] OSW supplies generation during cold winter and overnight hours, reducing the marginal hours gas units are run and easing stress on Long Island's constrained gas system.[139] OSW also plays a critical role in solving near-term reliability risks, buying time for the implementation of longer term investments.[140] The synergies between these resources improve the system's reliability and resilience and enables NG to be used where it is most impactful – for building heating in winter months and meeting electricity peak in summer months.

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136 PSEG Long Island. *2015 South Fork Resources Request for Proposals*. June 24, 2015. https://www.psegliny.com/aboutpseglongisland/proposalsandbids/2015southforkrfp

137 Long Island Power Authority. "South Fork RFP: Board Materials for the LIPA Board of Trustees." January 25, 2017. https://www.lipower.org/wp-content/uploads/2019/02/2017-01-South-Fork-Board-Material.pdf

138 "Celebrating One Year with South Fork Wind." 2025. LIPA. April 10, 2025. https://www.lipower.org/blog/celebrating-one-year-with-south-fork-wind/.

139 "New York Independent System Operator. *Power Trends 2025: A Balanced Path to a Reliable and Renewable Grid.* Rensselaer, NY: NYISO, 2025, 32. https://www.nyiso.com/documents/20142/2223020/2025-Power-Trends.pdf

140 Long Island Power Authority. "South Fork RFP: Board Materials for the LIPA Board of Trustees." January 25, 2017. https://www.lipower.org/wp-content/uploads/2019/02/2017-01-South-Fork-Board-Material.pdf

South Fork Wind's successful deployment demonstrates that OSW can serve as a scalable, near-term addition to regional grids in areas where permitting and supply chain constraints limit new gas infrastructure. As the first utility-scale OSW project to deliver power to the American grid, South Fork Wind illustrates how OSW can work alongside NG by easing near-term pressures, enhancing grid resilience, minimizing and deferring transmission investments, and supporting a diversified energy strategy aligned with national energy policy goals.

6.4 Findings: Literature review

6.4.1 Joint role in meeting American Energy Policy

Based on review of public information, we have identified several ways these resources can jointly support progress toward the energy dominance goals that have been highlighted as key targets. These include:

- **Energy independence and security:** The US has become a major natural-gas and LNG exporter,[141] helping buffer domestic and allied markets from global price shocks,[142] as seen after Russia's 2022 supply cuts to Europe.[143,144] While OSW is still emerging, the ~80 GW in development shows its potential to strengthen energy independence with fuel-free, domestic generation.[145] By reducing gas-fired output, OSW helps preserve limited gas and distillate supplies for higher-value heating needs and low-wind hours.

- **Reliability and resilience:** NG is the backbone of US reliability but is affected by winter fuel-deliverability constraints and cold-weather outages. OSW aligns well with emerging winter-peaking reliability needs, providing strong winter and nighttime output and achieving relatively high ELCCs.[146] Paired together, OSW and NG provide seasonally complementary reliability – NG covers summer peaks; OSW covers winter stress periods. (summer on the East Coast). An example is shown in Figure 9. This figure shows the average daily available

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141 US Energy Information Administration (EIA), *Natural gas explained—Natural gas imports and exports*, Eia.gov, 2016, https://www.eia.gov/energyexplained/natural-gas/imports-and-exports.php.

142 "Oil Prices Have Soared, Why Won't Opec Bring Them Down?" *BBC News*, sec. Business, May 3, 2022, https://www.bbc.com/news/business-61188579.

143 Mark Green, "Europe, Germany and the Continued Benefits of US LNG Exports," *American Petroleum Institute (API)*, Api.org, 2023, https://www.api.org/news-policy-and-issues/blog/2023/07/05/europe-germany-and-the-continued-benefits-of-us-lng-exports?.

144 Center for Strategic and International Studies (CSIS), *US LNG: Remapping Energy Security*, Csis.org, January 17, 2023, https://features.csis.org/us-lng-remapping-energy-security.

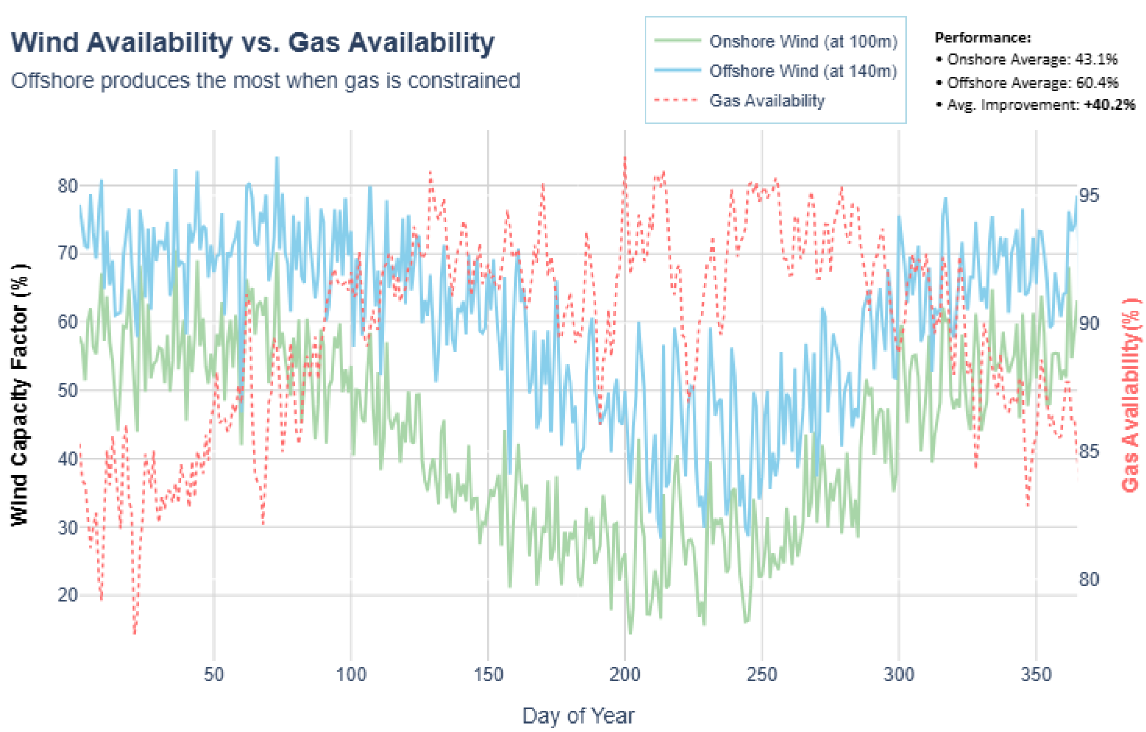
145 NREL, 2024, *OFFSHORE WIND MARKET REPORT 2024 EDITION*, Nrel.gov, 2024, https://www.nrel.gov/docs/fy24osti/90525.pdf.

146 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.* Charles River Associates, November 2025. https://media.crai.com/wp-content/uploads/2025/11/05132542/CRA-Report-Offshore-Winds-Contribution-to-Grid-Reliability-Resource-Adequacy-November-2025.pdf

generation from Revolution Wind (OSW), an onshore wind site in Rhode Island, and a NG plant. As shown in the figure, eastern wind farms produce the most during the winter, when NG faces its greatest likelihood out outages due to cold-weather, common-cause outages. At the same time, the summer shows the reverse trend. Wind generation can still contribute but produces less due to slower winds which can be covered by NG plants. The figure also shows the benefits of going offshore – OSW has higher capacity factors, particularly in the summer months, than onshore equivalents.

- **Economic growth & onshoring:** Rapid expansion in manufacturing, semiconductors, and data centers demands large-scale, reliable, low-cost electricity. Both offer critical pathways to bring the required net new energy and capacity to the grid to meet growing demand. OSW can deliver major volumes of local, fuel-free energy near coastal industrial hubs, reducing reliance on long transmission paths. OSW can also provide low-carbon generation to meet customer's preference. NG provides firm capacity to meet high load-factor industrial needs and support net-load ramps but is limited by regional fuel-infrastructure headroom in certain areas of the country. Combined, they can add new resources in regions where each is the most prudent, increasing the pace at which load can be reliability brought onto the system.

Figure 9: Resource availability comparison



6.4.2 Joint challenges

Despite the potential positive impacts of both of these resources in meeting load growth, both NG and OSW face structural development challenges that stem from broader constraints in the US energy-infrastructure ecosystem rather than from the characteristics of either technology alone. These shared constraints fall into three main categories: (1) global and domestic supply chain bottlenecks, (2) shortages of skilled labor and EPC capacity, and (3) fragmented, multi-layered permitting processes. Because these barriers affect both technologies in similar ways, many of the most effective solutions are those that expand systemwide capacity to plan, approve, and construct critical infrastructure rather than favoring one resource type over another.

Shared supply chain constraints

NG and OSW both rely on highly specialized, globally concentrated supply chains. For NG, the constraint manifests as limited availability of large gas turbines, long-lead auxiliary systems, steel forgings, and high-spec alloys. Turbine manufacturing lines serving power generation already operate near full utilization,[147] and long-standing shortages of castings, heat-treat equipment, and precision components have pushed delivery schedules for turbines into 2029 and beyond.[148,149] These same foundries and heavy-industrial suppliers are also required for OSW components: nacelle castings, tower sections, transition pieces, monopiles, and high-voltage subsea cables all depend on similar upstream metallurgical capacity.[150, 151, 152]

The US currently relies on a thin supply base for OSW installation equipment, particularly Jones Act[153]–compliant WTIVs, and on a small set of ports capable of marshaling OSW components.[154] NG and OSW therefore face structurally similar challenges: critical components are produced by a small number of manufacturers with limited ability to expand output quickly, and US-based assembly and logistics capacity has not kept pace with demand. Both resource types are

147 Mackenzie, Wood. 2025. "Wood Mackenzie." Woodmac.com. May 14, 2025. https://www.woodmac.com/press-releases/despite-surging-power-demand-gas-fired-power-faces-manufacturing-constraints-that-could-limit-near-term-growth/.

148 Congressional Research Service. Natural Gas Reliability: Issues for Congress. CRS Report R48127, July 15, 2024.

149 Sophie. 2025. "Costs to Build Gas Plants Triple, Says CEO of NextEra Energy." Gas Outlook. March 25, 2025. https://gasoutlook.com/analysis/costs-to-build-gas-plants-triple-says-ceo-of-nextera-energy/.

150 US Department of Energy. *Securing the US Supply Chain for the Wind Energy Industry.* Washington, DC 2023

151 National Renewable Energy Laboratory. *The Demand for a Domestic Offshore Wind Energy Supply Chain.* Golden, CO: NREL/TP-5000-81602, 2022.

152 Energy Transitions Commission. *Offshore Wind Insights Briefing.* Gland, Switzerland, 2023.

153 The Jones Act, formally the Merchant Marine Act of 1920, requires that cargo transported between two US points be carried on vessels that are built in the United States, owned by US citizens or entities, crewed primarily by US citizens, and registered under the US flag. A "Jones Act-compliant" vessel is one that meets all these criteria, allowing it to legally transport equipment, components, or personnel between US ports and project sites without relying on foreign-flagged ships.

154 Shenk, Mark. 2024. "Launch of US Wind Installation Vessel Masks Critical Shortage." *Reuters*, June 13, 2024. https://www.reuters.com/business/energy/launch-us-wind-installation-vessel-masks-critical-shortage-2024-06-13/.

exposed to global competition for equipment, extended delivery timelines, and sharply escalating capital costs. Both also face market and regulatory uncertainty which is creating headwinds for investment in these critically constrained elements of the supply chain.

Shared labor and EPC constraints

Workforce limitations affect NG and OSW in parallel. Both require skilled electricians, welders, technicians, and union labor with experience in large-scale energy-infrastructure construction. The retirement of much of the experienced thermal-generation workforce, combined with rapid labor absorption by LNG export terminals, semiconductor fabrication, data centers, and petrochemical expansions, has left few EPC firms with available capacity.[155] NG developers reported significant schedule extensions due to EPC unavailability, while OSW developers face parallel constraints in marine construction crews, high-voltage cable installers, and commissioning technicians.[156, 157]

Even where labor exists, it is highly localized and often immobile. For example, according to one of the stakeholders interviewed in this white paper, a single 500 megawatt data center may require up to 4,000 skilled workers during peak construction, drawing from the same labor pool needed to build NG plants and OSW ports. Both technologies therefore face rising labor costs, limited competition among EPCs, and long queues for firms capable of delivering large, complex projects on tight schedules.

Shared regulatory and permitting constraints

NG and OSW infrastructure both navigate fragmented, multi-agency permitting frameworks that introduce high levels of delay, uncertainty,[158] reversals,[159] and litigation risk.[160, 161] NG pipelines

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155 Kann, Shayle. 2025. "The Gas Turbine Crunch." Latitude Media. June 5, 2025. https://www.latitudemedia.com/news/catalyst-the-gas-turbine-crunch/.

156 Sophie. 2025. "Costs to Build Gas Plants Triple, Says CEO of NextEra Energy." Gas Outlook. March 25, 2025. https://gasoutlook.com/analysis/costs-to-build-gas-plants-triple-says-ceo-of-nextera-energy/.

157 "Rush for US Gas Plants Drives up Costs, Lead Times | Reuters Events | Renewables." 2025. Reutersevents.com. 2025. https://www.reutersevents.com/renewables/solar-pv/rush-us-gas-plants-drives-costs-lead-times.

158 Reuters. 2021. "Factbox: US Oil and Natgas Pipelines Delayed by Legal and Regulatory Battles." Reuters. February 2021. https://www.reuters.com/article/us-usa-canada-pipelines-factbox/factbox-u-s-oil-and-natgas-pipelines-delayed-by-legal-and-regulatory-battles-idUSKBN2A11EI.

159 Trump, Donald J. "Temporary Withdrawal of All Areas on the Outer Continental Shelf from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects." *The White House*, January 20, 2025. https://www.whitehouse.gov/presidential-actions/2025/01/temporary-withdrawal-of-all-areas-on-the-outer-continental-shelf-from-offshore-wind-leasing-and-review-of-the-federal-governments-leasing-and-permitting-practices-for-wind-projects/

160 Webster, Carpen. 2023. "US Offshore Wind's Growing Pains: Permitting and Cost Inflation." Atlantic Council. June 26, 2023. https://www.atlanticcouncil.org/blogs/energysource/us-offshore-winds-growing-pains-permitting-and-cost-inflation/.

161 Niezrecki, Christopher. 2024. "US Offshore Wind Farms Are Being Strangled with Red Tape." WIRED. May 26, 2024. https://www.wired.com/story/why-us-offshore-wind-power-is-struggling/.

require approvals from FERC, EPA, PHMSA, USACE, and multiple state water-quality and coastal-zone authorities – any one of which can stall or derail a project even after federal approval.[162, 163] OSW projects face a similar gauntlet: BOEM for leasing and site assessment, NOAA for protected species, EPA for air permits, Army Corps for underwater cable routes, and numerous state environmental and coastal regulators.

These overlapping reviews often introduce duplicative requirements, prolonged timelines, and inconsistent agency sequencing.[164] Litigation risk is significant for both sectors; pipelines such as MVP,[165, 166] ACP,[167] Constitution,[168, 169] and NESE[170, 171] demonstrate how legal challenges can delay or halt NG projects, while shifting federal policy, state opposition, and legal challenges have reversed progress on several OSW projects and related port investments. These shared permitting limitations elevate project costs, create financing risk premiums, and reduce the rate at which either technology can contribute new capacity to the grid.

Conclusions

This white paper evaluates how OSW and NG can jointly support America's energy goals in an era of rapid load growth, emerging winter and traditional summer reliability risk, and binding infrastructure constraints. Using a combination of quantitative modeling, stakeholder outreach, and qualitative case studies, we assess the roles that OSW and NG can play together in

162 "Interstate Natural Gas Pipeline Siting: FERC Policy and Issues for Congress." 2025. Congress.gov. 2025. https://www.congress.gov/crs-product/R45239.

163 "Interstate Natural Gas Pipeline Permitting Process – Environmental and Energy Law Program." 2023. Harvard.edu. 2023. https://eelp.law.harvard.edu/interstate-natural-gas-pipeline-permitting-process/.

164 "Can the Biden Administration Meet Its Offshore Wind Goals? | Blank Rome LLP." 2021. Blankrome.com. 2021. https://www.blankrome.com/publications/can-biden-administration-meet-its-offshore-wind-goals.

165 Mountain Valley Pipeline Wants Permit Extension until 2026 to Finish Last Elements." 2022. S&P Global Commodity Insights. 2022. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/natural-gas/062722-mountain-valley-pipeline-wants-permit-extension-until-2026-to-finish-last-elements.

166 Morehouse, Catherine. 2024. "FERC Gives Green Light to Start up Mountain Valley Pipeline." POLITICO. Politico. June 11, 2024. https://www.politico.com/news/2024/06/11/ferc-greenlights-mountain-valley-pipeline-startup-00162827.

167 Energy, Duke. 2020. "Dominion Energy and Duke Energy Cancel the Atlantic Coast Pipeline." Duke Energy | News Center. 2020. https://news.duke-energy.com/releases/dominion-energy-and-duke-energy-cancel-the-atlantic-coast-pipeline.

168 Williams Cancels N.Y. Constitution Pipeline." 2020. Pgjonline.com. 2020. https://pgjonline.com/news/2020/02-february/williams-cancels-ny-constitution-pipeline.

169 Disavino, Scott. 2025. "Williams Working with Federal, State Regulators to Revive Pennsylvania-New York Natgas Pipes." Reuters, May 29, 2025. https://www.reuters.com/business/energy/williams-working-with-federal-state-regulators-revive-pennsylvania-new-york-2025-05-29/.

170 Williams Throws in Towel on NESE Pipeline Project." 2024. Ieefa.org. 2024. https://ieefa.org/resources/williams-throws-towel-nese-pipeline-project.

171 "Williams to Revive Constitution, NESE Pipelines in Joint Effort with Regulators." 2025. Pgjonline.com. 2025. https://pgjonline.com/news/2025/may/williams-to-revive-constitution-nese-pipelines-in-joint-effort-with-regulators.

meeting reliability, affordability, and energy security objectives under realistic build and fuel-deliverability limits.

Across methods and regions, several consistent conclusions emerge.

1. **NG alone cannot fully resolve emerging reliability risks under realistic fuel and infrastructure limits.**

NG remains a cornerstone of grid reliability. It provides fast-ramping, energy-dense capacity that is critical for meeting net-load ramps, contingencies, and long-duration events. However, the headroom analysis for New York and New England shows that firm pipeline capacity places binding constraints on how much additional NG generation can be added in the near- to medium-term in some parts of the country. In several gas-constrained corridors, winter pipeline flows already approach physical or contractual limits during cold weather, leaving limited room for incremental NG generators operating on firm fuel. While NG resources can be added on interruptible contracts and other regions with more headroom, this mutes their reliability impact, particularly in the winter months where NG fuel systems are the most stressed.

In addition to fuel limits, the supply chain for NG turbines and other components and the labor pool to design and construct these power plants are constrained. The supply chain for NG turbine manufacturing is almost fully utilized – materially driving up prices and creating multi-year delays for turbines. Further, the skilled labor pool needed to construct these new plants has competing employment opportunities from booming data center and manufacturing sectors.

At the same time, electrification and industrial onshoring are driving faster winter than summer load growth in these regions. Without new non-gas resources, this trend will increase reliance on dual-fuel operation, raising costs and exposure to fuel-availability risk, and heighten the probability of emergency actions during extreme events. Even in planning exercises that assume substantial NG build, such as the Dominion IRP example, the system often still requires large amounts of external capacity purchases and non-gas builds to meet reliability requirements. This indicates that relying on NG alone, even under aggressive build assumptions, will not fully close emerging capacity gaps.

2. **OSW and NG exhibit strong complementarities in reliability and fuel security.**

The MRI (hit rate) and NYISO oil-firing analyses both show that OSW and NG provide complementary contributions to resource adequacy. On the Atlantic Coast, OSW tends to produce its highest output during winter and nighttime periods – precisely the hours when NG fuel-deliverability constraints are most severe. In California, similar synergies emerge: Pacific OSW generates during summer, which will remain California's period of stress. This alignment is reflected in the hit rate results, which show that each technology becomes more effective at reducing remaining risk when the other is present. Their seasonal and operational differences allow each to address risk hours in which the other is weak.

The fuel-oil analysis examines another element of OSW and NG interaction. OSW additions can offset winter load growth in downstate New York and substantially reduce the number of hours in which dual-fuel generators must switch to oil. In our view, these results will extend to other regions facing faster winter than summer growth. Lower oil-firing by adding winter-aligned fuel-free generation translates to multiple system benefits: reduced fuel costs, lower local emissions, preservation of limited on-site oil inventories for the highest-risk events, and reduced mechanical and maintenance stress on aging thermal units. By easing pressure during periods when NG units are most fuel-constrained, OSW effectively enhances the reliability contribution of the NG fleet.

3. OSW and NG together better support US energy-security and economic-growth objectives through complementary strengths.

Recent US energy policy has emphasized energy independence, resilience, and support for strategic industrial sectors such as AI data centers and semiconductor manufacturing. NG has already enabled the US to become a major exporter of fuel, insulating domestic and allied markets from some global fuel-price shocks. OSW, while still emerging, has the potential to become a large-scale, fuel-free domestic resource that is insulated from global fuel-price volatility, can be sited near coastal load centers, and meet consumer preference for emissions reduction.

Our review of policy, literature, and case studies suggests that OSW and NG play complementary roles in meeting these goals. NG provides firm, dispatchable capacity and supports high load-factor industrial demand. OSW reduces electric-sector NG use during constrained hours, eases pipeline stress in winter and overnight periods, and hedges fuel-price risk as load grows. In regions such as Dominion's service territory, even aggressive build-outs of traditional resources are insufficient to fully meet projected load growth without OSW. In regions where existing fuel and transmission systems are strained – like South Fork – locally connected OSW can harden existing fuel systems and delay transmission investments. Together, OSW and NG create a more robust platform for energy-intensive economic development than either could provide alone.

4. Supply-chain, labor, and permitting constraints are shared across technologies and limit the pace of deployment.

Our stakeholder outreach and literature review indicate that NG and OSW face many of the same structural barriers. Both rely on globally concentrated supply chains for turbines, heavy forgings, and critical components. Both require specialized EPC capacity and skilled labor that is increasingly scarce due to competing demand from LNG terminals, data centers, semiconductor facilities, and other industrial projects. Both must navigate fragmented, multi-layered permitting systems that can extend project timelines by several years and create significant litigation risk.

These constraints are already visible in project economics and timelines. Gas turbine backlogs now extend into the late 2020s, capital costs for new NG plants have risen sharply, and many OSW projects face delays driven by vessel availability, port limitations, regulatory uncertainty, and policy reversals. These structural limitations imply that the primary bottleneck is not a lack of viable technologies, but a constrained infrastructure and development ecosystem that slows deployment across the board.

A path forward

Given these shared constraints, we find that there may be benefits to reforms that strengthen systemwide capacity to plan, permit, finance, and build energy infrastructure across technologies. Streamlined, coordinated permitting processes can reduce schedule risk and lower financing costs for both OSW and NG projects. Expanding domestic manufacturing capacity for turbines, cables, vessels, and related components relieves upstream bottlenecks that affect all large-scale resources. Stable, long-term market signals could incentivize key stakeholders across the supply chain to make capital-intensive upgrades needed to expand manufacturing capacity. Workforce development and EPC-capacity expansion programs that focus on common skills in engineering, construction, and operations could ease labor constraints for both sectors.

Coordinated infrastructure planning could also play an effective role. Transmission upgrades, strategic port investments, and targeted pipeline expansions in select corridors can increase the flexibility of the power system to integrate new OSW and NG facilities. Aligning deployment timelines so that near-term OSW additions help fill emerging capacity gaps while longer-lead NG projects are developed could allow planners to manage risk across multiple time horizons.

More broadly, our analysis demonstrates that the scale and pace of projected load growth in the US require a portfolio-wide approach to reliability planning. The pace of new generation additions has not kept up with rapidly growing load. Without urgent action to bring new megawatts to the grid, we face material near-term reliability risks in many parts of the country.[172] In light of these challenges, OSW and NG need not be viewed as competing or mutually exclusive options. Instead, they are both effective, complementary resources – each with distinct strengths that address different reliability risks and operational needs. OSW provides critical winter and nighttime generation, directly mitigating fuel constraints, supporting decarbonization goals, and connecting to transmission-constrained coastal zones. Meanwhile, NG offers flexible, dispatchable capacity to cover low-wind periods and rapid demand swings and connect inland to regions with ample pipeline headroom. By pulling from different fuel sources, pairing both resources creates natural hedges if either faces development or operational setbacks. By leveraging both technologies, system operators and policymakers can better maintain reliability, enhance energy security, and support the nation’s economic and geopolitical leadership in an increasingly electrified and competitive global landscape.

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[172] US Department of Energy, Resource Adequacy Report: Evaluating the Reliability and Security of the US Electric Grid (DOE final report, July 7, 2025), developed with assistance from National Renewable Energy Laboratory and Pacific Northwest National Laboratory, and NERC data (DOE/Publication Number, July 7 2025), https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

Appendix

Stakeholder question list

Infrastructure & supply chain

1. What are the most significant supply chain constraints currently affecting the construction of natural gas power plants (e.g., turbines, piping, control systems)?
2. How have global manufacturing backlogs or transportation delays impacted your project timelines over the past 2–3 years?

Permitting & regulatory challenges

3. What are the most common permitting or regulatory hurdles you face when developing new NG power plants, particularly in the Northeast and Mid-Atlantic regions?
4. In light of recent developments – such as the Constitution Pipeline project being revisited – do you believe the regulatory environment for building natural gas infrastructure in the Northeast and Mid-Atlantic is becoming more favorable? If so, how is this influencing your project planning or investment outlook?

Market dynamics & demand

5. How has the recent surge in demand from data centers and manufacturing facilities influenced the types of projects you're being asked to build?
6. What trends are you seeing in terms of pricing of materials for gas turbines and OSW-related infrastructure?
7. Are you seeing increased competition for key components or labor due to overlapping demand from other industries (e.g., aerospace, LNG, renewables)?

Complementarity nature with offshore wind

8. From your perspective, how could offshore wind generation help alleviate some of the pressure on natural gas infrastructure, especially during peak demand periods?
9. Do you see opportunities for hybrid or complementary projects that integrate natural gas with renewables like offshore wind?

Strategic outlook

10. What strategies are EPC firms like yours adopting to mitigate risks associated with supply chain volatility or permitting delays?
11. Looking ahead, what do you see as the biggest risks and opportunities for natural gas power plant development in the next 5–10 years?

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